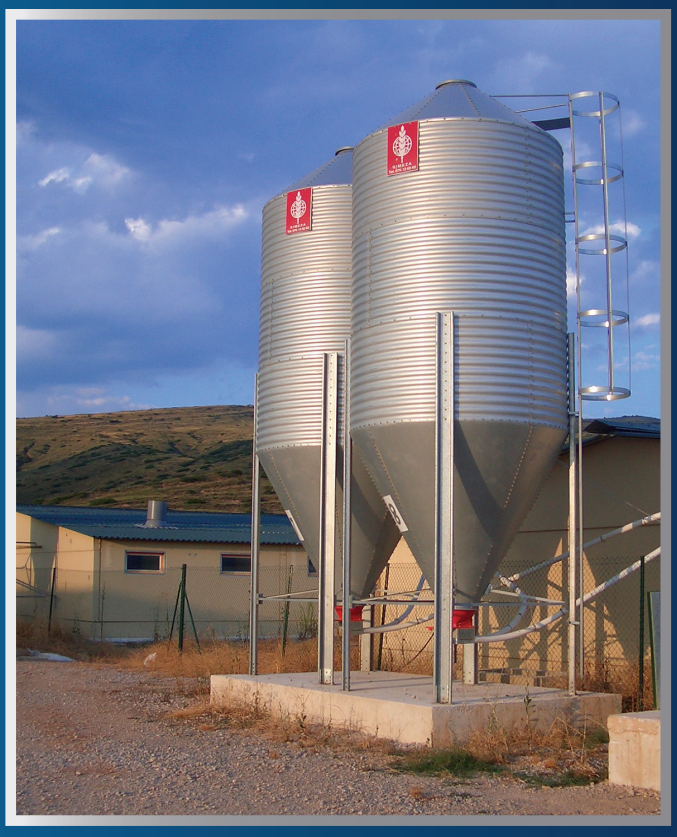
Journal of

SWINE HEALTH & PRODUCTION

September and October 2020 • Volume 28, Number 5



PRRSV exposure in the breeding herds and subsequent nursery mortality

Trevisan G, Robbins RC, Angulo J, et al

Hemoglobin concentrations in sows

Castevens K, Ferreira JB, Gillespie T, et al

Euthanasia training and perceived caretaker knowledge

Campler MR, Pairis-Garcia MD, Rault JL, et al

The Journal of the American Association of Swine Veterinarians

AMERICAN ASSOCIATION SWINE VETERINARIANS

Journal of Swine Health and Production

(**ISSN 1537-209X**) Volume 28, Number 5; September and October 2020

The *Journal of Swine Health and Production* is published by the American Association of Swine Veterinarians.

The *Journal of Swine Health and Production* is a refereed publication and is a benefit of membership in the American Association of Swine Veterinarians. Subscriptions ($US) are available to non-members at $150.00 per year (six issues) for United States, Canada, and Mexico. The cost is $185.00 for all countries outside North America. For inquiries regarding membership or subscriptions, please contact

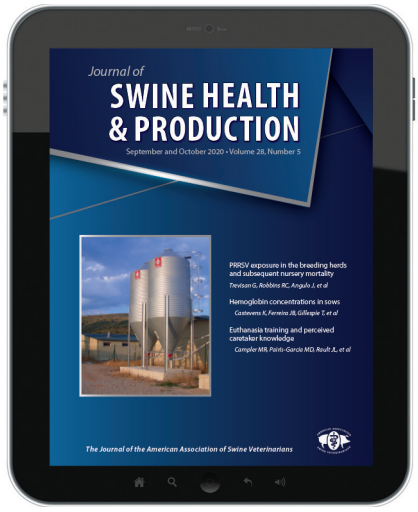
AASV
830 26th Street, Perry, IA 50220-2328
Tel: 515-465-5255; Fax: 515-465-3832
Email: aasv@aasv.org

Editorial questions, comments, and inquiries should be addressed to Karen Richardson, Publications Manager:
Tel: 519-856-2089;
Email: jshap@aasv.org

DISCLAIMER

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

Journal of Swine Health and Production is indexed in ISI® *Focus On: Veterinary Science & Medicine,*® and in *CAB Abstracts*, Euroscience VETLINE on CD-ROM



Download this issue to your iPad or Android tablet at
www.aasv.org/shap/issues/v28n5/v28n5jshap.pdf

Cover photo courtesy of Dr Antonio Palomo.

AASV Resources online at aasv.org

Author guidelines
aasv.org/shap/guidelines

Journal of Swine Health and Production
aasv.org/shap

Membership information
aasv.org/aasv/membership

Subscription information
ecom.aasv.org/journal

Upcoming meetings
aasv.org/meetings

Table of contents

"Regardless, it is going to be a bumpy path for our current and future students to negotiate and they need our support now more than ever. I mention all this to simply say, when you are able to do so safely, do not forget to reach out and mentor a junior colleague. They are the future of our profession."

quoted from Executive Editor's Message, page 243

3E Environment Enrichment Encouragement

A platform for nurturing & developing weaned pigs

STEP 2 Enrichment

Nutrients Through Water

When pigs are not yet eating dry feed, avoid nutrient deficiencies by enriching the water.

When pigs are off-feed gut integrity becomes compromised when villi in the gut lining shrinks, making nutrient absorption less efficient.
Avoid nutrient deficiencies by enriching the water of weaned pigs.

BLUE 2® by TechMix
Provides needed energy, electrolytes and acidification in this iso-osmotic formulation.

LIQUITEIN® SWINE by TechMix
Delivers functional plasma proteins, energy and electrolytes.

NeXtein by TechMix **APF™**
Offers functional proteins in a palatable, animal protein free, iso-osmotic formula.

Nutrient Dense Liquid™

The products above contain 3 times greater nutrient density than traditional stock solutions - yet can be conveniently delivered through the proportioner.

877-466-6455 · TechMixGlobal.com

TechMix **Redefining hydration** to keep animals **drinking, eating & producing.**

@techmixglobal

See the forest and the trees

I did not plan to use another 2020 vision analogy, but then one day I heard the saying "he/she can't see the forest for the trees" and it sparked the fireworks. This phrase negatively describes someone who is so focused on the details that they do not see the big picture. However, I believe being capable of focusing on details is a great ability that some possess innately. Think how often you see a job description that states individuals must be detail oriented? These individuals get things done and follow standard operating procedures very well. Helping them understand how their day-to-day actions contribute to the big picture can give them motivation to stay focused and avoid burnout. These people are important to the entire swine industry.

While focusing on details is important, it is also important to understand how getting those details right affects the big picture. I remind the less detail-oriented caretakers to see the PIGS in the pen, not a PEN of pigs to encourage them to watch individual pigs for signs of disease or injury. By focusing on each pig in a barn of thousands, we can identify problems before they get out of control. Each individual pig's health and welfare affects the health and welfare of the site, farm, and system that it is being raised within and thus affects the entire swine industry.

The forest is made up of many trees with different characteristics (species and age) and the individual contributions of each tree keep the forest healthy. Some produce fruit or nuts that feed wildlife, some have thorns that protect bird nests from predators, and some stay green year-round to provide winter shelter. One thing all these trees have in common is that they hold soil moisture, prevent soil erosion, and convert carbon dioxide to oxygen. While each pig in our industry does not have that many different characteristics, they all are excellent at converting poor quality grain protein into high quality protein food. Keeping in mind our big picture goal of feeding the world high quality protein can help keep us on task even when financial benefits are non-existent.

As swine veterinarians we have chosen to focus on one species, but we should keep in mind the bigger picture of the veterinary profession. Providing our expertise with swine to the veterinary community is our role in keeping the veterinary profession healthy. Do your part to communicate with other veterinarians in your community and educate them about the unique details of the swine industry.

The AASV "forest" is made up of members who all have unique characteristics. These unique characteristics help keep our association healthy. Mutual respect is the key to keeping our organization strong during these stressful periods in our world. It is possible to stand firm in your convictions while keeping an open mind to others. Much like the trees, we all protect the health and welfare of the pigs by using our diverse abilities.

"The AASV 'forest' is made up of members who all have unique characteristics."

I think the AASV and its members are perfectly positioned to see both the forest and the trees. We already possess the diversity of thinking to do all the details correctly while keeping the swine industry healthy and sustainable. Keep up the good work seeing the forest AND the trees!

Jeff Harker, DVM
AASV President

FIGHT BAD CORN

M-Mobilize®

IT'S NO RISK-INSURANCE FOR MYCOTOXINS.

M-Mobilize should be part of your strategy in managing challenges with corn. Why? Because M-Mobilize includes a proprietary *Bacillus* strain that promotes gut integrity and encourages a healthy microbiome. How do we know? Because we've invested significantly to operate our own research farms, designed to replicate a commercial farm environment.

UNITED® ANIMAL HEALTH

OUR EXTENSIVE COMMERCIAL TRIALS REVEAL SOME STUNNING RESULTS.

Ask your vet or nutritionist to request results of our research trials: **UnitedAnH.com/Corn**

The decision to depopulate

As all of you know, coronavirus disease 2019 (COVID-19) has had a dramatic impact on the swine industry. Human exposure has resulted in significant decreases in processing plant capacity which led to an inevitable backlog of market swine. Processing capacity in the United States is approximately 510,000 head per day resulting in a weekly capacity of somewhere between 2.75 million and 3 million head per week. At its lowest, daily capacity dropped to approximately 42% during April 2020. That means approximately 215,000 hogs per day were not able to be harvested at that time.

Overall, it is estimated that, during the 2 months in which the industry suffered significant processing disruption, 2.5 to 3 million market-ready hogs were unable to go to market. Veterinarians and producers alike expressed concern that, unless something could be done, massive depopulations were likely going to be necessary. Having to depopulate large numbers of animals due to a non-disease related market disruption was a situation the industry had never considered.

Fortunately, farmers and veterinarians are very industrious. They have been able to find alternative outcomes for many of these animals. Utilizing efforts to hold animals in place, slow growth, repurpose vacant facilities, adopt non-traditional marketing strategies, altering breeding programs, etc have enabled producers to avoid or delay much of the anticipated depopulation.

Ultimately, however, depopulation has been unavoidable for thousands of animals. This is obviously something none of us involved in swine production wants to have to do. Having to depopulate healthy animals goes against every fiber of our being. The question then becomes how to best conduct the depopulation. The American Veterinary Medical Association's (AVMA) Guidelines for the Depopulation of Animals serves as an important resource to help guide veterinarians' efforts to work with their clients to find the most practical solutions.

The AVMA Guidelines importantly draw the distinction between euthanasia and depopulation defining depopulation as the rapid destruction of a population of animals in response to urgent circumstances with as much consideration given to the welfare of the animals as practicable. The document outlines the criteria necessary when considering methods of depopulation. In the swine section, the authors divide the acceptable methods into a preferred category and a category of methods designated as permitted under constrained circumstances.

The AASV Pig Welfare Committee developed a policy statement adopted by the AASV Board of Directors recommending that "priority should be given to those methods classified as 'Preferred'" but went on to recognize that the "circumstances surrounding the COVID-19 processing disruption may require the use of methods classified as 'Permitted in Constrained Circumstances'." Producers and veterinarians have to evaluate a number of factors including animal welfare, human safety, human mental well-being, regulatory factors, availability of necessary resources, time constraints, number and size of the animals, social distancing considerations, etc before making the final decision regarding which method is most appropriate on an individual farm or system.

"Having to depopulate large numbers of animals due to a non-disease related market disruption was a situation the industry had never considered."

There is no one-size-fits-all method that works in every case. In the end, several preferred methods were used including gunshot, captive bolt, and carbon dioxide. In some cases, however, it was determined that a method not listed as preferred, such as ventilation shutdown plus (VSD+), would have to be used. No matter what method is chosen, it is important that the method is performed in a manner that achieves the criteria outlined in the AVMA's guidelines for an acceptable outcome.

Of these methods, VSD+ is probably the most controversial. Unfortunately, there is not much scientific analysis of the physiological effects of hyperthermia in swine. The AVMA guidelines stipulate that use of this method should include the addition of heat or carbon dioxide to achieve at least 95% mortality within 1 hour. In practice, it was determined that the addition of humidity and heat facilitated the ability to achieve a successful outcome. These criteria are difficult to achieve on the average farm. If this method is to be used, it is imperative that a veterinarian supervise the process and that facilities be provided that ensure these minimal standards are met. This means that it is unacceptable to just roll up the curtains, shut off the ventilation, and walk away. As a method of last resort, VSD+ must be monitored, highly engineered, and process-controlled. Trained personnel must be present to humanely dispatch any survivors at the one-hour endpoint.

The veterinarians who have been involved in conducting VSD+ have established some baseline standards including increasing the temperature to 120°F within 30 minutes with the addition of steam to maintain at least 80% relative humidity. Facilities were modified at a significant cost to ensure the

Executive Director's message continued on page 241

Executive Director's message continued from page 239

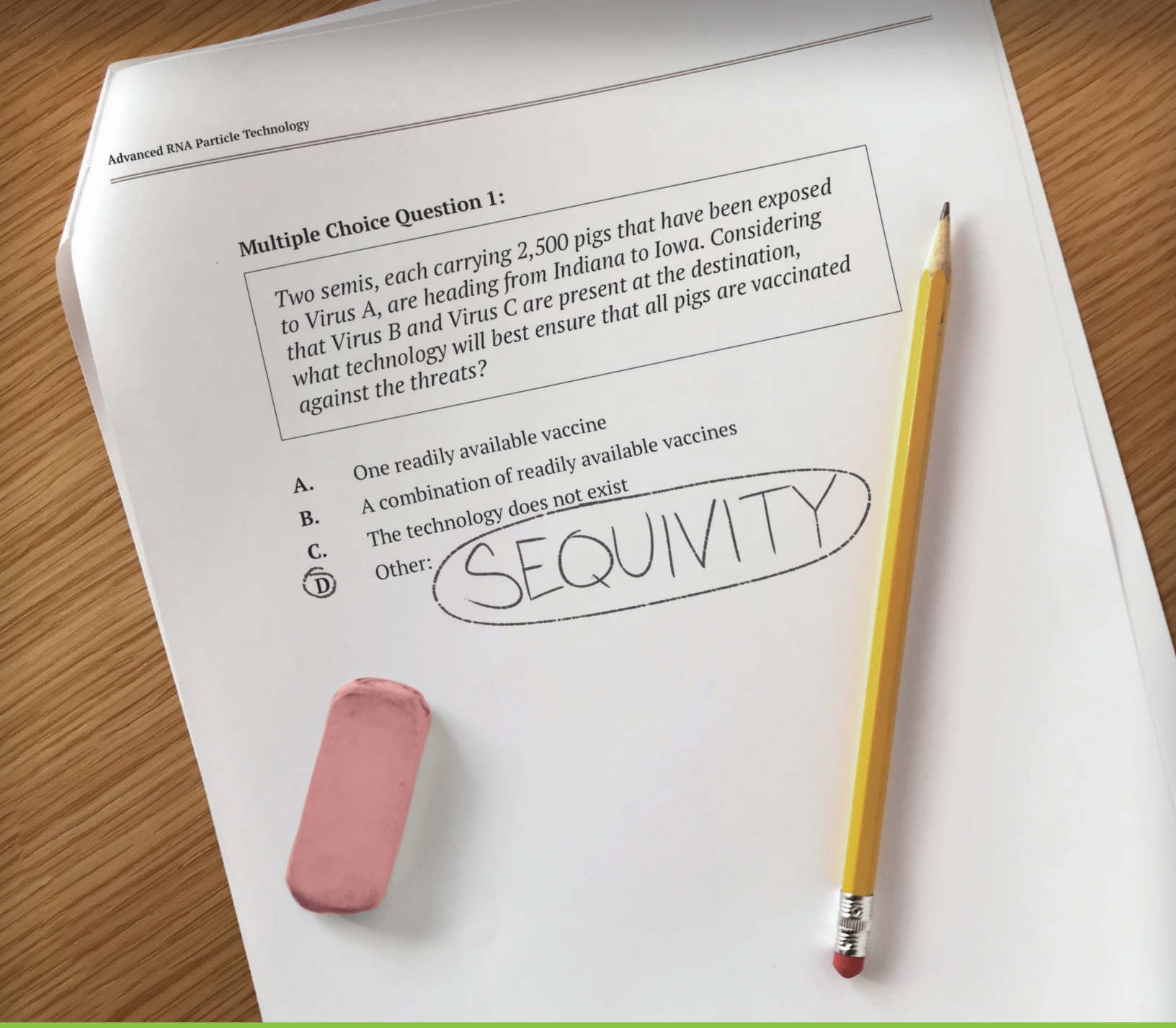
adequate application of heat and humidity and to facilitate the removal of the carcasses. Given these parameters, they reportedly were able to achieve at least 99% mortality within 60 minutes. Even under these conditions, VSD+ has significant drawbacks including a lack of information regarding the physiological impacts of hyperthermia, length of time to death (especially when compared with preferred methods resulting in comparatively rapid death), and public perception. Additional research is needed to determine whether or not VSD+ is an acceptable method of depopulation and, if so, under what specific criteria.

