Factors to Consider Regarding Surveillance, Biosecurity and Movement Permitting of Sheep in a Foot and Mouth Disease Outbreak

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Introduction

Over the past several years, Secure Food Supply (SFS) business continuity plans have been developed for beef, pork, and milk producers in the event of a foot and mouth disease (FMD) outbreak in the United States. The development of these plans involved discussions among the livestock industries and federal and state regulatory officials, facilitated by academia, to come to a consensus and to produce the Secure Beef Supply (SBS), the Secure Pork Supply (SPS) and the Secure Milk Supply (SMS) Plans. The plans are intended to help producers protect their animals from infection. They also facilitate animal and product movement from premises that are under movement restrictions in a regulatory Control Area whose animals and products are at a low risk of being infected. Many of the concepts and components of those plans are relevant to a Secure Sheep and Wool Supply (SSWS) Plan. However, there are some important differences between sheep and other species regarding FMD infection and in husbandry practices that need to be addressed.

The **purpose** of this document is to summarize the various factors to consider regarding surveillance, biosecurity, and movement permitting of sheep as compared to the approach in other SFS Plans.

FMD Response Guidance

There are several guidance documents for Responsible Regulatory Officials to use in an FMD Outbreak. The goals of the SFS Plans align with these guidance documents.

- The goal is to detect FMD as quickly as possible and to work aggressively to stamp it out, if possible, to return the U.S. to FMD free status. (see: *Foot-and-Mouth Disease Response Plan: The Red Book*, www.aphis.usda.gov/animal_health/emergency_management/downloads/fmd_responseplan.pdf)
    - Regulatory Control Areas will be established around the infected premises.
    - Movement of animals, products and vehicles/materials into, within, and out of an FMD Control Area will be based on risk and be by permit only.
- During an outbreak, while there is still a chance of stamping out FMD infection in the U.S. or in a particular state, all infected animals, herds, and flocks will likely be depopulated, preferably within 24 to 48 hours of detection of infection. Carcasses must be disposed of in a biosecure manner and according to federal, state, and local environmental regulations.
    - If animals are ordered to be depopulated by regulatory officials, the federal government is currently obligated to pay the owners 50% of the appraised value of the animals (Title 9 Code of Federal Regulations 53.2, Determination of existence of disease; agreements with States.).
- In an extensive and rapidly moving outbreak, it may not be possible to stamp out the infection, so alternate approaches may be needed (see: *Classification of Phases and Types of a Foot-and-Mouth Disease Outbreak and Response*, www.aphis.usda.gov/animal_health/emergency_management/downloads/phases-and-types-of-an-fmd-outbreak_2013.pdf)

- At the beginning of a U.S. FMD outbreak, the USDA may request a 72-hour movement standstill for all susceptible species. It will be up to the State Animal Health Officials to implement the standstill orders in their states. See: *Managed Movement of Susceptible Livestock Species in the U.S. during a Foot and Mouth Disease Outbreak*, November 2019.
    - Overview (two-page) available at: www.cfsph.iastate.edu/pdf-library/FMD-Resources/disease-fmd-sfs-managed-movement-overview.pdf
    - Considerations for Regulatory Officials (six-pages) available at: www.cfsph.iastate.edu/pdf-library/FMD-Resources/disease-fmd-sfs-managed-movement-regulatory-officials.pdf

Common Factors

The Secure Food Supply (SFS) Plans provide guidance for producers with susceptible livestock species with no evidence of FMD infection located in a regulatory Control Area. The focus of the SFS Plans is to resume movement as quickly as possible without contributing to the spread of FMD virus. There are common factors across the various Secure Food Supply Plans including:

- Getting and validating a Premises Identification Number (PIN) for all livestock operations.
- Enhancing biosecurity procedures to protect the animals from exposure as it the producer's responsibility to prevent their animals from becoming infected.
- Conducting active observational surveillance and reporting clinical signs to enhance early detection of FMD infection.
- Laboratory testing, if indicated.
- Establishing movement permit guidance for premises within a regulatory Control Area.

