

# Feed: A new pathway for the domestic and transboundary spread of viral pathogens of veterinary significance

Protecting, improving and monitoring the health of herds and flocks is the goal of the veterinary profession. Over time, veterinary science has identified multiple routes of pathogen entry into animal populations, including infected breeding stock and semen, contaminated transport, fomites and aerosols. In response, science-based biosecurity protocols have been designed to reduce or eliminate these risks. In contrast, the ability of feed and feed ingredients to serve as vehicles for the transport and transmission of viral pathogens is a new discovery, previously thought not to occur, and therefore ignored at the level of the classroom, the farm, government administration, global animal health organizations and elected officials.

The original hypothesis surrounding the risk of feed was based on observations from field veterinarians in 2013 and 2014, following the introduction of porcine epidemic diarrhoea virus (PEDV) into the United States. The widespread, rapid movement of a previously unidentified viral pathogen across long distances, simultaneously infecting unrelated swine production systems housed under conditions of high biosecurity raised the initial awareness to the possibility that contaminated feed could be involved, and that an intervention strategy may be needed. Following proof of this hypothesis, published by Dee et al. (2014), a large body of supporting scientific evidence evaluating the transport and transmission of multiple viral pathogens, such as African swine fever virus, classical swine fever virus and pseudorabies virus in feed and feed ingredients was published, heightening the awareness of this novel risk factor and justifying the need for this Special Issue. In response to this challenge, the Special Issue brings together 16 new articles focused on the ability of feed and feed ingredients to serve as vehicles for the domestic and transboundary spread of viruses of veterinary significance, both at the level of foreign animal disease and domestic endemic disease. Included are literature reviews, case studies from Asia and Latin America, numerous original research articles, along with several articles describing the response of the North American swine industry to the risk of viral transmission in feed and feed ingredients.

The Special Issue opens with a review of the literature focused on the question of whether we can effectively manage the risk of parasites, prions and pathogens in the global food industry (Shurson et al., 2021a). This is followed by a second review focusing on new perspectives for evaluating the risk of African swine fever virus (ASFV) in global feed ingredient supply chains (Shurson et al., 2021b). Following the reviews, two case studies describe PEDV infection through contaminated feed and feed transport, including an overview of interventions applied to manage this risk. These are interesting cases, as one

occurred in China (Wu et al., 2021) and the other in Mexico (Mantilla-Garrido et al., 2021), demonstrating the global nature of the risk of feed.

Following the case studies are original articles, which bring forth new information regarding the stability and infectivity of foot and mouth disease virus (Stenfeldt et al., 2021), and Seneca Virus A (Caserta et al., 2021) in feed, the oral infective dose in feed, and the efficacy of feed additives as mitigants to reduce risk. We then explore the ability to sample feed correctly to maximise the sensitivity and specificity of detection, as well as how to manage viral contamination of feed at the level of the farm and the feed mill. These topics are timely, as ASFV DNA has been detected in commercial feed systems in Asia, with a range of 0.5–2.0% of samples collected from dust from complete feed and grain-based ingredients, such as soybean meal, testing positive by PCR. Extending the concept of ASFV risk in feed, this Special Issue describes the complexities of ASFV contamination of the feed milling environment, including an evaluation of feed dust sampling for the detection of the virus at the level of the feeder (Khanal et al., 2021), the feed mill and the swine production facility (Gebhardt et al., 2021). This Special Issue also covers the field of feed risk mitigation, studying the effect of mixing and feed batch sequencing on the distribution of ASFV in feed batches (Elijah et al., 2021), and an evaluation of a novel monoglyceride feed additive designed to reduce the risk of the original viral nemesis in feed, PEDV (Phillips et al., 2021).

At this point, the Special Issue leaves the laboratory and ventures into the real world to explore the risk of transboundary spread of viral pathogens through feed imports. Two original research articles are presented, both of which use data from the US Government Harmonized Tariff schedule to assess the risk of virus entry to the United States from ASFV-positive countries, either through soy-based imports (Blomme et al., 2021) or via imports of select swine feed ingredients and pork products (Patterson, 2021). This is followed by a publication describing a demonstration project designed to evaluate viral survival in feed under conditions of trans-continental transport, involving a commercial vehicle, realistic volumes of feed, a representative route of travel across the continental United States and the use of bulk sampling methods. This is the first scientific evidence of the survival of viruses of veterinary significance in feed under real-world conditions (Dee et al., 2021).

Finally, the Special Issue explores the North American response to the risk of infection associated with feed, beginning with the initial attempt to quantify the risk of ASFV introduction to the United States through feed (Schambow et al., 2021), followed by a review of Canada's

national approach to manage the risk of ASFV-entry through plant-based feed ingredients (Calvin et al., 2021). The Special Issue closes with a comprehensive review of the collaborations within this new area of science, a description of progress made and obstacles encountered, as the topic of feed risk was introduced and advanced across agriculture, followed by a discussion of the challenges of the risk of feed to the US swine industry: past, present and future (Becton et al., 2021).

Looking back, biosecurity programs of modern swine operations have been designed to ameliorate validated routes of pathogen entry, through the quarantine and testing of incoming breeding stock, daily testing of semen from AI centres, shower-in entry protocols for personnel, decontamination of incoming supplies, transport sanitation and the filtration of incoming air. To compliment this approach, this Special Issue ushers in the concept of 'Next Generation Biosecurity', raising the awareness of the risk of feed and the need for a science-based program to biosecure feed and feed ingredients as they move between countries and between farms. Specific examples of this next-generation approach are the national programs in Canada and Australia, both of which incorporate certification, inspection, auditing and mitigation efforts to safely manage the entry of high-risk feed ingredients from high-risk counties. In support of this movement, the European Food Safety Administration recently published a scientific opinion stating that the risk of feedborne spread of ASFV across the European Union is low but cannot be ignored, due to high consequence. In addition, the US swine industry is currently organising standards for a national feed safety biosecurity protocol under the umbrella of the Swine Health Improvement Plan, with the goal of implementing a science-based 'Responsible Imports' approach to the risk management of feed. Clearly, this new area of science has generated a significant amount of activity in a relatively short period of time, resulting in new approaches for dealing with feed risk, all the way from the international border to the feed mill, with one goal in mind: to protect the farm.

In summary, the science of feed and feed ingredients as risk factors for the domestic and transboundary spread of viral pathogens of veterinary significance is based upon a great collaboration of timely and accurate field observations that were yoked in scientific rigour through data from controlled experiments, real-time reporting and peer-reviewed publications, resulting in implementation of validated interventions at the level of the farm. This information has changed and continues to change human behaviour regarding the management and movement of feed and feed ingredients, all in service of the greater good of global agriculture, striving for healthier animals, lower costs and an abundance of highly nutritious food for all. We hope that readers will find this Special Issue interesting and that the knowledge it embodies will raise awareness of the risk of feed, enhance efforts to manage this risk and to further safeguard farms, industries and nations.

#### DATA AVAILABILITY STATEMENT

All data in the article have been made available.

#### CONFLICT OF INTEREST

The authors have no conflicts of interest.

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