As you know, the activist groups have targeted VSD+ as cruel and inhumane. That is to be expected. They have their own agendas. The somewhat disappointing pushback has come from within our own profession. A small but vocal group of veterinarians have spoken out against depopulation for market disruption and especially against VSD+. While I support everyone having and expressing their opinion, it is disappointing that members of our own profession often do not bother to reach out and try to learn why things are being done the way they are before attacking their fellow colleagues.

Most of their attacks have targeted AVMA for producing the guidelines on depopulation and, most directly, for including VSD+ in those guidelines. To their credit, the AVMA has tried to explain the process they went through to develop those guidelines (it took a couple of years, over 60 volunteers, multiple reviews, and a public comment period) and has stood behind their document. I applaud their efforts to educate our colleagues and the public.

To that end, we must make sure that we do our part to ensure we follow the stipulations and criteria outlined in those guidelines. When faced with the need to depopulate a group of animals, veterinarians should work closely with their clients to prioritize those methods that are listed as preferred. Only after considering all those options, should we elect to resort to a method not listed as preferred. When choosing a method not categorized as preferred, extra steps should be taken to ensure compliance with the criteria that allow for the use of those methods. Remember, first and foremost, veterinarians speak for the pig.

Harry Snelson, DVM
Executive Director



SEQUIVITY™
RNA Particle Technology

We're not just solving a problem. We're solving your problem.

For veterinarians looking to stay ahead of ever-changing disease challenges, SEQUIVITY is the answer. A revolutionary RNA particle technology, SEQUIVITY is a platform for the creation of herd- and strain-specific vaccines for disease challenges such as PCV2, PCV3, rotavirus, influenza and more.

Ask your veterinarian or Merck Animal Health representative what SEQUIVITY can do for you.

Find the answer at sequivity.com

MERCK Animal Health

Mentoring amid COVID-19

It is September already and with the fall season comes a new academic year for our veterinary students, university staff, and faculty. It seems that there is no such thing as "veterinary business as usual" now, and this is also true for our veterinary students. I find it somewhat overwhelming to speculate and write a message about the changes that our veterinary students and academic colleagues are going to face this academic year. As with all my messages, I am writing this well in advance of print, in fact in the middle of a legitimate Canadian July heatwave, and everything seems to change daily. But, learning over the past few months and some speculation suggests that university back-to-school strategies are going to be highly varied from school-to-school and from region-to-region, they will be dynamic and continue to change day-by-day. As we continue to navigate the COVID-19 landscape into the fall, our veterinary students are going to be facing many unknowns with respect to how they are going to obtain the necessary skills and learning outcomes for entry-level competencies. Universities are trying to navigate the delivery of veterinary curriculum via online courses with some face-to-face options for clinical hands-on laboratories. It is a challenging time to be a practicing veterinarian and also a challenging time to be a student veterinarian. Our successors and our academic colleagues training our successors are struggling too. This is also certainly the case for students aspiring to apply to veterinary school. Many universities require mentoring hours to apply, some universities may modify these admission requirements, some may not, and time will tell. Regardless, it is going to be a bumpy path for our current and future students to negotiate and they need our support now more than ever. I mention all this to simply say, when you are able to do so safely, do not forget to reach out and mentor a junior colleague. They are the future of our profession.

"As we continue to navigate the COVID-19 landscape into the fall, our veterinary students are going to be facing many unknowns with respect to how they are going to obtain the necessary skills and learning outcomes for entry-level competencies."

Terri O'Sullivan, DVM, PhD
Executive Editor

ORIGINAL RESEARCH PEER REVIEWED

Relationship between weekly porcine reproductive and respiratory syndrome virus exposure in breeding herds and subsequent viral shedding and mortality in the nursery

Giovani Trevisan, DVM, MBA, PhD; Rebecca C. Robbins, DVM, PhD; Jose Angulo, DVM; Luc Dufresne, DVM; Will A. Lopez, DVM, PhD; Nubia Macedo, DVM, PhD; Daniel C. L. Linhares, DVM, MBA, PhD

Summary

Objective: Describe the relationship of weekly breeding herd status based on processing fluid (PF) testing for porcine reproductive and respiratory syndrome virus (PRRSV) RNA by quantitative reverse transcriptase-polymerase chain reaction (qRT-PCR) on subsequent viral shedding and cumulative mortality during the nursery phase.

Materials and methods: Weekly cohorts (n = 121) of newborn piglets were classified into PRRSV exposure groups according to PRRSV detection in PF: low (quantification cycles [Cq] ≤ 27), medium (27 < Cq ≤ 34), high (34 < Cq ≤ 37), and negative (Cq > 37). At 6 weeks of age, oral fluids (OF) were collected from a subset of 41 cohorts, tested by qRT-PCR, and results used to classify the nursery shedding status into the same aforementioned categories. Cumulative nursery mortality was recorded for all 121 cohorts and compared between the different PRRSV exposure groups. Test agreement was assessed between PF and OF results of 41 cohorts. Moreover, the effect of 4:1 OF pooling on the probability of testing qRT-PCR-positive was evaluated.

Results: The nursery mortality for low Cq cohorts was 3.40 percentage points (range, 3.28-3.99) higher than other exposure groups. Overall, Cq values were higher in PF than in OF samples, and fair agreement ($\kappa = 0.2398$) between PF and OF was encountered. Compared to individual samples, 4:1 OF pooling resulted in 100% specificity and 76.92% sensitivity.

Implications: Weekly PF testing for PRRSV allowed for exposure group classification for each pig batch produced, which was a good predictor of subsequent cumulative nursery mortality.

Keywords: swine, porcine reproductive and respiratory syndrome virus, processing fluid, closeout performance, nursery mortality

Received: October 17, 2019
Accepted: April 1, 2020

Resumen - Relación entre la exposición semanal al virus del síndrome reproductivo y respiratorio porcino en granjas reproductoras y la posterior eliminación viral y mortalidad en el destete

Objectivo: Describir la relación del estado semanal del hato reproductor basado en la prueba de fluidos de procesamiento (PF) para el ARN del virus del síndrome reproductivo y respiratorio porcino (PRRSV) mediante la reacción cuantitativa en cadena de la polimerasa con transcriptasa reversa (qRT-PCR) en la subsecuente eliminación viral y la mortalidad acumulada durante la fase de destete.

Materiales y métodos: Las cohortes semanales (n = 121) de lechones recién nacidos se clasificaron en grupos de exposición al PRRSV según la detección del PRRSV en PF: bajo (ciclos de cuantificación [Cq] ≤ 27), medio (27 < Cq ≤ 34), alto (34 < Cq ≤ 37), y negativo (Cq > 37). A las 6 semanas de edad, se colectaron fluidos orales (OF) de un subconjunto de 41 cohortes, analizados por qRT-PCR, y los resultados se utilizaron para clasificar el estado de eliminación en los destetes utilizando las mismas categorías antes mencionadas. La mortalidad acumulada en el destete se registró para las 121 cohortes y se comparó entre los diferentes grupos de exposición al PRRSV. En 41 cohortes se evaluó la concordancia de prueba entre los resultados de FP y OF. Además, se evaluó el efecto de la agrupación de OF 4:1 sobre la probabilidad de obtener una qRT-PCR-positiva.

Resultados: La mortalidad en el destete en las cohortes con bajo Cq fue de 3.40 puntos

GT, WAL, NM, DCLL: Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, Iowa.

RCR, LD: Seaboard Foods LLC, Guymon, Oklahoma.

JA: Zoetis Inc, Parsippany, New Jersey.

Corresponding author: Dr Daniel C. L. Linhares, 2221 Lloyd Veterinary Medical Center, 1600 South 16th Street, Ames, IA 50011; Tel: 515-294-9358; Email: linhares@iastate.edu.

This article is available online at http://www.aasv.org/shap.html.

This article was derived from Dr Trevisan's PhD thesis, Iowa State University, Ames, Iowa.

Trevisan G, Robbins RC, Angulo J, Dufresne L, Lopez WA, Macedo N, Linhares DCL. Relationship between weekly porcine reproductive and respiratory syndrome virus exposure in breeding herds and subsequent viral shedding and mortality in the nursery. *J Swine Health Prod.* 2020;28(5):244-253.

porcentuales (rango, 3.28-3.99) más alta que los otros tres grupos de exposición. En general, los valores de Cq fueron más altos en PF que en las muestras de OF, y se encontró una concordancia media ($\kappa = 0.2398$) entre PF y OF. En comparación con las muestras individuales, la combinación de OF 4:1 dio como resultado una especificidad del 100% y una sensibilidad del 76.92%.

Implicaciones: La prueba semanal de PF para PRRSV permitió la clasificación del grupo de exposición para cada lote de cerdos producidos, lo que fue un buen predictor de la posterior mortalidad en el destete.

Résumé - Relation entre l'exposition hebdomadaire au virus du syndrome reproducteur et respiratoire porcin dans des troupeaux de reproducteurs et l'excrétion virale et les mortalités subséquentes dans les pouponnières

Objectif: Décrire la relation du statut hebdomadaire d'un troupeau de reproducteurs basé sur les tests utilisant le liquide de procédures (PF) pour l'ARN du virus du syndrome reproducteur et respiratoire porcin (PRRSV) par réaction d'amplification en chaîne quantitative avec la transcriptase reverse (qRT-PCR) sur l'excrétion virale subséquente et la mortalité cumulative durant la période en pouponnière.

Matériels et méthodes: Des cohortes hebdomadaires (n = 121) de porcelets nouveaunés furent classifiés en groupes d'exposition au PRRSV selon la détection de PRRSV: bas (cycles de quantification [Cq] ≤ 27), moyen (27 < Cq ≤ 34), élevé (34 < Cq ≤ 37), et négatif (Cq > 37). À 6 semaines d'âge, des fluides oraux (OF) furent prélevés d'un sous-groupe de 41 cohortes, testés par qRT-PCR et les résultats utilisés pour classifier le statut excréteur de la pouponnière à l'intérieur des mêmes catégories que mentionnées précédemment. La mortalité cumulative dans la pouponnière fut notée pour toutes les 121 cohortes et comparée entre les différents groupes d'exposition au PRRSV. L'accord des tests fut évalué entre les résultats pour PF et OF des 41 cohortes. De plus, l'effet de regrouper les OF dans un ratio 4:1 sur la probabilité de s'avérer positif par qRT-PCR fut évalué.

Résultats: La mortalité en pouponnière pour les cohortes avec un Cq bas était de 3.40 points de pourcentage (écart, 3.28-3.99) plus élevée que dans les autres groupes d'exposition. De manière générale, les valeurs de Cq étaient plus élevées dans les échantillons de PF que dans ceux d'OF, un accord acceptable ($\kappa = 0.2398$) entre PF et OF fut observé. Comparativement aux échantillons individuels, le regroupement 4:1 a résulté en une spécificité de 100% et une sensibilité de 76.92%.

Implications: Les tests hebdomadaires sur le PF pour le PRRSV ont permis une classification en groupe d'exposition pour chaque lot de porcs produits, ce qui était un bon prédicteur de la mortalité cumulative subséquente en pouponnière.

Porcine reproductive and respiratory syndrome (PRRS) is one of the most economically important diseases affecting the global swine industry. The economic losses attributed to this disease in the US swine industry was estimated to be $663.91 million annually.[1] The PRRS-attributed mortality can reach up to 20% in weaning and grower pigs.[2] Approximately 55% ($361.85 of $663.91 million) of the economic impact related to PRRS in the United States is due to production losses in the growing-pig herd.[1] Altogether, PRRS causes a loss of 9.93 million pigs per year in the United States.[1] To help the swine industry to standardize classification regarding PRRS virus (PRRSV) shedding and exposure in sow farms, a guideline was proposed in 2011 by the American Association of Swine Veterinarians (AASV).[3] This allowed veterinarians to conduct benchmarking of PRRSV status change within and between production systems.[4-6] A methodology to classify growing pigs as either positive or negative based on polymerase chain reaction and enzyme-linked immunosorbent assay test results was previously proposed.[3] However, there has been limited advancement in methodologies to classify batches of growing pigs according to PRRSV status beyond positive or negative.

Oral fluid (OF) testing was described in 2008 as a population-based specimen for PRRSV herd monitoring.[7,8] Oral fluid is a practical sample type to collect, requires less labor and time, and represents the status of more pigs in the population when compared with the use of individual serum samples.[7] Due to its usefulness to monitor PRRSV in grower animals, further evaluation[9] and guidelines for spatial sampling have been described.[10] In 2017, processing fluid (PF) was identified as a new population-based sample type to monitor PRRSV in newborn piglets.[11] Processing fluid is an aggregate population sample derived from the serosanguinous fluid recovered from piglet castration and tail docking (ie, processing), and has been shown to be a reliable, practical, and time-efficient sample type to monitor PRRSV and PRRSV shedding in the breeding herd.[12-14]

In 2018, OF and PF corresponded to 35% and 11% of all cases submitted for PRRSV RNA detection by quantitative reverse transcriptase-polymerase chain reaction (qRT-PCR) to the four major US swine-centric veterinary diagnostic laboratories.[15] This demonstrates a considerable use of both population-based sample types by the US swine industry for PRRSV testing. However, to the best of our knowledge, there is no data on the relationship between PRRSV qRT-PCR test results from PF samples and the subsequent nursery mortality. Also, there is no information in the peer-reviewed literature on the agreement between PRRSV qRT-PCR results on PF (typically collected at 3-5 days of age) and OF collected from the same cohort of pigs when they reach the nursery (3-7 weeks of age). Understanding these relationships will allow veterinarians to strategically design monitoring and surveillance systems to identify batches of pigs at higher risk of PRRS-attributed mortality, PRRSV shedding in the nursery, or both. Therefore, the main purpose of this study was to evaluate the relationship between PRRSV RNA qRT-PCR quantification cycle (Cq) results obtained on PF and the subsequent nursery mortality for 121 cohorts raised in field conditions. Secondary objectives were to assess the agreement of PRRSV RNA qRT-PCR results between PF (3-5 days of age) and OF (6 weeks of age) in 41 cohorts of pigs and to describe the effect of pooling OF samples (4:1) on the diagnostic sensitivity and specificity.