Sheep that are not in a Control Area should be able to move after the 72-hour movement standstill order without a permit. However, a standstill could remain in effect until the extent of the outbreak is reasonably characterized (goal of within 96 hours of first diagnosis). Caution must be used because the movement of infected but undetected sheep can be a major contributing factor in spreading FMD as seen in the 2001 UK outbreak.

Factors to Consider

The following are factors to consider when adapting the guidance in the SBS, SMS, and SPS Plans to sheep and wool.

Clinical Signs in Sheep

- FMD lesions are typically mild or inapparent in adult sheep.
    - It may be difficult to detect FMD infection in a flock of adult sheep; many infected sheep may not have vesicular lesions.
    - Since FMD causes mild, usually subclinical disease in sheep, infection with FMD virus may go undetected for a relatively long time (Goris, 2008).
    - Movement of infected, but undetected sheep was a major contributor to FMD spread in the 2001 United Kingdom outbreak.
    - Due to the often inapparent nature of FMD infection in sheep, movement of infected but undetected sheep presents a major risk for moving the virus during an FMD outbreak (Barnett, 1999).
- Clinical signs of FMD in sheep, lameness being the most common, can be confused with other, more common diseases. During the 2001 UK outbreak, more than half of the sheep flocks depopulated due to clinical signs suggestive of FMD tested negative for FMD virus.
- Mortality due to FMD may be high in young lambs. This can vary with the age of the lambs, strain of FMD virus, and the challenge dose they are exposed to. Reported mortality rates vary widely, from 4.7% in an outbreak in India to 94.5% of lambs 2–25 days old in an outbreak in

Russia (Ryan, 2008). Among newborn lambs, 90% mortality has been reported (Chevskii, 1964). Infected lambs may die due to cardiac infection and heart failure without having vesicular lesions. "…the image of large numbers of lambs falling down dead when stressed, as may occur when a stranger walks into the flock, is dramatic." (Kitching, 2002). The presence of maternal antibody in colostrum-fed lambs will likely reduce the mortality rate if the ewe was previously infected with FMD or vaccinated against the infecting strain of FMD.

Virus Transmission

Getting Infected

- Sheep are highly susceptible to FMD virus by the aerosol route (Kitching, 2002).
  - Pigs shed high concentrations of aerosolized virus. Sheep that are near infected pigs may be more likely to get infected by the aerosol route (Donaldson, 2001).
  - Sheep have a lower respiratory volume so while they can become infected by the aerosol route, they are less likely than cattle who have a higher respiratory volume (take in more virus) (Kitching, 2002).
- Sheep are most often infected by direct contact with infected animals (Kitching, 2002).
- Not all sheep in a flock may become infected, based on serology results. In one report, only 20% of sheep in a flock became infected. This probably depends on the strain of the virus (Kitching, 2002).
- FMD virus can cross the placenta and cause death in fetal lambs. This has apparently not been reported in other species (Ryan et. al., 2007).

Spreading Infection

- Sheep are unlikely to contribute significantly to virus spread to other FMD susceptible species by the aerosol route (Donaldson, 2001).
  - Sheep produce much less aerosolized virus than pigs and are not likely to spread virus through the airborne route further than 100 meters (Kitching, 2002).
  - FMD virus is poorly transmitted between sheep by the airborne route because of low shedding of aerosolized virus (Valarcher, 2008).
- Probability of transmission from infected sheep is highest during the viremic phase and peaks at or just before the appearance of clinical signs. Virus in the blood (viremia) ends when antibody appears. Duration of viremia is between 1 and 5 days. "Some, possibly most, strains of FMD virus may die out if they are restricted to sheep" (a closed herd) (Kitching, 2002). Virus is recoverable from oral swabs from sheep for 28 to 30 days after infection, however most transmission occurs during the first week of infection (Bravo de Rueda, 2014; Elbe, 2015).
- Sheep can become long term carriers of the virus, however, there is no evidence of virus transmission from these carriers either under natural conditions or experimental conditions (Paton, 2018).
- "Experimental data suggest that FMD virus infectivity is maximized at relative humidity levels greater than 60% and drastically reduced below 55%. Based on previous FMD outbreaks in which airborne spread was implicated, FMD virus can survive in the environment at temperatures as high as 27ºC (81ºF). Presence of cloud cover, absence of precipitation, stable wind direction, and low to moderate wind speeds are thought to maintain aerosolized FMD virus stability, increasing the possibility of airborne transmission between premises." (Hagerman, 2018). This may be a concern for sheep flocks near an infected pig herd. However, as stated above, sheep are most often infected by direct contact with infected animals (Kitching, 2002).