Materials and methods

Study design

This study was approved by the Iowa State University Institutional Animal Care and Use Committee under protocol number 3-18-8730-S. This prospective analytical

study was designed in August of 2017 and the farms were recruited between September and November 2017. The study was conducted using 2 pig flows, each with 6 commercial sow farms and 4 nursery farms between January and August 2018. The farms were geographically isolated from other production systems and were part of the same swine production system. Weekly batches of newborn piglets were monitored at sow farms for exposure to PRRSV by testing one aggregated PF sample for each cohort using a commercial qRT-PCR assay. For each cohort, qRT-PCR Cq results were categorized into PRRSV exposure groups: low, medium, high, or negative. The nursery mortality, summarized as the cohort's cumulative mortality during the nursery period (3-9 or 10 weeks of age), was recorded for each cohort. The distribution of mortality for each exposure group was recorded. Furthermore, PRRSV shedding in the nursery was assessed in 41 cohorts by testing OF samples collected at 6 weeks of age and tested for PRRSV RNA using commercial qRT-PCR-based methods. The OF sample results were categorized using the same criteria used for PF samples, based on the sample with the lowest Cq value for each cohort. The agreement criteria of PRRSV qRT-PCR results between PF and OF samples was described according to Landis and Koch criteria.[16]

Study herds and PRRSV exposure cohorts

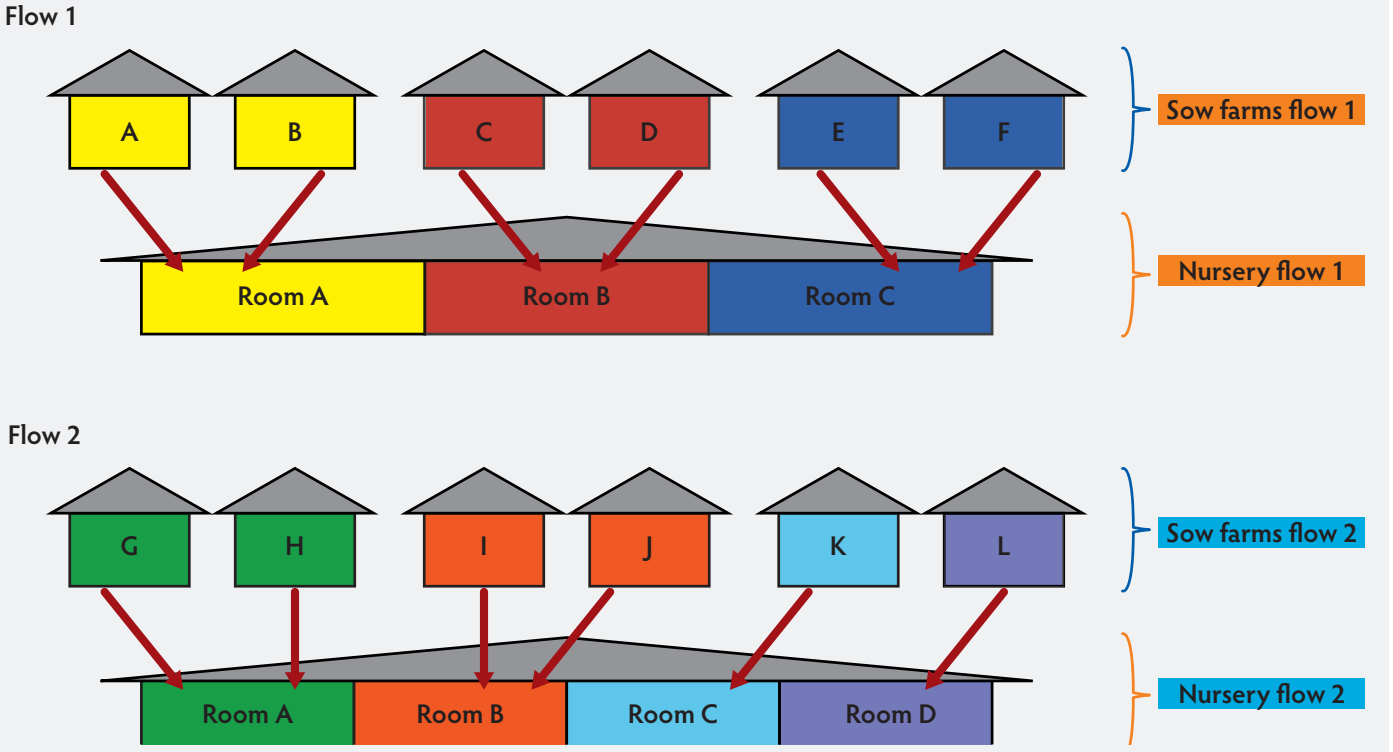
We recruited breed-to-wean herds endemically infected with PRRSV and classified as "positive unstable" according to the AASV PRRSV classification terminology.[3] All study herds reported use of PRRS Ingelvac MLV (Boehringer Ingelheim Vetmedica Inc) in the replacement gilts at 26 weeks of age. Targeting days having the highest number of processed litters, PF samples were collected 3 days per week and pooled for 1 test per cohort. A cohort was defined as a weekly group of weaned piglets (15-19 days of age) moved to one nursery barn and room. The pig flows of the study population are described in Figure 1. Eight different nursery farms (nursery farms 1-8) were used for piglet placement after weaning. Flow 1 included sow farms A to F and 4 nursery farms with 3 rooms each. Flow 2 included sow farms G to L and 4 nursery farms with 4 rooms each. In 10 (sow farms A to J) of the 12 sow farms, piglet cohorts from 2 farms were commingled in a nursery room. Piglet cohorts from the 2 largest sow farms (K and L) were not commingled and each cohort flowed into a single nursery room. For commingled rooms, piglets were placed in pens separated by sow farm of origin. The company veterinary health service standard operational procedure was to collect 4 OF samples the first week of the month from each sow farm cohort at six weeks of age. Commingled cohort PRRSV status was defined by the lowest results obtained on PF PRRSV qRT-PCR Cq values. Results of OF PRRSV qRT-PCR samples were recorded and compared to the results of PF samples of respective non-commingled flows (Figure 1).

Sample collection and diagnostic testing

For each sow farm, PF obtained from 3 days of collection within the same week were pooled into 1 weekly PF sample. The PF were stored in 50 mL Falcon tubes (Fisher Scientific), frozen at -20°C, and submitted to the Iowa State University Veterinary Diagnostic Laboratory for testing. Both PF and OF samples were tested using the same procedures for PRRSV qRT-PCR commercial kits as previously described.[17,18] The results were reported as the Cq value.[19]

During the first week of each month, OF samples were collected from cohorts (n = 41) that were six weeks of age. Non-commingled flows collected 4 OF samples and commingled flows collected 8 OF samples (4 samples per sow farm of origin) from different pens

Figure 1: Diagram demonstrating the organization of sow farm and nursery from flows 1 and 2. Of the 121 cohorts, 87 (71.9%) were commingled from sow farms A to J and 34 (28.1%) were non-commingled from sow farms K and L.



within a barn following a spatial zig-zag distribution pattern as described by Rotolo et al.[10] The OF samples were tested individually and in pools of 4:1 for PRRSV RNA by qRT-PCR.

Defining breeding herd PRRSV exposure and nursery PRRSV shedding status

The qRT-PCR test results for PF of each cohort were used to categorize PRRSV exposure of each group: low when Cq was ≤ 27, medium when 27 < Cq ≤ 34, high when 34 < Cq ≤ 37, and negative when Cq > 37. Similarly, the lowest qRT-PCR Cq value of OF samples were used to categorize the nursery PRRSV shedding status using the same cut offs established for PF (low, medium, high, and negative). The proposed Cq cutoffs for PRRSV exposure groups were based on expected 10-fold change of the amount of PRRSV RNA in the sample. Each 10-fold change in RNA copies per milliliter is mathematically proportional to 3.3 Cq values.[20] To facilitate communications regarding the level of PRRSV exposure between veterinarians and producers, the cutoffs were adjusted to the nearest integer representing the expected 10-fold change, ie, the cutoff for the medium vs high PRRSV exposure group was rounded from 33.7 to 34, and the cutoff between the low vs medium PRRSV exposure groups was rounded from 27.1 to 27.

Evaluating the effect of OF pooling on qRT-PCR testing

For the comparison between individual and pooled OF results, 66 sets of OF were tested by qRT-PCR in pools of 4:1. At the midpoint of the study, 10 PRRSV open reading frame-5 (ORF-5) sequences were performed from 6 PF and 4 OF samples. The sample having the lowest qRT-PCR Cq values were strategically selected for ORF-5 sequencing. Sequencing was performed to describe the PRRSV present in the study population.

Statistical analysis

The main objective of this study was to describe the relationship between PRRSV exposure status based on PF sample test results (low, medium, high, or negative) and the subsequent nursery mortality. This relationship was described by a generalized linear mixed model using PROC GLIMMIX in SAS 9.4 (SAS Institute Inc), using cumulative nursery mortality counts as the dependent variable, assuming a Poisson distribution, and the exposure group as the explanatory variable in the model. The number of pigs placed in the nursery was used as the offset variable. Additionally, the mortality count difference between groups was tested by a Chi-square test. A similar procedure was used to analyze the relationship between the level of PRRSV shedding in the nursery and the cumulative nursery mortality using OF results. Agreement of categorized qRT-PCR Cq results between PF and OF were reported using crude agreement, and Cohen's Kappa test. Kappa analysis was performed in SAS 9.4. Specificity, sensitivity, positive predictive value, and negative predictive value for the OF 4:1 pooling effect compared to individual sample result were calculated.

Results

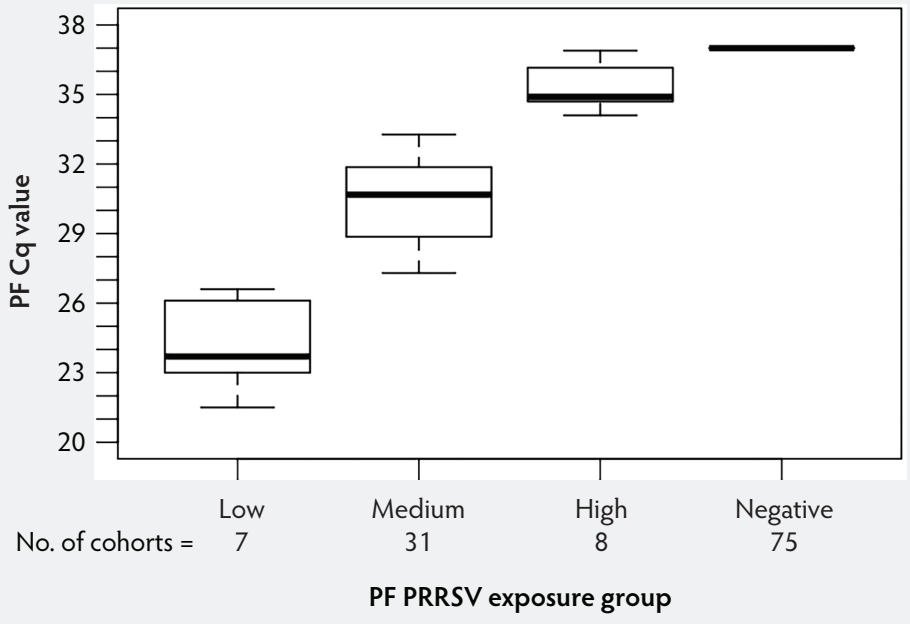
Based on PF testing in the breeding herds, the number of cohorts and Cq value distribution for each PRRSV exposure group is presented in Figure 2. The mortality distribution for 121 cohorts according to PF PRRSV exposure group is presented in Figure 3. The number of piglets that contributed to a PF sample per farm and week ranged from 400 to 2300 piglets. The lowest Cq value obtained from PF samples was 21.5 (Figure 2).

Pig cohorts belonging to the low exposure group had significantly higher nursery mortality than other groups ($P < .001$; Table 1). Mortality differences between the medium, high, and negative groups were small as compared to differences between these groups and the low group. The overall mean mortality for the low group was 3.40 percentage points higher than all other groups. There was no significant difference in the mean mortality for high vs negative exposure groups.

Based on OF testing in the nursery, the number of cohorts and Cq value distribution for each PRRSV shedding group is presented in Figure 4. The mortality distribution for each OF PRRSV shedding group is presented in Figure 5. Nursery mortality comparisons between PRRSV shedding groups for 41 cohorts is shown in Table 2. There was no nursery cohort classified in the low shedding group (Figure 4). Nursery cohorts in the medium shedding group had 1.33 percentage points higher mortality than those in the high group ($P < .001$) and 1.57 percentage points higher mortality than those in the negative group ($P < .001$). Nursery cohorts in the high shedding group had 0.25% numerically higher mortality compared to negative cohorts ($P = .18$).

The relationship between qRT-PCR results from PF and OF samples and nursery mortality is presented in Figure 6. Cohorts categorized as low PRRSV exposure and medium PRRSV shedding had the highest

Figure 2: Distribution of cohorts and PF Cq values for each PRRSV exposure group using qRT-PCR. PF = processing fluids; Cq = quantification cycle; PRRSV = porcine reproductive and respiratory syndrome virus; qRT-PCR = quantitative reverse transcriptase-polymerase chain reaction.



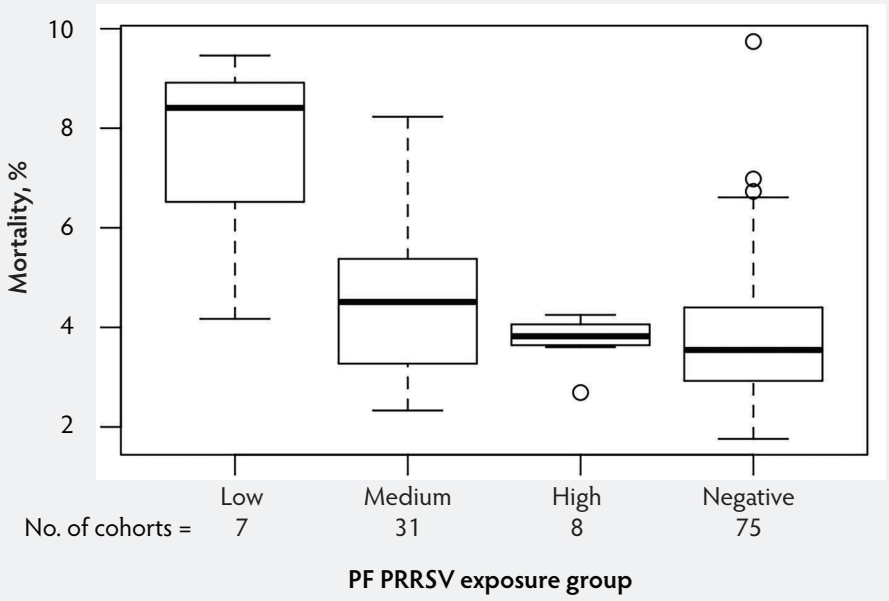
mortality compared to all other groups. Cohorts with medium exposure and medium shedding had higher mortality compared to cohorts with medium exposure and negative shedding. Cohorts with negative exposure had similar mean mortality in all 3 nursery shedding groups, but cohorts that had negative exposure and negative shedding had the smallest variability in mortality. There was only one cohort that had high exposure and medium shedding.

The overall crude agreement of PRRSV by qRT-PCR results between PF and OF was 63.41%. The Kappa agreement test, which excludes the agreement by chance, was 0.2398 as shown in Figure 7.

A total of 66 sets of OF were tested for PRRSV by qRT-PCR individually and in pools of 4:1. The specificity obtained for this analysis was 100% and the sensitivity was 76.92% (Figure 8). The positive predictive value was 100% and negative predictive value was 94.64%. There was a failure to detect PRRSV RNA in 3 pooled OF samples where at least one of the individual samples contributing to the pool returned a positive on individual testing. The qRT-PCR Cq value for the individual positive samples that contributed to the PCR-negative pools ranged from 34.67 to 36.75. In the same cohorts, a negative result on PF samples was previously obtained.

Ten ORF-5 PRRSV sequences were performed in 6 PF samples collected from 6 different sow farms and 4 OF samples from 2 different commingling flows representing piglets from 4 different sow farms. Samples with low and medium Cq values were used for sequencing. Four of six PF samples and all OF samples returned a restriction fragment length polymorphism (RFLP) vaccine-like type 2-5-2 sequence with more than 98% similarity with the PRRS Ingelvac modified-live virus vaccine strain. One PF sample returned an RFLP wild-type 1-1-1 sequence and one sample (Cq = 32.21) failed to be sequenced.

Figure 3: Distribution of nursery mortality rate for each PF PRRSV exposure group. PF = processing fluids; PRRSV = porcine reproductive and respiratory syndrome virus.



Discussion

This was a prospective study using PF PRRSV qRT-PCR Cq values to classify 121 cohorts according to PRRSV exposure status in the breeding herd. This status was used as an indicator for subsequent nursery mortality. Exposure groups classified as low had higher mortality than all other exposure groups. In this study the cumulative nursery mortality was 3.99 percentage points higher for the low compared to the high PRRSV exposure group and 3.76 percentage points higher when comparing the low with the negative PRRSV exposure groups. Additionally, 41 cohorts were tested for PRRSV RNA by qRT-PCR at 6 weeks of age using OF samples to assess the level of PRRSV shedding in the nursery. Associations between PRRSV exposure in the breeding herd and PRRSV shedding in the nursery, as well as nursery mortality, were investigated. To the best of our knowledge, this was the first work describing the agreement between PF and subsequent nursery OF results for PRRSV qRT-PCR testing obtained from the same cohorts. Using qRT-PCR for PRRSV detection, PF results had a fair agreement with OF results ($\kappa = 0.2398$)

Table 1: Pairwise comparisons of nursery mortality between PRRSV exposure groups determined by PF testing

PRRSV exposure group comparison	Mean difference in mortality (95% confidence limits)	Tukey *P* value
Low vs Medium	3.28 (2.88, 3.46)	< .001
Low vs High	3.99 (3.52, 4.12)	< .001
Low vs Negative	3.76 (3.48, 4.03)	< .001
Medium vs High	0.70 (0.46, 0.83)	< .001
Medium vs Negative	0.47 (0.45, 0.73)	< .001
High vs Negative	-0.23 (0.21, 0.01)	.13

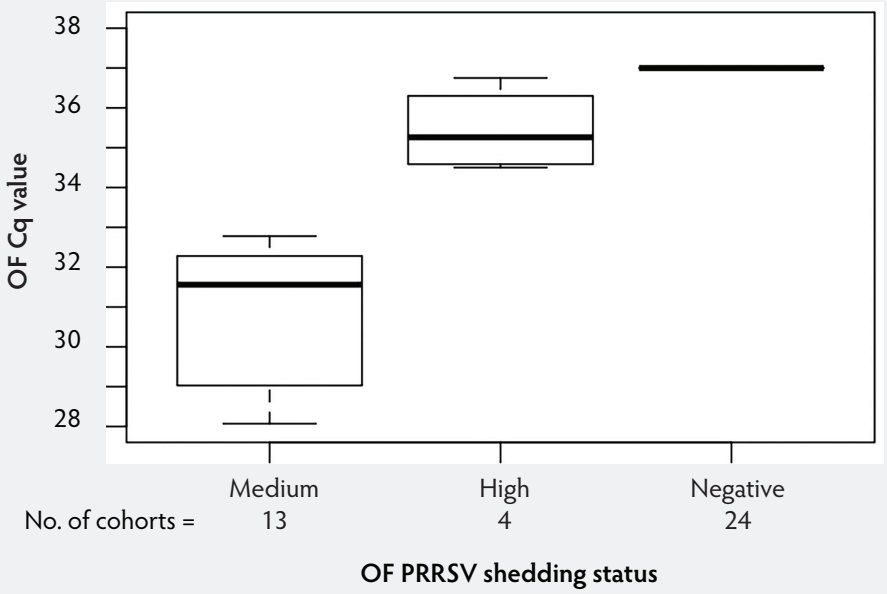
PRRSV = porcine reproductive and respiratory syndrome virus; PF = processing fluids.

Table 2: Pairwise comparisons of nursery mortality between PRRSV shedding groups determined by OF testing

PRRSV shedding group comparison	Mean difference in mortality (95% confidence limits)	Tukey *P* value
Medium vs High	1.33 (1.03, 1.62)	< .001
Medium vs Negative	1.57 (1.38, 1.77)	< .001
High vs Negative	0.25 (0.02, 0.52)	.18

PRRSV = porcine reproductive and respiratory syndrome virus; OF = oral fluids.

Figure 4: Distribution of cohorts and OR Cq values for each PRRSV shedding group using qRT-PCR. OF = oral fluids; Cq = quantification cycle; PRRSV = porcine reproductive and respiratory syndrome virus; qRT-PCR = quantitative reverse transcriptase-polymerase chain reaction.



and are most likely to be influenced by the interval between collections, differences in the sample matrices, or both. Cohort classification of shedding status in the nursery tended to differ from the sow herd exposure status classification. All cohorts classified as low exposure groups using PF samples were classified as medium shedding status using OF samples. Also, this study evaluated the impacts of 4:1 OF sample pooling tested for PRRSV RNA by qRT-PCR. Pooling OF samples in a 4:1 ratio proved to be a practical approach for monitoring PRRSV in endemic herds. When the pooled sample failed to detect the positive result of an individual sample, the Cq value on the individual sample was > 34, and the high exposure group did not differ in cumulative nursery mortality from the negative exposure group.

The overall findings indicate that PRRSV qRT-PCR Cq values from PF samples can be used as an indicator for expected cumulative nursery mortality differences. As the Cq value of PF samples decreased, the subsequent overall nursery mortality increased. The most significant difference was the low PRRSV exposure group, which had the highest mortality among all exposure groups. As presented in Table 1, the higher mortality of the low exposure group when compared with all other exposure groups indicates that Cq values can be used as an inversely proportional predictor of nursery mortality, ie, the lower the Cq value the higher the expected nursery mortality. The polymerase chain reaction assay measures the amount of nucleic acid detected in the samples, but does not indicate the presence of infectious material.[21] Results from qRT-PCR assays were used in studies to determine virulence of PRRSV strains[22] and efficacy of vaccines.[23] In general, the lower the Cq value, the higher the expected concentration of a pathogen's genomic copies. For the low PRRSV exposure group, the expected higher pathogen concentration in the samples was associated with the increased subsequent nursery mortality. The high PRRSV exposure group, represented by the last 10-fold increase in the detection of PRRSV by qRT-PCR, had similar mean mortality as the negative exposure group, suggesting that a Cq value above 34 is indicative of a lower concentration of PRRSV genomic copies in the PF sample and, therefore, lower virus circulation among the newborn population with a small effect on nursery mortality. Alternatively, it may only be detection of PRRSV genetic material without the presence of infectious virus. Similarly, when considering the level of PRRSV shedding in the nursery, which was measured using qRT-PCR on OF samples, cohorts that had the smallest Cq values (medium Cq shedding group) had higher mortality rates than high or negative shedding groups.

Considering a mortality difference of 3.76 between the low and negative PRRSV exposure groups and that $40.89 was the average estimated purchase price[24] for a 12 lb piglet between January to July 2018, this increased mortality represents a loss of $153.75 (3.76 × $40.89) per 100 head placed in the nursery. The qRT-PCR Cq values of PF samples can be used as an indicative tool to develop strategic PRRSV vaccination interventions[25-27] and management practices for different exposure groups to reduce significant economic production losses.

Co-infections between PRRSV and other pathogens are commonly reported. The most frequently reported co-infection agents include influenza A virus, *Streptococcus suis*,

porcine circoviruses, *Haemophilus parasuis, Mycoplasma hyopneumoniae,* and *Pasteurella multocida.*[28,29] Thus, watching for infection with other pathogens and proper treatment may help to prevent mortality. Additionally, measures that can be used to reduce the PRRSV spread and circulation in contaminated cohorts and reduce mortality include changing needles between animals when administering treatment,[30] using needle-free technologies,[31] adoption of all-in/all-out nursery flows with proper facility sanitation and disinfection between cohorts,[32,33] and adoption of management changes to reduce exposure to bacteria to eliminate losses in the farrowing house.[34]

Overall, the Cq value results from PF samples were lower than OF samples, indicating that the concentration of PRRSV RNA present in each sample type is different. All the cohorts (n = 7) that were classified as a low PRRSV exposure group in the breeding herd moved to a medium nursery shedding group based on OF testing. There was a fair agreement of binary qRT-PCR results obtained between PF and subsequent OF samples. This fair agreement could be explained by the time difference in the collection, as samples were collected with a five-week interval. Other potential interference was the sample size, whereas PF collection from all castrated litters during the collection days potentially included more piglets than collection of 4 OF samples. Additionally, it is biologically possible that positive piglets tested using PF were not positive at the moment of OF collection since most individual piglets are likely no longer viremic after 28 days post PRRSV infection.[31,35,36] Another possibility is that the number of nursery pens sampled (n = 4) was not sufficient to detect a positive sample when prevalence in the barn is low. In this study, it is plausible that a positive or negative result on PF was not a good indicator for the subsequent OF result. Nevertheless, this was a field-based study, and thus it is possible to have inhibitors present in OF samples which are not present in PF samples, and vice versa, influencing the polymerase chain reaction outcome. However, qRT-PCR Cq values obtained from PF samples were used to categorize cohorts according to PRRSV exposure and were successfully used as an explanatory indicator for cumulative nursery mortality.

Figure 5: Distribution of nursery mortality rate for each OF PRRSV shedding group. OF = oral fluids; PRRSV = porcine reproductive and respiratory syndrome virus.

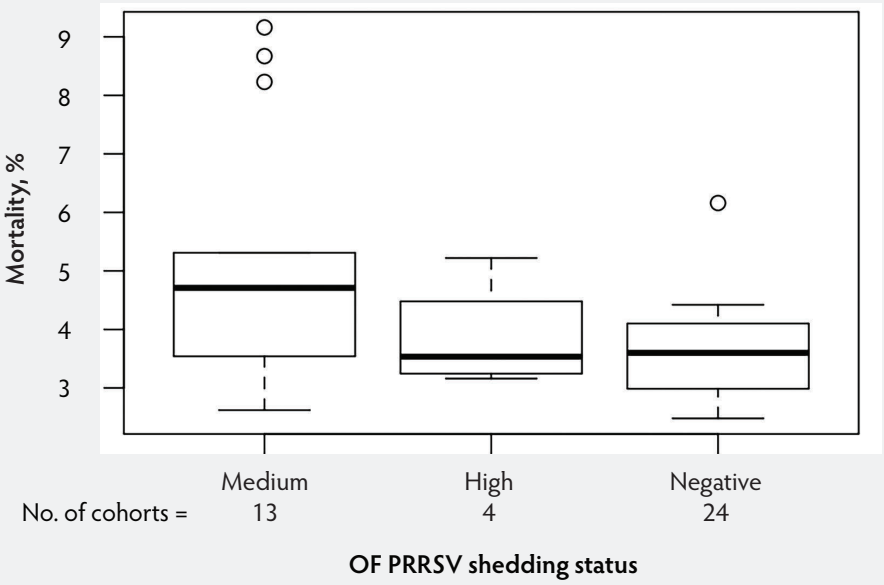
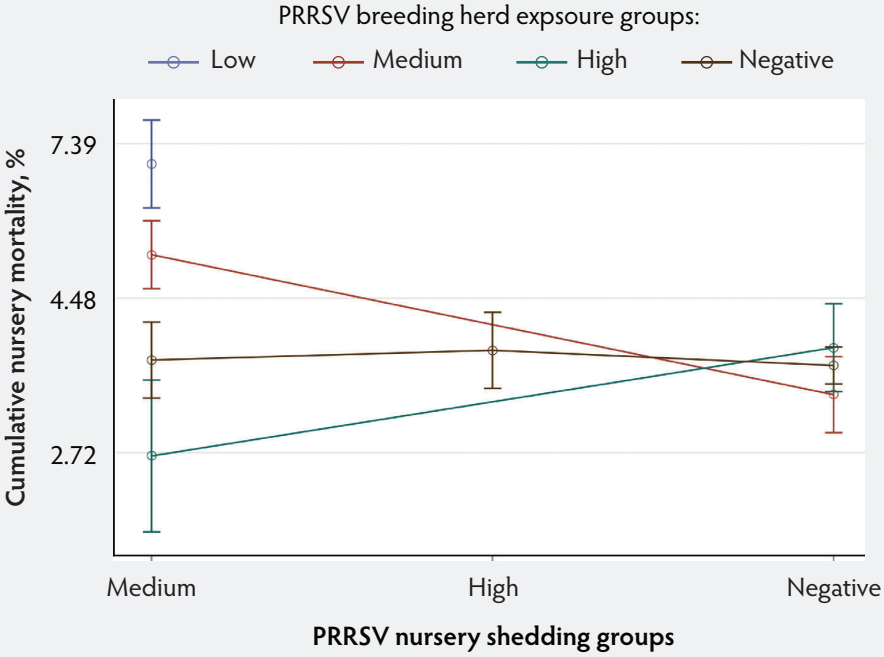


Figure 6: Least squares means of nursery mortality by PRRSV exposure in the breeding herd (based on PF testing results; colored lines) and subsequent PRRSV shedding in the nursery (based on OF testing results; on x-axis). Circles represent the mean group mortality and the whiskers represent 2 SD of the mean. PRRSV = porcine reproductive and respiratory syndrome virus; PF = processing fluids; OF = oral fluids.



The pooling effect on the probability of PRRSV RNA detection by qRT-PCR has been investigated in other studies for serum and blood swab,[37] semen,[38] and OF.[39,40] The described pooling of individual samples in a 5:1 ratio comes with the expense of losing sensitivity to detect PRRSV, but allows to cover more individual samples in a qRT-PCR test. Pooling of PF was also described,[41] and the pooling of PF samples from the room of collection did not reduce the sensitivity to detect a PRRSV-positive sample when compared to a pooled PF sample from an individual litter. For the current study, pooling OF in a factor of 4:1 resulted in a specificity of 100% and a sensitivity of 76.92%. For all 3 cases where individual results did not agree with the pooled sample results, the Cq value of the individual sample was above 34, but the cohort was classified in the high nursery shedding group. This finding aligned with previous work where pooled OF samples having Cq > 34 had a diagnostic sensitivity of only 27%.[40] Cohorts classified as high for nursery shedding did not differ from negative cohorts in percent cumulative mortality. Pooling OF samples for PRRSV shedding monitoring purposes could be a good approach to allow inclusion of a larger number of piglets for PRRSV testing. When a positive result was obtained from the pooled sample, it represented a truly positive aggregated sample according to the 100% positive predictive value. For the 3 samples which did not agree on the individual versus pooled testing, two factors may have contributed. First, the PRRSV prevalence within the cohort had been low resulting in the failure to detect the virus. Previous work did not find a difference for detecting PRRSV RNA using OF in pools of 3:1 or 6:1.[42] Second, the OF pooling effect could have potentially diluted the positive sample increasing the final Cq value above the negative cut-off limit of 37 and, as a consequence, classifying the sample as negative. The effect of OF sample pooling on the increase of Cq value was not investigated.

The use of PF as a sample type to characterize weekly batches of suckling piglets according to PRRSV exposure status in breeding herds was demonstrated as a practical and efficient approach, serving as a good indicator for subsequent cumulative mortality in the nursery. Being aware of this relationship aids the development of strategies for disease prevention and to minimize losses caused by PRRSV.

Implications

Under the conditions of this study:

- Processing fluid can be used to characterize PRRSV exposure of newborn pigs.
- Low PRRSV exposure groups had higher nursery mortality than all other groups.
- Pools of 4:1 OF samples were useful to monitor PRRSV status.

Acknowledgments

The authors acknowledge Zoetis and Seaboard Foods, LLC for providing funds for this project. Dr Trevisan thanks Laura Bradner, Maria Augustina Eizmendi, and Thaire Marostica for their veterinary diagnostic laboratory support and Michelle Uptergrove and Casey Thomlinson for their management of sample collection and shipment to the veterinary diagnostic laboratory.

Conflict of interest

Dr Jose Angulo is a member of the Zoetis US Pork Technical Services team. Drs Rebecca Robbins and Luc Dufresne are members of Seaboard Foods, LLC. Zoetis and Seaboard Foods, LLC provided diagnostic funding for this project.

Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

References

1. Holtkamp DJ, Kliebenstein JB, Neumann EJ, Zimmerman JJ, Rotto HF, Yoder TK, Wang C, Yeske PE, Mowrer CL, Haley CA. Assessment of the economic impact of porcine reproductive and respiratory syndrome virus on United States pork producers. *J Swine Health Prod*. 2013;21(2):72-84.

2. Zimmerman JJ, Benfield DA, Dee SA, Murtaugh MP, Stadejek T, Stevenson GW, Torremorell M. Porcine reproductive and respiratory syndrome viruses (Porcine Arteriviruses). In: Zimmerman JJ, Karriker LA, Ramirez A, Schwartz KJ, Stevenson GW. *Diseases of Swine*. 10th ed. Ames, IA: Wiley-Blackwell; 2012:461-486.

Figure 7: Crude agreement and Kappa analysis for PRRSV qRT-PCR results obtained from processing fluid and oral fluid from the same cohort. Crude agreement varies from 0 to 100. Kappa varies from 0 to 1. For crude agreement and Kappa agreement zero means no agreement and 1 means perfect agreement. PRRSV = porcine reproductive and respiratory syndrome virus; qRT-PCR = quantitative reverse transcriptase-polymerase chain reaction.

		Oral fluid result: +	Oral fluid result: -	
Processing fluid result	+	9	7	16
	-	8	17	25
		17	24	41

Crude agreement	0.6341
Kappa agreement	0.2398

Figure 8: Sensitivity and specificity analysis for oral fluid samples tested for PRRSV by qRT-PCR individually and in pools of 4:1. PRRSV = porcine reproductive and respiratory syndrome virus; qRT-PCR = quantitative reverse transcriptase-polymerase chain reaction.

		Individual samples: +	Individual samples: -	
Pooled samples	+	10	0	10
	-	3	53	56
		13	53	66

Sensitivity	76.92%
Specificity	100%

3. Holtkamp DJ, Polson DD, Torremorell M, Morrison B, Classen DM, Becton L, Henry S, Rodibaugh MT, Rowland RR, Snelson H, Straw B, Yeske P, Zimmerman J. Terminology for classifying swine herds by porcine reproductive and respiratory syndrome virus status. *J Swine Health Prod*. 2011;19(1):44-56.

4. Sanhueza JM, Vilalta C, Corzo C, Arruda AG. Factors affecting porcine reproductive and respiratory syndrome virus time-to-stability in breeding herds in the Midwestern United States. *Transbound Emerg Dis*. 2019;66(2):823-830.

5. Tousignant SJ, Perez A, Lowe JF, Yeske P, Morrison RB. Temporal and spatial dynamics of porcine reproductive and respiratory syndrome virus infection in the United States. *Am J Vet Res*. 2015;76(1):70-76.

6. Perez AM, Linhares DCL, Arruda AG, VanderWaal K, Machado G, Vilalta C, Sanhueza JM, Torrison J, Torremorell M, Corzo CA. Individual or common good? Voluntary data sharing to inform disease surveillance systems in food animals. *Front Vet Sci*. 2019;6:194. doi:10.3389/fvets.2019.00194

7. Prickett JR, Kim W, Simer R, Yoon K-J, Zimmerman J. Oral-fluid samples for surveillance of commercial growing pigs for porcine reproductive and respiratory syndrome virus and porcine circovirus type 2 infections. *J Swine Health Prod*. 2008;16(2):86-91.