Disease Monitoring and Diagnostic Testing (Surveillance)

- The first case of FMD in a state must be confirmed by the USDA Foreign Animal Disease Diagnostic Laboratory (FADDL) at Plum Island, NY.

- The National Animal Health Laboratory Network (NAHLN) labs are approved by APHIS to test sheep for FMD virus using the National Veterinary Services Laboratory (NVSL)-NAHLN PCR protocol. Approved samples from sheep that may be submitted for testing by a veterinarian to a NAHLN laboratory include: vesicular tissue and fluid, lesion swabs or oral swabs. There are no approved tests for detection of FMD virus in wool (Dr. C. Loiacono, personal communication, July 2019).
- The list of NAHLN labs approved to test for FMD is on the USDA APHIS website: https://www.aphis.usda.gov/animal_health/nahln/downloads/fmd_lab_list.pdf
- Mouth swab samples were better at detecting FMD virus infection in sheep than plasma samples (Elbe, 2015). (Note: Plasma is not an approved sample type for sheep in the U.S. as of March 2020.)
- Research on sampling and diagnostic testing protocols that do not rely on individual animal sampling (such as pooled oral fluid sampling) is needed for managing an FMD outbreak and for eventual FMD eradication (Poonsuk, 2018).
- In contrast to cattle and swine, active observational surveillance (AOS) for clinical signs in sheep does not provide confidence that a sheep flock is not infected with FMD virus. However, AOS should still be conducted in order to find infected flocks. Sheep with suspicious clinical signs should be examined by a veterinarian and samples collected and tested.
- There is no practical sampling protocol for lab testing available as of March 2020 for a flock of adult sheep that provides a high degree of confidence that a flock is not infected with FMD. Sheep can shed the virus before clinical signs appear, and sheep often do not have obvious clinical signs. A large percentage of the flock would need to be tested in order to have confidence that the flock is negative, since, in some cases, only a minority of the sheep in a flock may be infected. If the flock could potentially be exposed to FMD virus, then testing within 2 or 3 days of movement would be necessary to establish with a high degree of confidence that the flock was FMD-free.
- Testing sheep with clinical signs, or cardiac muscle from lambs that have died suddenly, is valuable for proving the presence of infection (Kitching, 2002).
- It may be possible to place 2-3 bovine calves in each pen of sheep in a feedlot to serve as an indicator species for FMD infection. Prior to placement, the calves must be antibody negative and should be removed as soon as clinical signs of FMD appear. The sensitivity of using calves mixed with sheep as an indicator species for FMD infection is not known (Bravo de Rueda, 2014). Placing calves in a sheep flock as an indicator species in a Control Area would require Regulatory Official approval.
- Llamas are sometimes mingled with sheep. They are resistant to FMD infection, would not be effective as an indicator species and play a minor role, if any, in transmitting the virus to domestic livestock (Fondevila, 1995).
- Perhaps testing for antibodies after 3 weeks of isolation and biosecurity for a closed flock would provide confidence that the flock is negative. However, as of March 2020, the NAHLN labs are not approved to test for antibody to FMD virus. Vaccination would make detection of infection in the flock through antibody testing much more problematic.

Enhanced Biosecurity

- Effective enhanced biosecurity may be very difficult to implement with sheep on pasture, especially on shared pasture/rangeland ground.
- An assessment of biosecurity risks for FMD spread in commercial sheep in Australia concluded that producers should focus on (Fountain, 2018):
    - Maintenance of boundary fences and prevention of nose to nose contact with other flocks or susceptible species.
    - Inspection and quarantine of new stock before integration into the flock.

    - Personal hygiene and equipment disinfection to prevent introduction through fomites.
- Flocks that are infected and allowed to recover must have and follow a flock enhanced biosecurity plan to prevent infecting other flocks or susceptible species until they are declared by Regulatory Officials to be recovered and non-infectious.