8. Prickett J, Simer R, Christopher-Hennings J, Yoon K-J, Evans RB, Zimmerman JJ. Detection of porcine reproductive and respiratory syndrome virus infection in porcine oral fluid samples: a longitudinal study under experimental conditions. *J Vet Diagn Invest*. 2008;20(2):156-163.

9. Ramirez A, Wang C, Prickett JR, Pogranichniy R, Yoon K-J, Main R, Johnson JK, Rademacher C, Hoogland M, Hoffmann P, Kurtz A, Kurtz E, Zimmerman J. Efficient surveillance of pig populations using oral fluids. *Prev Vet Med*. 2012;104(3-4):292-300.

10. Rotolo ML, Sun Y, Wang C, Giménez-Lirola L, Baum DH, Gauger PC, Harmon KM, Hoogland M, Main R, Zimmerman JJ. Sampling guidelines for oral fluid-based surveys of group-housed animals. *Vet Microbiol*. 2017;209:20-29.

*11. Lopez WA, Zimmerman JJ, Angulo J, Linhares DCL. Processing fluids for detection of PRRS activity in neonates. *ISU James D. McKean Swine Disease Conference*. Ames, IA. 2017:65.

12. Lopez WA, Angulo J, Zimmerman JJ, Linhares DCL. Porcine reproductive and respiratory syndrome monitoring in breeding herds using processing fluids. *J Swine Health Prod*. 2018;26(3):146-150.

13. Vilalta C, Sanhueza J, Alvarez J, Murray D, Torremorell M, Corzo C, Morrison R. Use of processing fluids and serum samples to characterize porcine reproductive and respiratory syndrome virus dynamics in 3 day-old pigs. *Vet Microbiol*. 2018;225:149-156.

14. Trevisan G, Jablonski E, Angulo J, Lopez WA, Linhares DCL. Use of processing fluid samples for longitudinal monitoring of PRRS virus in herds undergoing virus elimination. *Porcine Health Manag*. 2019;5:18. doi:10.1186/s40813-019-0125-x

15. Trevisan G, Linhares LCM, Crim B, Dubey P, Schwartz KJ, Burrough ER, Main RG, Sundberg P, Thurn M, Lages PTF, Corzo CA, Torrison J, Henningson J, Herrman E, Hanzlicek GA, Raghavan R, Marthaler D, Greseth J, Clement T, Christopher-Hennings J, Linhares DCL. Macroepidemiological aspects of porcine reproductive and respiratory syndrome virus detection by major United States veterinary diagnostic laboratories over time, age group, and specimen. *PLoS One*. 2019;14(10):e0223544. doi:10.1371/journal.pone.0223544

16. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159-174.

17. Pepin BJ, Kittawornrat A, Liu F, Gauger PC, Harmon K, Abate S, Main R, Garton C, Hargrove J, Rademacher C, Ramirez A, Zimmerman J. Comparison of specimens for detection of porcine reproductive and respiratory syndrome virus infection in boar studs. *Transbound Emerg Dis*. 2015;62(3):295-304.

18. Chittick WA, Stensland WR, Prickett JR, Strait EL, Harmon K, Yoon K-J, Wang C, Zimmerman JJ. Comparison of RNA extraction and real-time reverse transcription polymerase chain reaction methods for the detection of porcine reproductive and respiratory syndrome virus in porcine oral fluid specimens. *J Vet Diagn Invest*. 2011;23(2):248-253.

19. Bustin SA, Benes V, Garson JA, Hellemans J, Huggett J, Kubista M, Mueller R, Nolan T, Pfaffl MW, Shipley GL, Vandesompele J, Wittwer CT. The MIQE guidelines: minimum information for publication of quantitative real-time PCR experiments. *Clin Chem*. 2009;55(4):611-622.

20. Wernike K, Hoffmann B, Dauber M, Lange E, Schirrmeier H, Beer M. Detection and typing of highly pathogenic porcine reproductive and respiratory syndrome virus by multiplex real-time rt-PCR. *PLoS One*. 2012;7(6):e38251. doi:10.1371/journal.pone.0038251

21. Christopher-Hennings J, Erickson GA, Hesse RA, Nelson EA, Rossow S, Scaria J, Slavic D. Diagnostic tests, test performance, and considerations for interpretation. In: Zimmerman JJ, Karriker LA, Ramirez A, Schwartz KJ, Stevenson GW, Zhang J, eds. *Diseases of Swine*. 11th ed. Ames, IA: Wiley Blackwell; 2019:75-97.

22. Johnson W, Roof M, Vaughn E, Christopher-Hennings J, Johnson CR, Murtaugh MP. Pathogenic and humoral immune responses to porcine reproductive and respiratory syndrome virus (PRRSV) are related to viral load in acute infection. *Vet Immunol Immunopathol*. 2004;102(3):233-247.

23. Zuckermann FA, Garcia EA, Luque ID, Christopher-Hennings J, Doster A, Brito M, Osorio F. Assessment of the efficacy of commercial porcine reproductive and respiratory syndrome virus (PRRSV) vaccines based on measurement of serologic response, frequency of gamma-IFN-producing cells and virological parameters of protection upon challenge. *Vet Microbiol*. 2007;123(1-3):69-85.

*24. Schulz L. Estimated Livestock returns. Estimated returns-Swine. Wean to feeder. **http://www2.econ.iastate.edu/estimated-returns/Wean%20to%20Feeder%20Excel.xlsx**. Accessed January 31, 2019.

25. Linhares DCL, Cano JP, Wetzell T, Nerem J, Torremorell M, Dee SA. Effect of modified-live porcine reproductive and respiratory syndrome virus (PRRSv) vaccine on the shedding of wild-type virus from an infected population of growing pigs. *Vaccine*. 2012;30(2):407-413.

*26. Moura CAA, Philips R, Silva GS, Mondaca E, Scheidt A, Kjaer J, Linhares DCL. Economic and production benefit of 2 PRRS MLV doses compared to a single dose vaccination program on growing pigs. *Proc 50th AASV*. Orlando, FL. 2019:44-46.

*27. Moura CAA, Silva GS, Linhares DCL. Production benefit of two PRRS MLV doses compared to a single dose vaccination program on nursery pigs. *ISU James D. McKean Swine Disease Conference*. Ames, IA. 2018:32-34.

28. Done SH, Paton DJ. Porcine reproductive and respiratory syndrome: clinical disease, pathology and immunosuppression. *Vet Rec*. 1995;136(2):32-35.

*29. Trevisan G, Linhares L, Crim B, Dubey P, Schwartz KJ, Burrough E, Sharma A, Gauger P, Harmon K, Zhang J, Main RG, Magalhaes ES, Sundberg P, Thurn M, Lages P, Corzo C, Torrison J, McGaughey R, Henningson J, Herrman E, Hanzlicek G, Marthaler D, Gupta S, Greseth J, Clement T, Christopher-Hennings J, Linhares D. Veterinary laboratory diagnostic data on PRRSV: lessons and applications. *ISU James D. McKean Swine Disease Conference*. Ames, IA. 2019:29-31.

30. Otake S, Dee SA, Rossow KD, Joo HS, Deen J, Molitor TW, Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by needles. *Vet Rec*. 2002;150(4):114-115.

31. Zimmerman JJ, Dee SA, Holtkamp DJ, Murtaugh MP, Stadejek T, Stevenson GW, Torremorell M, Yang H, Zhang J. Porcine reproductive and respiratory syndrome viruses (Porcine Arteriviruses). In: Zimmerman JJ, Karriker LA, Ramirez A, Schwartz KJ, Stevenson GW, Zhang J, eds. *Diseases of Swine*. 11th ed. Ames, IA: Wiley Blackwell; 2019:685-708.

32. Dee SA, Joo HS, Polson DD, Park BK, Pijoan C, Molitor TW, Collins JE, King V. Evaluation of the effects of nursery depopulation on the persistence of porcine reproductive and respiratory syndrome virus and the productivity of 34 farms. *Vet Rec*. 1997;140(10):247-248.

33. Dee SA, Joo HS. Prevention of the spread of porcine reproductive and respiratory syndrome virus in endemically infected pig herds by nursery depopulation. *Vet Rec*. 1994;135(1):6-9.

34. McCaw MB. Effect of reducing crossfostering at birth on piglet mortality and performance during an acute outbreak of porcine reproductive and respiratory syndrome. *J Swine Health Prod*. 2000;8(1):15-21.

35. Shin J-H, Molitor TW. Assessment of porcine reproductive and respiratory syndrome virus RNA load in sera and tissues during acute infection. *J Vet Sci*. 2002;3(2):75-86.

36. Rossow KD, Bautista EM, Goyal SM, Molitor TW, Murtaugh MP, Morrison RB, Benfield DA, Collins JE. Experimental porcine reproductive and respiratory syndrome virus infection in one-, four-, and 10-week-old pigs. *J Vet Diagn Invest*. 1994;6(1):3-12.

37. Rovira A, Clement T, Christopher-Hennings J, Thompson B, Engle M, Reicks D, Muñoz-Zanzi C. Evaluation of the sensitivity of reverse-transcription polymerase chain reaction to detect porcine reproductive and respiratory syndrome virus on individual and pooled samples from boars. *J Vet Diagn Invest*. 2007;19(5):502-509.

38. Reicks DL, Muñoz-Zanzi C, Mengeling W, Christopher-Hennings J, Lager K, Polson D, Dee S, Rossow K. Detection of porcine reproductive and respiratory syndrome virus in semen and serum of boars during the first six days after inoculation. *J Swine Health Prod*. 2006;14(1):35-41.

39. Lebret A, Boulbria G, Berton P, Moalic P-Y, Le Guennec J, Bouchet F, Auvigne V, Normand V. Monitoring PRRSV-1 in suckling piglets in an endemic herd using reverse transcriptase quantitative real time polymerase chain reaction: comparison of the rate of detection in serum and oral fluid samples and evaluation of pooling. *Porcine Health Manag*. 2019;5:8. doi:10.1186/s40813-019-0115-z

*40. Baker KL, Seate J, Zimmerman JJ, Dion K. Detecting porcine reproductive and respiratory syndrome virus (PRRSV) via polymerase chain reaction (PCR) by pooling pen-based oral fluid samples. *Proc 50th AASV*. Orlando, FL. 2019:105-106.

*41. Lopez WA, Gauger P, Harmon K, Bradner L, Macedo N, Silva G, Linhares DCL. To pool or not to pool processing fluid for PRRSV testing by PCR: that is the question. *ISU James D. McKean Swine Conference*. Ames, IA. 2018:30-31.

*42. Parker S, Scheidt A, Polson D, Robbins R. Oral fluids sample collection and post-collection processing to enhance porcine reproductive and respiratory syndrome virus sequencing. *Proc 44th AASV*. San Diego, CA. 2013:279-280.

* Non-refereed references.

Conversion tables

Weights and measures conversions

Common (US)	Metric	To convert	Multiply by
1 oz	28.35 g	oz to g	28.4
1 lb (16 oz)	453.59 g	lb to kg	0.45
2.2 lb	1 kg	kg to lb	2.2
1 in	2.54 cm	in to cm	2.54
0.39 in	1 cm	cm to in	0.39
1 ft (12 in)	0.31 m	ft to m	0.3
3.28 ft	1 m	m to ft	3.28
1 mi	1.6 km	mi to km	1.6
0.62 mi	1 km	km to mi	0.62
1 in^2	6.45 cm^2	in^2 to cm^2	6.45
0.16 in^2	1 cm^2	cm^2 to in^2	0.16
1 ft^2	0.09 m^2	ft^2 to m^2	0.09
10.76 ft^2	1 m^2	m^2 to ft^2	10.8
1 ft^3	0.03 m^3	ft^3 to m^3	0.03
35.3 ft^3	1 m^3	m^3 to ft^3	35
1 gal (128 fl oz)	3.8 L	gal to L	3.8
0.264 gal	1 L	L to gal	0.26
1 qt (32 fl oz)	946.36 mL	qt to L	0.95
33.815 fl oz	1 L	L to qt	1.1

Temperature equivalents (approx)

°F	°C
32	0
50	10
60	15.5
61	16
65	18.3
70	21.1
75	23.8
80	26.6
82	28
85	29.4
90	32.2
102	38.8
103	39.4
104	40.0
105	40.5
106	41.1
212	100

°F = (°C × 9/5) + 32
°C = (°F - 32) × 5/9

Conversion chart, kg to lb (approx)

Pig size	Lb	Kg
Birth	3.3-4.4	1.5-2.0
Weaning	7.7	3.5
	11	5
	22	10
Nursery	33	15
	44	20
	55	25
	66	30
Grower	99	45
	110	50
	132	60
Finisher	198	90
	220	100
	231	105
	242	110
	253	115
Sow	300	135
	661	300
Boar	794	360
	800	363

1 tonne = 1000 kg
1 ppm = 0.0001% = 1 mg/kg = 1 g/tonne
1 ppm = 1 mg/L

Brief Communication

Peer reviewed

Assessment of hemoglobin concentration in relation to sow reproductive stage and parity

Kayla Castevens, DVM; Juliana Bonin Ferreira, BVSc, DVSc; Thomas Gillespie, DVM, DABVP; Christopher Olsen, DVM, MS; Jens-Peter Nielsen, DVM, PhD; Glen Almond, DVM, PhD

Summary

The study objective was to determine if sows are anemic at any reproductive stage or parity. Hemoglobin concentrations were determined for 2683 sows from 11 farms. The overall trend was for hemoglobin concentrations to peak during mid-gestation and reach a nadir in early lactation when most (74.2%) sows were anemic.

Keywords: swine, sows, hemoglobin, iron

Received: November 5, 2019
Accepted: March 26, 2020

Resumen - Evaluación de la concentración de hemoglobina en relación con la etapa reproductiva de la cerda y la paridad

El objetivo del estudio fue determinar si las cerdas están anémicas en cualquier etapa reproductiva o paridad. Se determinaron las concentraciones de hemoglobina para 2683 cerdas de 11 granjas. La tendencia general fue que las concentraciones de hemoglobina alcanzaron su punto máximo durante la mitad de la gestación y alcanzaron su punto más bajo en la lactancia temprana cuando la mayoría de las cerdas (74.2%) estaban anémicas.

Résumé - Évaluation de la concentration d'hémoglobine en lien avec le stade de reproduction et la parité de truies

L'objectif de la présente étude était de déterminer si les truies sont anémiques à n'importe lequel des stades de reproduction ou de parité. Les concentrations d'hémoglobine furent déterminées chez 2683 truies provenant de 11 fermes. La tendance générale était que les concentrations d'hémoglobine atteignaient un pic durant la mi-gestation et un nadir au début de la lactation lorsque la plupart (74.2%) des truies étaient anémiques.

Iron deficiency anemia in neonatal pigs is a major limitation for optimal health and performance. To correct this deficiency, and resultant anemia, iron injections are given early in the piglet's life.[1-4] In contrast, the prevalence of anemia in sows has not been widely studied. Advances in genetic and reproductive research has led to highly prolific sows, which have a high nutritional demand to support the growth and development of large and frequent litters. While iron and other trace minerals are commonly present in excess in sow diets, the absorption capacity may not allow for optimal levels of iron to be maintained throughout a sow's lifetime. This potentially leads to conditions such as iron deficiency anemia.[5-7] Results from one study showed that hemoglobin (Hb) concentrations in sows decreased with age, thereby, supporting the concept that iron demands are greater than the quantity absorbed from a sow's diet.[8]

Attempts to manipulate the iron concentrations in sows to reduce anemia in piglets have been largely unsuccessrul.[5-7] This lack of response in the progeny was likely due to the controlled transfer of iron in the endometrium.[9] Another study reported that low Hb concentrations in sows may impact the incidence of stillborn piglets.[10] While reports on this topic were inconsistent with at least one study finding no correlation between sows' Hb concentrations and stillbirth occurrence,[8] a recent investigation found that sows with Hb concentrations below 10 g/dL had significantly more stillborn piglets (1.7 stillborn/litter) compared to non-anemic sows (1.1 stillborn/litter).[11]

Therefore, the present study was designed to evaluate Hb concentrations in sows of different parities and at various reproductive stages. The overall goal was to determine if sows are anemic at any reproductive stage or parity.

Materials and methods

All animals were raised and managed on commercial farms in North Carolina (n = 7 farms) and Indiana (n = 4 farms). The genetic lines of the sows were proprietary. Each farm was Pork Quality Assurance Plus certified and followed the animal care standards of the National Pork Board.[12] An Institutional Animal Care and Use Committee protocol was not required.

The study was a cross-sectional design including 2683 sows from 11 farms which ranged in size from 2400 to 4000 sows/farm. All animals included were normal, productive sows

KC, JBF, GA: College of Veterinary Medicine, North Carolina State University, Raleigh, North Carolina.

TG: Performance Health PC, Battle Ground, Indiana.

CO: Pharmacosmos Inc, Watchung, New Jersey.

J-PN: Royal Veterinary College, Copenhagen, Denmark.

Corresponding author: Dr Glen Almond, Department of Population Health and Pathobiology, College of Veterinary Medicine, North Carolina State University, 1060 William Moore Drive, Raleigh, NC 27607; Tel: 919-513-6370; Fax: 919-513-6464; Email: gwalmond@ncsu.edu.

This article is available online at http://www.aasv.org/shap.html.

Castevens K, Ferreira JB, Gillespie T, Olsen C, Nielsen J-P, Almond G. Assessment of hemoglobin concentration in relation to sow reproductive stage and parity. *J Swine Health Prod.* 2020;28(5):254-257.

from the general population of each farm. Approximately 250 blood samples were collected from each farm representing 10 sows/parity/reproductive stage (Table 1). Reproductive stages were defined as early (approximately 25-35 days), mid (approximately 50-70 days), and late (approximately 100 or more days) gestation, and early (< 7 days postpartum) and late (> 14 days postpartum) lactation. Parity groups were 0 (gilts), 1, 2, 3, and ≥ 4.

The Hb concentrations were measured on the farms using a HemoCue Hb 201+ (HemoCue America).[4] Previous studies demonstrated that this instrument was reliable[2]; however, it may overestimate the Hb concentrations by 4%.[1] Blood samples were taken from the ear veins of sows,[1,8] and loaded into disposable microcuvettes via capillary action. The microcuvette was placed in the HemoCue Hb 201+ and the resulting Hb concentration displayed and recorded within 60 seconds.

The Hb data was analyzed using an analysis of variance, with state, farm, parity, and stage as the independent variables (Statistix 10, Analytical Software). A significant interaction between parity and stage was present. Means were compared with Tukey's honest significant difference test. Using < 10 g/dL as the cutoff for anemia,[11] sows were classified as anemic or non-anemic. For each category (parity and reproductive stage), the percentage of anemic animals was determined and compared with Chi-square tests.

Table 1: Numbers of sows (n = 2683) sampled by reproductive stage and parity

	Reproductive Stage				
Parity	Early Gestation	Mid Gestation	Late Gestation	Early Lactation	Late Lactation
0	105	108	109	103	106
1	110	107	104	97	103
2	105	109	110	110	107
3	110	110	110	110	100
≥ 4	110	110	110	110	110
Total	**540**	**544**	**543**	**530**	**526**

Results

Due to the significant interaction between parity and reproductive stage, it was not possible to separate the effects of these variables (Figure 1). The Hb concentrations typically were lower ($P = .04$) in early and late lactation than at other stages of reproduction regardless of parity. Gilts (1st pregnancy) had higher ($P = .04$) Hb concentrations than other parities of sows in mid-gestation. In general, it was evident that parity 0, 1, and 2 animals had higher Hb concentrations than parity 3 and ≥ 4 animals during gestation; however, these differences were not evident during lactation. The overall trend was for Hb concentrations to peak during mid-gestation, then be lower in late gestation and reach a nadir in early lactation.

All but one farm in North Carolina had similar, overall Hb concentrations (Figure 2). These concentrations were consistently less than 10 g/dL. In contrast, the four farms in Indiana had greater ($P = .01$) Hb concentrations than all the North Carolina farms. No differences were evident among the four Indiana farms.

Cumulatively, 1333 (49.7%) of the 2683 sows tested were anemic using a < 10 g/dL cutoff for sow anemia.[11] When evaluated by parity, 206 (38.8%) of 531 gilts tested below this cutoff, while parity ≥ 4 sows had 321 (58.4%) of 550 sows considered anemic. Of all gilts and sows tested, more sows were anemic ($P = .01$) during early or late lactation (74.2% and 67.3%, respectively) than during early, mid or late gestation (30.9%, 29.6%, 47.6%, respectively).

Discussion

This method of Hb assessment provided a quick and inexpensive method for on-farm use. It was previously shown[2] that values obtained from the HemoCue Hb 201+ correlate well with laboratory results with a 97% sensitivity and 100% specificity in the diagnosis of anemia (< 8.0 g/dL) and Hb measurements of 2.7 to 11.2 g/dL.

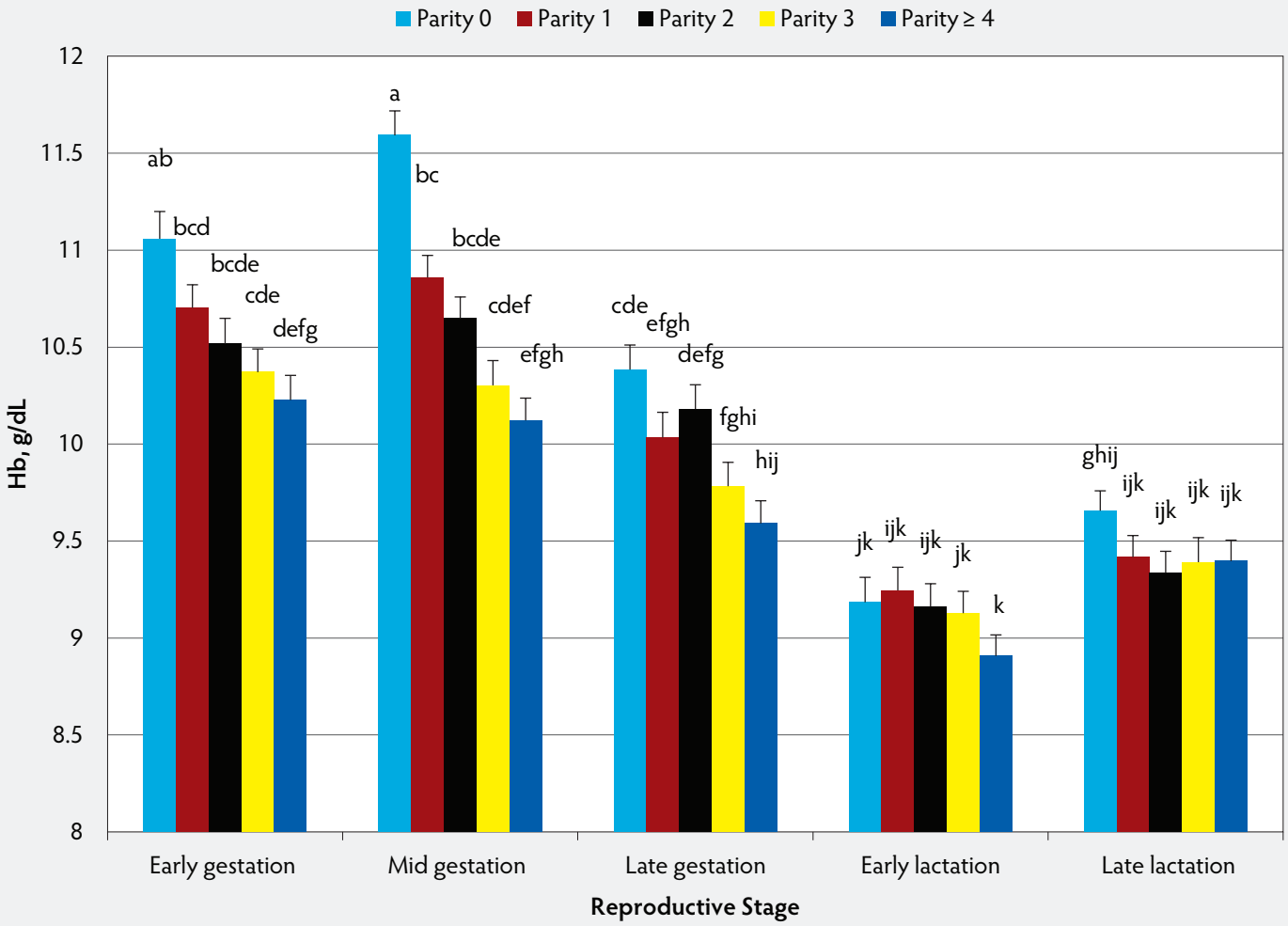
These data raise the question of how anemia impacts sow health and reproduction over time. For example, if a sow is anemic in mid-gestation, is she more likely to become more anemic by early lactation? While not evaluated in this cross-sectional study, a previous cohort study demonstrated that with each successive parity, the Hb concentrations decreased and did not recover to values observed as gilts or first parity sows.[8] Severe anemia could lead to reproductive issues or sow death,[13,14] and an increase in the number of stillborn pigs.[11]

Feeding high levels of iron to sows during late gestation[6,15] or parenteral injections of iron dextran to gestating sows failed to increase placental transfer of iron to fetuses.[16] However, there have been few attempts to increase the Hb concentrations and the hematological status of sows. Regardless of the Hb status of sows in gestation, it is apparent that the sows become anemic in lactation.

The difference between the farm locations was unexpected. While precise feed analyses were not available, the difference may be explained, at least in part, by the inclusion levels of phytase in the diets. Indiana farms included a higher level of phytase (1250 FTU/kg) in the sow diets than North Carolina farms (750 FTU/kg). Since phytates form insoluble complexes with several minerals including iron, the increased phytase possibly contributed to greater Hb concentrations in the Indiana farms. Phytases increase the release of phosphate and other minerals, such as iron, from phytates,[17] and the phytases may enhance iron absorption from 0.6% to 42% in cereal meals.[18] Therefore, the different phytase levels among farms in the two states may have contributed to the differences in Hb concentrations.

Generally, while the results demonstrated that Hb concentrations varied among sows, a considerable number (49.7%) would be considered anemic based on the cutoff of 10 g/dL suggested in a previous study.[11] Trends can be observed in the data with mean Hb declining in a stepwise fashion as sows age. This supports a potential link between anemia and stillbirth occurrence as a higher occurrence of stillbirths are often observed in higher parity sows.

Figure 1: Mean (SEM) hemoglobin (Hb) concentrations in gilts and sows at various stages of reproduction. Bars with different superscripts differ (P = .04).



While further study is necessary, iron supplementation at critical periods or at the onset of anemia may be required to sustain a sow at higher reproductive performance levels. The critical limit of Hb concentrations for the gilt or sow to be considered anemic is unknown at this time. It was previously stated that Hb concentrations between 10 and 16 g/dL were considered normal.[8] Based on the present results, it is evident that most (74.2%) sows are anemic in lactation and that higher parity sows (parity 3 and ≥ 4) are more likely to have reduced Hb concentrations in late gestation. The precise influence of sow anemia on the long-term reproductive performance and longevity of sows requires further study.

Implications

Under the conditions of this study:

- Many sows are anemic during lactation regardless of parity.
- Higher parity sows are more likely to be anemic during gestation.
- Sow iron requirements during late gestation and lactation require more study.

Acknowledgments

The authors acknowledge the support of the veterinarians and pork producers who facilitated the study. Partial funding was provided by Pharmacosmos, Inc.

Conflict of Interest

One author (C. Olsen) is employed by Pharmacosmos, Inc. His role was limited to the review of the manuscript.

Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

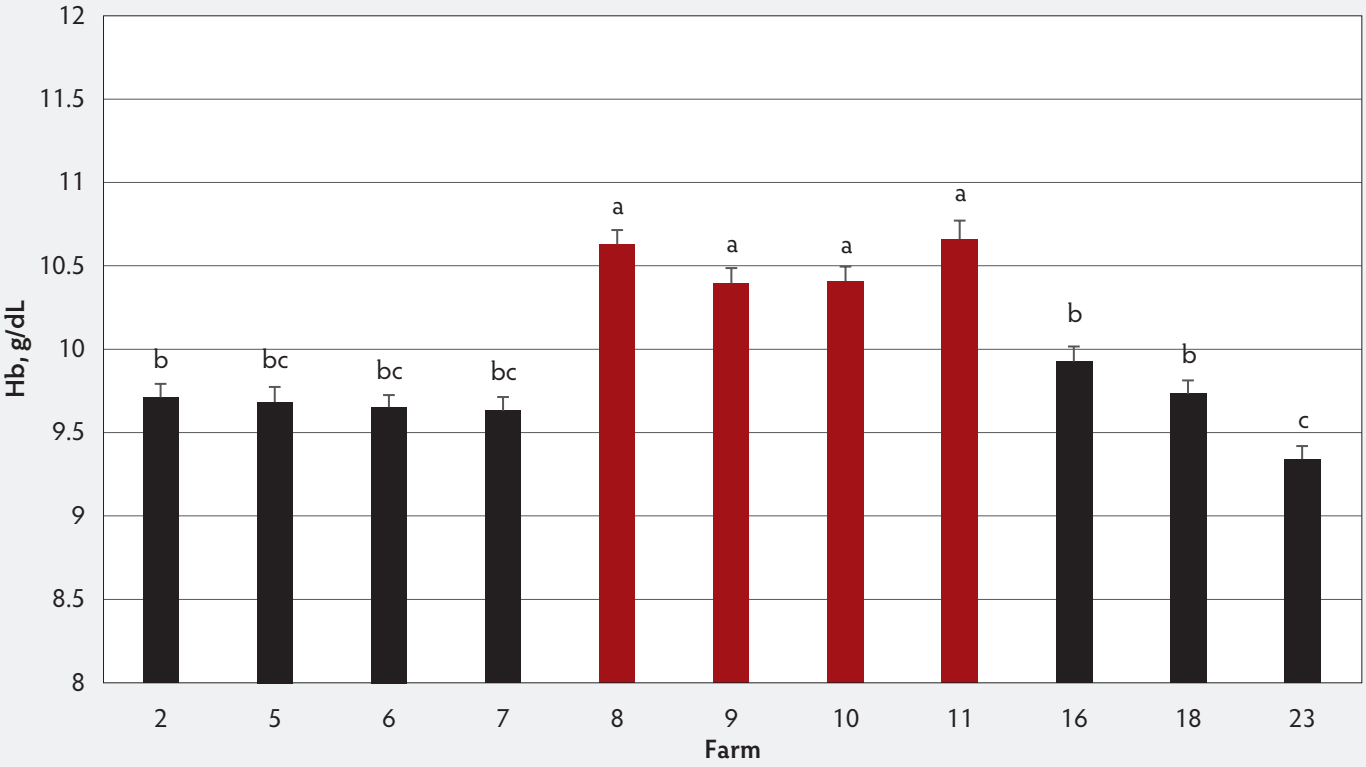
References

1. Maes D, Steyaert M, Vanderhaeghe C, López Rodgríguez A, de Jong E, del Pozo Sacristán R, Vangroenweghe F, Dewulf J. Comparison of oral versus parenteral iron supplementation on the health and productivity of piglets. *Vet Rec.* 2011;168:188-192.

2. Kutter APN, Mauch JY, Riond B, Martin-Jurado O, Spielmann N, Weiss M, Bettschart-Wolfensberger R. Evaluation of two devices for point-of-care testing of haemoglobin in neonatal pigs. *Lab Anim.* 2012;46:65-70.

3. Perri AM, Friendship RM, Harding JCS, O'Sullivan TL. An investigation of iron deficiency and anemia in piglets and the effect of iron status at weaning on post-weaning performance. *J Swine Health Prod.* 2016;24:10-20.

Figure 2: Comparison of overall mean (SEM) hemoglobin (Hb) concentrations in gilts and sows on 11 farms. The red bars represent Indiana farms and the black bars represent North Carolina farms. Bars with different superscripts differ (P = .01).



4. Almond G, Byers E, Seate J, Boyer P. Supplemental iron dextran injections: influence on hemoglobin concentrations and piglet growth. *J Swine Health Prod*. 2017;25:308-312.

5. Chaney CH, Barnhart CE. Effect of iron supplementation of sow rations on the prevention of baby pig anemia. *J Nutr*. 1963;81:187-192.

6. Wang J, Li D, Che L, Lin Y, Fang Z, Xu S, Wu D. Influence of organic iron complex on sow reproductive performance and iron status of nursing pigs. *Livest Sci*. 2014;160:89-96.

7. Novais AK, Abércio da Silva C, Siva dos Santos RK, Dias CP, Callegari MA, de Oliveira ER. The effect of supplementing sow and piglet diets with different forms of iron. *R Bras Zootec*. 2016;45:615-621.

8. Normand V, Perrin H, Auvigne V, Robert N, Laval A. Anaemia in the sow: a cohort study to assess factors with an impact on haemoglobin concentration, and the influence of haemoglobin concentration on the reproductive performance. *Vet Rec*. 2012;171:350-354.

9. Mahan DC, Vallet JL. Vitamin and mineral transfer during fetal development and the early postnatal period in pigs. *J Anim Sci.* 1997;75:2731-2738.

10. Rootwelt V, Reksen O, Farstad W, Framstad T. Postpartum deaths: piglet, placental, and umbilical characteristics. *J Anim Sci.* 2013;91:2647-2656. doi:10.2527/jas.2012-5531

11. Bhattarai S, Framstad T, Nielsen JP. Stillbirths in relation to sow hematological parameters at farrowing: A cohort study. *J Swine Health Prod*. 2018;26:215-222.