FMD Vaccination

- Sheep are usually given one-half to one-third of the FMD vaccine dose used in cattle (Kitching, 2002, Madhanmohan, 2012).
- Testing for antibodies to non-structural virus proteins to Detect Infection in Vaccinated Animals (DIVA) has not been validated as of March 2020 for use in sheep.
- Vaccinating the sheep population for FMD may not be necessary to control and eradicate the disease in the U.S. For example, Uruguay vaccinated only the cattle population during the final stages of the successful FMD eradication program in the early 1990s and left the approximately 20 million sheep unvaccinated during this period (Kitching, 2002).
- High potency FMD vaccines are capable of inhibiting local virus replication and consequently persistence and the carrier state in sheep (Barnett, 2004).
- The risk of spreading FMD virus through movement of FMD vaccinated cattle, sheep and pigs is extremely small. The risk of FMD transmission from products derived from vaccinated animals is even smaller (Garland, 2011). Empirical evidence over many years strongly indicates the absence of FMD risk from vaccinated animals or products derived from them (Garland, 2011). Under experimental conditions, vaccinated sheep that were intentionally infected did not transmit FMD virus (Eble, 2015).

Movement and Decontamination of Wool in an FMD Outbreak

- Wool from an infected flock, and perhaps all wool from a Control Area will be considered to be contaminated with FMD virus.
- Transport of wool from a Control Area will require a permit.
- Wool to be transported to a decontamination site must be sealed in an airtight container with biosecurity steps taken to prevent spread of infection by the truck or driver.
- The World Organization for Animal Health (OIE) has established recommendations for treatment of wool to destroy FMD virus in the 2019 Terrestrial Animal Health Code: http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_fmd.htm
- Recommendations for handling and decontaminating wool can be found in the SSWS document: *Wool Handling during a Foot and Mouth Disease (FMD) Outbreak* (securesheepwool.org).

Disposition of FMD Infected Flocks

- The disposition of FMD infected sheep flocks will likely vary with the extent of the FMD outbreak nationally, and in the State where the flock is located (see: *Classification of Phases and Types of a Foot-and-Mouth Disease Outbreak and Response*, http://www.cfsph.iastate.edu/pdf/phases-and-types-of-an-fmd-outbreak). The goal will be to stamp out FMD infection rapidly. This will ideally require rapid depopulation of all infected animals and herds/flocks. However, in an extensive and rapidly moving FMD outbreak, it may not be possible or desirable to stamp out all infected herds/flocks, so alternate approaches may be needed. For example, infected flocks may be isolated, with a requirement for a flock enhanced biosecurity plan, and allowed to recover.
- Sheep that have recovered from FMD infection will need a permit to move off the premises.
- Sheep that have recovered from FMD must be capable of passing USDA FSIS ante-mortem inspection to be sent to slaughter.

Summary of Implications of the Differences in FMD Infection between Sheep, Cattle and Swine for Management of FMD Infection in Sheep

- Peak risk of FMD transmission by sheep occurs before clinical signs appear. Difficulty in detecting infection in adult sheep means Active Observational Surveillance for clinical signs in sheep is less reliable to provide evidence for freedom from infection. Movement of infected but undetected sheep has been a major contributor to spread of FMD in some previous outbreaks in other countries. More reliance on stop movement of sheep and biosecurity measures will be needed to avoid spreading infection.
- Relatively mild clinical signs in adult sheep means the consequences to animal health and production will likely be less severe in adult sheep than in cattle or swine that are allowed to recover. An infected flock that is not depopulated will likely have a high death loss in young lambs where the virus is circulating.
- Risk of transmission from an infected flock of sheep to other flocks or species through aerosol is less likely compared to swine and bovine species. Sheep could potentially spread FMD by aerosol for no more than 100 meters.
- Since some, possibly most, strains of FMD virus may die out if they are restricted to a closed herd of sheep (Kitching, 2002), an infected flock of sheep is likely to clear the virus sooner than a herd of cattle or swine.

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Additional Resources

The Secure Sheep and Wool Supply website has additional resources available at: www.securesheepwool.org

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