*12. National Pork Board. *Swine Care Handbook*. Des Moines, Iowa: National Pork Board; 2018.

13. Moore R, Redmond H, Livingston C. Iron deficiency anemia as a cause of stillbirths in swine. *J Am Vet Med Assoc*. 1965;147:746-748.

*14. Lamana García-Fuente J. Effect of amino acid-chelated minerals on swine reproduction: a practical case. *Proc 14th IPVS Congress*. Bologna, Italy. 1996:450.

15. Brady PS, Ku PK, Ullrey DE, Miller ER. Evaluation of an amino acid-iron chelate hematinic for the baby pig. *J Anim Sci*. 1978;47:1135-1140.

16. Ducsay CA, Buhi WC, Bazer FW, Roberts RM, Combs GE. Role of uteroferrin in placental iron transport: effect of maternal iron treatment on fetal iron and uteroferrin content and neonatal hemoglobin. *J Anim Sci.* 1984;59:1303-1308.

17. Vashishth A, Ram S, Beniwal V. Cereal phytases and their importance in improvement of micronutrients bioavailability. *3 Biotech*. 2017;7:42-49.

18. Nielsen AVF, Inge T, Meyer AS. Potential of phytase-mediated iron release from cereal-based foods: a quantitative view. *Nutrients.* 2013;5:3074-3098.

* Non-refereed references.

PRODUCTION TOOL PEER REVIEWED

Interactive euthanasia training program for swine caretakers; a study on program implementation and perceived caretaker knowledge

Magnus R. Campler, PhD; Monique D. Pairis-Garcia, PhD, DVM, DACAW; Jean-Loup Rault, PhD; Grahame Coleman, PhD; Andréia G. Arruda, PhD, DVM

Summary

Implementing timely and humane euthanasia on-farm is of key importance for safeguarding animal welfare. Equally important is the skill, attitude, and knowledge among caretakers to successfully perform euthanasia on-farm. This study investigated the potential of an interactive euthanasia training program in conjunction with a survey designed to investigate attitudes and perceived knowledge of the Common Swine Industry Audit euthanasia guidelines. The survey results showed that caretakers self-reported improved knowledge of industry expectations immediately post training compared to their perceived knowledge pre-training. This study provides insight regarding interactive training programs and identifies variation in perceived euthanasia knowledge within swine caretaker demographics.

Keywords: swine, timely euthanasia, swine welfare, caretaker training, interactive training program

Received: September 20, 2019
Accepted: March 26, 2020

Resumen - Programa interactivo de capacitación sobre la eutanasia para los encargados de los cerdos; un estudio sobre la implementación del programa y la percepción del conocimiento del personal

La implementación oportuna y humana de la eutanasia en la granja es de vital importancia para proteger el bienestar animal. Igualmente importante es la habilidad, actitud y conocimiento de los responsables de los cerdos para realizar con éxito la eutanasia en la granja. Este estudio investigó el potencial de un programa interactivo de capacitación sobre eutanasia junto con una encuesta diseñada para investigar las actitudes y la percepción del conocimiento de los lineamientos de eutanasia en la Auditoría de la Industria Porcina Común. Los resultados de la encuesta mostraron que los responsables de los cerdos reportaron una mejora en el conocimiento de las expectativas de la industria inmediatamente después de la capacitación en comparación con su percepción antes de la capacitación. Este estudio proporciona una visión de la relación de los programas de capacitación interactivos e identifica la variación en el aparente conocimiento sobre la eutanasia entre la demografía del personal responsable de los cerdos.

Résumé - Programme de formation interactif sur l'euthanasie pour les animaliers porcins; une étude sur l'implantation du programme et les connaissances perçues des éleveurs

La réalisation d'une euthanasie humanitaire et en temps opportun à la ferme est d'importance primordiale pour préserver le bien-être animal. Tout aussi important est l'habileté, l'attitude et la connaissance parmi les animaliers pour réaliser une euthanasie réussie à la ferme. La présente étude a examiné le potentiel d'un programme de formation interactif sur l'euthanasie en conjonction avec un sondage visant à investiguer les attitudes et connaissance perçues des directives sur l'euthanasie du Common Swine Industry Audit euthanasia guideline. L'étude a démontré quel les animaliers ont auto-rapporté une connaissance améliorée des attentes de l'industrie immédiatement post-formation comparativement à leur connaissance perçue pré-formation. La présente étude fournie une connaissance concernant des programmes de formation interactifs et identifie des variations dans les connaissances perçues sur l'euthanasie parmi les données démographiques relatives aux animaliers.

The ability to identify compromised animals and perform timely euthanasia of food animals is a skill often acquired by caretakers after receiving substantial on-farm work experience. Frequently, an on-farm euthanasia standard operating protocol

MRC: Department of Animal and Food Sciences, University of Kentucky, Lexington, Kentucky.

MDP-G: Department of Population Health and Pathobiology, North Carolina State University, Raleigh, North Carolina.

J-LR: Institute of Animal Welfare Science, University of Veterinary Medicine, Vienna, Austria.

GC: University of Melbourne, Animal Welfare Science Centre, Faculty of Veterinary and Agricultural Sciences, VIC, Australia.

AGA: Department of Veterinary Preventive Medicine, College of Veterinary Medicine, The Ohio State University, Columbus, Ohio.

Corresponding author: Dr Monique Pairis-Garcia, Department of Population Health and Pathobiology, CVM Main Building, 1060 William Moore Drive, Raleigh, NC 27607. Tel: 614-688-1968; Email: pairis-garcia@ncsu.edu.

This article is available online at http://www.aasv.org/shap.html.

Campler MR, Pairis-Garcia MD, Rault JL, Coleman G, Arruda AG. Interactive euthanasia training program for swine caretakers; a study on program implementation and perceived caretaker knowledge. *J Swine Health Prod.* 2020;28(5):258-264.

is implemented after consultation with a farm's veterinarian. However, veterinarians are unlikely to be on-farm daily to ensure that farm protocols are followed or to train inexperienced caretakers. Moreover, not all veterinary students or veterinarians have extensive euthanasia experience or feel comfortable performing euthanasia.[1,2] Although national standards on timely euthanasia have been developed, success of the euthanasia process relies heavily upon the decision-making process and skillset of individual caretakers.[3,4] A commonly overlooked factor about timely euthanasia is an individual caretaker's attitude and willingness to perform the act. Early work has shown that caretakers' attitudes can affect their behavior towards animals and that among veterinary professionals, 78% of participants felt that they lacked euthanasia training and the ability to deal with feelings associated with conducting euthanasia.[5-7] A more recent survey study found that insufficient perceived knowledge about euthanasia was significantly linked to the indecisiveness and avoidance to perform euthanasia and caretakers feeling guilty about performing euthanasia.[8] Additionally, previous survey studies found that negative attitudes towards euthanasia may influence willingness to perform euthanasia.[9,10] It was also reported that among caretakers working in swine systems in North Carolina, 87% of participants understood the welfare aspects of euthanizing sick pigs, but 46% of respondents said they wished to never have to carry out euthanasia again.[9] One approach to improving attitudes towards euthanasia is to implement training programs for veterinarians and caretakers regarding euthanasia decision-making. In a recent US survey representing 175 swine caretakers in 8 states, only half of participating swine caretakers were trained in euthanasia techniques.[11] Given this opportunity for training, it is critical to develop euthanasia training that provides essential information to guide those making euthanasia decisions while accounting for the education and experience levels of swine caretakers.[3] Thus, the aim of this study was to investigate the potential of an interactive training program on swine caretakers' knowledge and attitudes towards timely euthanasia. We hypothesized that caretakers' self-report on their ability to detect compromised pigs, ability to determine when compromised pigs needed to be euthanized, and their perceived euthanasia skills, would increase post training.

Materials and methods

This study was reviewed and approved by The Ohio State University Institutional Review Board (IRB:2017E0106) for Human Subjects Research.

Caretakers from 8 Ohio swine farms were invited to receive timely euthanasia training using an interactive, computer-based multimedia software program and to take part in this study. Invitations to participate in this study were conducted by email correspondence to farm managers, owners who had previously enrolled staff in educational workshops, or those with involvement in previous studies with this research group. All surveys and training for caretakers working in breeding and gestation farms were conducted on-farm and any caretaker present at the time of the visit was eligible to participate. For nursery and finishing farms, caretakers were invited to join the training program at one centralized location. The participating caretakers had to complete all available modules in the training program and the pre- and post-training surveys to be included in the study. All caretakers in this study were part of a larger 2017 training study.[8,12] Caretaker participation for all farm systems was voluntary and caretakers were free to take part in the program as much or as little as they wished and could end training at any time. Eighty-two of 84 participating caretakers from 8 different farms with mixed production stages/classes of pigs finished the required training modules and the pre- and post-training surveys.

Instrument selection

The survey instrument was based on a previously developed framework by Rault and colleagues[13] who used 2 assembled focus groups of 13 swine caretakers and 12 farm supervisors to discuss timely euthanasia opinions, problems, and experiences. A subsequent questionnaire was sent to 120 caretakers from 10 commercial swine herds of varying sizes (50 to 4754 sows). The questionnaire was carefully designed to properly assess caretaker attitudes towards euthanasia, factors related to decision making, such as inadequate knowledge, knowledge seeking, and confidence by self-assessment, and to obtain various caretaker demographics. The outcomes of these survey studies are important to reveal local caretaker attitudes, experience with euthanasia, and confidence levels performing euthanasia. Knowledge regarding the local caretaker population may help with the development of euthanasia training practices and improve the quality of euthanasia practices. Thus, using the initial work of Rault and colleagues[13] as a foundation, the authors developed a pre- and post-training survey in collaboration with an internationally renowned swine expert with extensive experience of caretaker training and survey study development. The 7 key statements specifically targeted and analyzed for this study were selected by the authors in consultation with the swine expert as important indicators of caretakers' perceived knowledge of, and attitudes about, euthanasia practices. The 7 statements were:

1. I can determine when a pig needs to be euthanized.
2. I understand how to make good euthanasia decisions.
3. I can evaluate sick or injured pigs to decide if euthanasia is needed.
4. I am not aware of euthanasia guidelines in the Common Swine Industry Audit.
5. I know that pigs with certain conditions must be euthanized immediately.
6. I am confident I can make good euthanasia decisions when needed.
7. I am aware of the importance of timely euthanasia.

The training program did not save individual caretakers' performance scores or navigation history throughout the training modules (eg, number of incorrect choices, number of attempts, or time to completion) as anonymity, confidentiality, and flexibility were key components to ensure participation. This also enabled the training program to be completely functional on a standard USB flash drive without the complications of securely storing data for individuals offline or through internet-based databases or cloud services.[12] Additionally, this training platform served as a case study of how computer-based interactive training could be implemented for training swine caretakers on-farm without any requirements for computer hardware, software, or internet access.

Data collection

Immediately prior to participating in the interactive euthanasia training program caretakers signed a consent form and completed a survey containing questions about age, gender, work experience, herd size, previous euthanasia experience, and main work area or production type. Additionally, caretakers responded to 7 key

statements regarding their confidence and knowledge in relation to timely euthanasia as previously described.

These key statements established a baseline for individuals prior to the training session, allowing for comparison of the responses to the same questions post training. The questions were answered on a 5-point scale: 1) strongly disagree, 2) disagree, 3) neither agree nor disagree, 4) agree, or 5) strongly agree. The post-training survey was taken approximately one hour after the completed training program session.

Training program

The training program was interactive using computer-based multimedia software designed to function on any laptop or workstation with or without internet access (Figure 1).[12] The use of an interactive computer-based software enabled the caretakers to interact with a series of case studies across 3 swine production stages: breeding stock, piglets, and wean to grow-finish pigs. Each production stage contained 5 different case studies based on 5 specific criteria defined in the Common Swine Industry Audit (CSIA) and each case study provided information about treatment history, clinical signs, and the severity of the particular condition of the pig.[12,14] Feedback was provided after each decision to ensure that caretakers understood the appropriateness of their decisions based on industry guidelines; alternative treatment options were also included, if available, for a particular case study. Case studies were designed to allow for different levels of caretaker engagement; they included multiple-choice questions and scenarios where an active choice had to be made by caretakers to move forward through the program (Figure 2). The estimated time to complete all case studies for all production stages was 30 to 45 minutes. Each case study provided caretakers with a digital certificate of completion to confirm caretakers completed the case study correctly.

Statistical analysis

Basic descriptive analyses were conducted using descriptive plots and statistics (mean, SD, and range). Data were initially checked for recording errors and missing data. Statement or demographic answers left blank by caretakers were considered missing (pre-training statement 3 and 5; n = 1) and excluded from analyses using those parameters. To analyze effects of training sessions on caretaker knowledge, pre- and post-training survey answers were compared for each of the 7 statements (Table 1) using the Wilcoxon signed rank test. The effect of predictors of interest including caretaker age, gender, work experience, farm herd size, and farm production type were tested on score improvement (yes or no) for each statement using mixed effect logistic regression models. All analyses were conducted using Stata/IC 14.1 (StataCorp LP). Model-building steps included first checking for linearity between continuous variables and the log odds of the outcome. Because the linearity assumption was not met for predictors of interest, age was divided into 2 categories (< 30 years [n = 44] and ≥ 30 years [n = 38]); pig experience was divided into 2 categories (< 2 years [n = 41] and ≥ 2 years [n = 41]); and farm size (number of pigs) was divided up into 3 categories (≤ 1500 [n = 3], 1501-3000 [n = 3], and > 3000 [n = 2]). A mixed effect logistic regression model was built for each statement using farm as a random effect to account for clustering of caretakers within farms. A final statistical significance was declared at $P < .05$ and tendency at $.05 < P < .10$.

Results

Of the 84 caretakers completing all training modules in the study, 2 caretakers failed to complete the post-training survey, resulting in a 97.6% response rate. The median age of the remaining 82 caretakers was 29 years (range, 18-59 years; first quartile = 24 years; third quartile = 42 years); 44 (53.7%) were 29 years or younger and 38 (46.3%) were older than 30. Of the remaining 82 caretakers, 71 (86.6%) self-identified as male and 11 (13.4%) as female. The mean work experience with pigs was 8.5 years (median = 2.25 years; range, 2 weeks to 52 years) with 41 (50.0%) caretakers having less than 2 years of work experience. Thirty-four (41.5%) caretakers primarily worked in

Figure 1: Screen capture from the timely euthanasia training application showcasing A) the starting page and B) the option menu to choose case studies for breeding stock, piglets, or wean to grow-finish pigs. This feature enables caretakers to learn about their production system but also to get additional useful information of other parts of the production system.

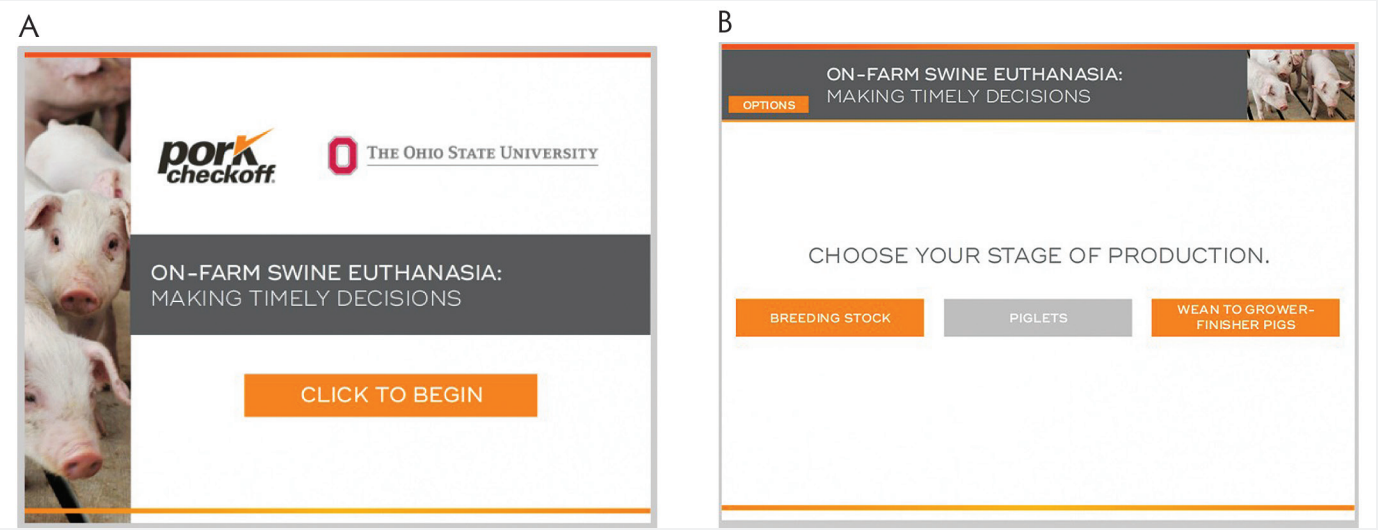


Figure 2: Screen capture from the timely euthanasia training application showcasing A) a multiple choice question for a piglet case study and B) the correct answer screen after choosing one or more correct answers.

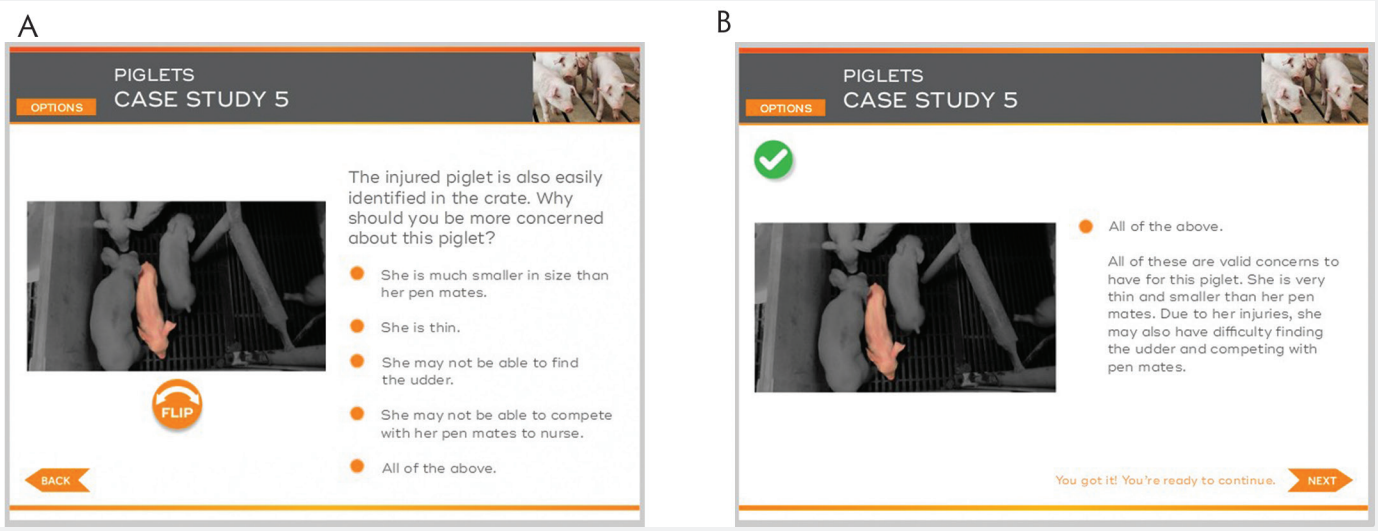


Table 1: Five conditions requiring immediate euthanasia based on the Common Swine Industry Audit standards

1.	Pigs which have shown no response after two days of intensive care or which have no prospect for improvement unless otherwise recommended by a veterinarian
2.	Severely injured or non-ambulatory* pigs with the inability to recover
3.	Any non-ambulatory* pig with a body condition score of 1
4.	Pigs with hernias that are perforated or hernias that touch the ground while the pig is standing, impede movement, and are ulcerated
5.	Pigs with uterine prolapses or any untreated necrotic prolapses

* The 2015 Common Swine Industry Audit defined a non-ambulatory animal as one which cannot rise, or which can stand with support but cannot bear weight on two or more legs.[14]

farrowing, 27 (32.9%) in breeding/dry sow, and 21 (25.6%) in weaner/nursery. The mean size of farm on which survey caretakers worked was 3100 pigs with a range from 1300 to 7000 head. The number of participants that cared for > 100 pigs on a daily basis was 7 (8.5%), while 19 (23.2%) participants cared for 100 to 500 pigs, 5 (6.1%) cared for 501 to 1000 pigs, 18 (22.0%) cared for 1001 to 2500 pigs, 31 (37.8%) cared for > 2500 pigs, and 2 participants did not answer (2.4%). Twenty-seven (32.9%) caretakers reported previous experience with euthanasia before starting to work with pigs, while 41 (50.0%) caretakers had their first euthanasia experience when they started working with pigs and 14 (17.1%) had not euthanized any animal to date. Of the caretakers that did not report any euthanasia experience, 3 caretakers had 3, 5, and 10 years of experience working with pigs, respectively, while the remaining 11 caretakers had a mean work experience with pigs of 5 weeks.

Wilcoxon signed rank test

The Wilcoxon signed rank test revealed a decrease in agreement score for statement 4 (I am not aware of euthanasia guidelines in the Common Swine Industry Audit; $P = .007$; Table 2) indicating that caretakers reported increased knowledge of these guidelines after the training session. No other statistically significant differences were found for caretakers' perceived knowledge for all other statements (Table 2).

Mixed effect logistic regression

For statement 1 (I can determine when a pig needs to be euthanized), the mixed effect logistic regression models revealed the odds (reported as odds ratio) of younger caretakers improving their agreement score tended to be higher compared to older caretakers (0.28; 95% CI, 0.06-1.27; $P = .099$; Table 3). Similarly for statement 3 (I can evaluate sick or injured pigs to decide if euthanasia is needed), the odds of younger caretakers improving their score tended to be higher compared to older caretakers (0.3; 95% CI, 0.07-1.19; $P = .087$; Table 3). No other statistically significant predictors were found for models about statements 2 and 4 through 7. ($P > .10$; Table 3).

Discussion

The results of this survey reveal participation in the training program increased caretakers' self-report of improved knowledge of the

Table 2: Wilcoxon signed rank test and descriptive values for pre- and post-training survey scores

Statement	Pre-training survey score		Post-training survey score		Num Diff	Min*	Max*	No. of respondents	*P*
	Median	IQR	Median	IQR					
1) I can determine when a pig needs to be euthanized	4	1	4	1	0.04	2	5	82	.97
2) I understand how to make good euthanasia decisions	4	1	4	1	0.08	2	5	82	.44
3) I can evaluate sick or injured pigs to decide if euthanasia is needed	4	1	4	1	0.07	1	5	81	.99
4) I am not aware of euthanasia guidelines in the Common Swine Industry Audit†	2	2	2	1	-0.39	1	5	82	.007
5) I know that pigs with certain conditions must be euthanized immediately	5	1	4.5	1	-0.06	2	5	81	.16
6) I am confident I can make good euthanasia decisions when needed	4	1	4	1	0.08	1	5	82	.27
7) I am aware of the importance of timely euthanasia	5	1	5	1	-0.10	1	5	82	.16

* Minimum and maximum values represent the lowest and highest score given for each statement in either the pre- or post-training survey.
† Due to negation in statement, a lower score is better.
IQR = interquartile range; Num Diff = numerical difference.

CSIA timely euthanasia guidelines.[14] In addition, younger caretakers were more likely to report having learned how to determine when a pig needs to be euthanized after participating in this computer-based interactive training program compared to older caretakers.

Developing training materials capable of educating all levels of employees is important to ensure a high standard of on-farm animal welfare. For instance, previous research found swine caretakers retained information better if training was conducted using a computer program compared to traditional textbook learning.[15] Interactive training programs and computer-based learning games have shown to increase learning and understanding of material by helping trainees or caretakers focus and participate in the learning activity.[16-18] Although improvement was seen for all caretakers for statement 4 (I am not aware of euthanasia guidelines in the Common Swine Industry Audit), no improvement was noted for the other statements. The overall rate of agreement was high for the perceived level of knowledge, decision-making, confidence, and awareness of timely euthanasia during the pre-training survey, making a significant increase in agreement difficult to achieve post training. It was hypothesized that experienced caretakers were already knowledgeable and had dealt with most of these case study examples previously and therefore did not gain knowledge from the training program.[19] Overall, caretakers in this study scored high in agreement for all statements prior to training except the one about CSIA, suggesting caretakers perceived themselves knowledgeable and experienced in dealing with euthanasia but not with official CSIA guidelines. The fact that younger, and possibly more inexperienced, caretakers tended to be more likely to improve their scoring for statements 1 (I can determine when a pig needs to be euthanized) and 3 (I can evaluate sick or injured pigs to decide if euthanasia is needed) compared to older caretakers could be explained by lack of experience. However, it is possible younger caretakers may be more familiar and comfortable with computer-based training compared to older colleagues and therefore felt more engaged and able to learn from a relatively short (30 to 45 minutes) multimedia-based training session. Furthermore, 50% of caretakers had less than 2 years of work experience which may not be enough time to receive proper on-farm training, first-hand experience, confidence, or the opportunity or trust to act upon a multitude of scenarios including euthanizing compromised pigs. Work experience did not influence any training statements in this study, highlighting the challenges in how to reach caretakers of all ages and experience levels. Moreover, farm size, gender, and farm production type did not have a significant effect on responses to training statements suggesting other factors such as individual motivation to learn, ability to process and apply training material, or attitude towards participating in training programs may play a larger part in caretaker training. Results from our study suggest future training programs should be refined to account for entry-level caretakers with little to no experience and more senior experienced caretakers. The flexibility inherent when using computer-based training allows for training programs or individual modules to be updated or customized to facilitate and accommodate training based on varying caretaker background factors such as education level or linguistic skills. However, improving the degree of caretaker comfort in

Table 3: A univariable regression model analysis between improvements on scores and predictors of interest for each of the 7 survey statements

	Two-level variables*								
	Age			Work experience			Gender		
Statement	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***
1) I can determine when a pig needs to be euthanized	0.28	0.06-1.27	.099	0.38	0.11-1.36	.14	0.48	0.06-4.14	.51
2) I understand how to make good euthanasia decisions	0.29	0.06-1.33	.11	0.99	0.28-3.45	.98	0.53	0.06-4.67	.57
3) I can evaluate sick or injured pigs to decide if euthanasia is needed	0.3	0.07-1.19	.087	0.53	0.15-1.95	.34	1.18	0.22-6.33	.85
4) I am not aware of euthanasia guidelines in the Common Swine Industry Audit	0.74	0.29-1.88	.53	0.71	0.28-1.81	.48	2.8	0.77-10.2	.12
5) I know that pigs with certain conditions must be euthanized immediately	0.88	0.18-4.29	.87	0.35	0.06-2.11	.25	NA†	NA†	NA†
6) I am confident I can make good euthanasia decisions when needed	0.75	0.20-2.81	.67	0.64	0.18-2.28	.49	0.44	0.05-3.86	.46
7) I am aware of the importance of timely euthanasia	0.51	0.08-3.25	.48	0.51	0.09-3.28	.47	4.00	0.56-28.45	.17

	Three-level variables*							
	Farm size,				Production			
Statement	**No. of pigs**	**OR**	**95% CI**	***P***	**type**	**OR**	**95% CI**	***P***
1) I can determine when a pig needs to be euthanized	0-1500	1	-	-	Farrowing	1	-	-
	1501-3000	1.6	0.29-8.86	.59	Breeding	0.81	0.21-3.23	.77
	> 3000	1.74	0.30-10.1	.54	Wean-to-finish	0.78	0.17-3.51	.74
2) I understand how to make good euthanasia decisions	0-1500	1	-	-	Farrowing	1	-	-
	1501-3000	0.56	0.13-2.43	.44	Breeding	2.19	0.40-12.10	.37
	> 3000	0.42	0.08-2.15	.30	Wean-to-finish	1.40	0.25-7.80	.70
3) I can evaluate sick or injured pigs to decide if euthanasia is needed	0-1500	1	-	-	Farrowing	1	-	-
	1501-3000	0.56	0.13-2.43	.44	Breeding	1.71	0.44-6.68	.44
	> 3000	0.58	0.13-2.71	.49	Wean-to-finish	0.62	0.11-3.59	.59
4) I am not aware of euthanasia guidelines in the Common Swine Industry Audit	0-1500	1	-	-	Farrowing	1	-	-
	1501-3000	1.15	0.31-4.20	.83	Breeding	0.48	0.14-2.65	.25
	> 3000	1.7	0.40-7.23	.47	Wean-to-finish	1.52	0.46-5.05	.49
5) I know that pigs with certain conditions must be euthanized immediately	0-1500	1	-	-	Farrowing	1	-	-
	1501-3000	NA†	NA†	NA†	Breeding	2.78	0.46-16-65	.26
	> 3000	NA†	NA†	NA†	Wean-to-finish	0.77	0.06-10.15	.84
6) I am confident I can make good euthanasia decisions when needed	0-1500	1	-	-	Farrowing	1	-	-
	1501-3000	1.22	0.25-5.88	.81	Breeding	1.21	0.27-5.31	.80
	> 3000	0.83	0.15-4.63	.83	Wean-to-finish	0.74	0.15-3.54	.70
7) I am aware of the importance of timely euthanasia	0-1500	1	-	-	Farrowing	1		
	1501-3000	0.23	0.02-2.7	.24	Breeding	NA†	NA†	NA†
	> 3000	0.96	0.14-6.39	.97	Wean-to-finish	NA†	NA†	NA†

* Reference categories were age (< 30 years and ≥ 30 years); work experience (< 2 years and ≥ 2 years); gender (male and female); farm size (≤1500 pigs, 1501-3000 pigs, and > 3000 pigs); and production type (farrowing, breeding, and wean-to-finish).

† Model did not converge.

OR = odds ratio; NA = not applicable.

performing euthanasia by computer training programs may require multiple training sessions, more in-depth structured learning modules, or sessions taught in parallel with hands-on training to ensure a high skill level in swine caretakers. Additionally, trained and confident caretakers will be more comfortable conducting complex decision making, such as qualitative euthanasia decisions about pigs with certain conditions or performing timely euthanasia, ensuring a high animal welfare standard on US swine farms. With continuous advancements in computer technology and increased availability of mobile platforms in mind, the use of interactive training may still be a promising way to both standardize and improve on-farm education to ensure well-educated, confident, and capable caretakers.

Strengths and limitations

The main strength of this study is its diverse participant demographics, which represent a wide range of ages, experience levels, and perceived skill levels regarding timely euthanasia, often found in the swine industry. Furthermore, the study highlights the challenge in providing effective training for a vast population of caretakers with different backgrounds, work assignments, experience, and skill levels. The authors acknowledge that this was a limited study with a short survey and a limited number of participants over a short period of time, which limits the data analysis and interpretation of caretakers' perceived and true knowledge. We also recognize that, because the survey was taken shortly after the training session, no time was allowed for transferring any new knowledge into practice, which would help with skill improvement. For these reasons, the authors acknowledge the main limitation of this study is the lack of validation of individuals' true performance on specific modules during training. Therefore, analyses for this project were focused on caretakers' perceptions of their knowledge change regardless of their training performance. Since caretakers only performed one training session, a test of knowledge retention was not conducted. Thus, these results should be interpreted carefully and not extrapolated to the entire swine industry, but rather be considered a focused timestamp of swine caretaker attitudes for a small part of the eastern corner of the Midwest. Finally, the postulated hypotheses could not be confirmed by the results derived from the study. Overall, caretakers did not self-report an increased ability to detect compromised pigs, how to determine when to euthanize compromised pigs, or increased euthanasia skills post training. We suggest that the acknowledged limitations from this study should be incorporated into a more detailed expansion of the training software and training platform to investigate the long-term efficacy of the program.

Implications

Under the conditions of this study:

- Interactive modules may facilitate young or inexperienced caretaker training.
- Perceived knowledge should be accounted for in future training concepts.
- Caretaker demographics may dictate training stratification and success rate.

Acknowledgments

The authors would like to acknowledge the swine farm managers and caretakers who participated in the study. Funding was provided by the National Pork Checkoff.

Conflict of interest

None reported.

Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

References

1. Dickinson GE, Roof PD, Roof KW. A survey of veterinarians in the US: euthanasia and other end-of-life issues. *Anthrozoös*. 2011;24:167-174.

2. Hart LA, Mader B. Pretense and hidden feelings in the humane society environment: a source of stress. *Psychol Rep*. 1995;77:554.

3. Turner PV, Doonan G. Developing on-farm euthanasia plans. *Can Vet J*. 2010;51:1031-1034.

*4. Gemus-Benjamin M, Kramer S, Bratton A, Conklin T. A perspective of stockpersons and the humane euthanasia of swine. *MSU Pork Q*. 2015;20:1-6.

5. Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process*. 1991;50:179-211.

6. Hemsworth PH, Coleman GJ, Barnett JL. Improving the attitude and behaviour of stockpersons towards pigs and the consequences on the behaviour and reproductive performance of commercial pigs. *Appl Anim Beh Sci*. 1994;39:349-362.

7. Adams CL, Conlon PD. Professional and veterinary competencies: addressing human relations and the human-animal bond in veterinary medicine. *J Vet Med Educ*. 2004;31:66-71.

8. Campler MR, Pairis-Garcia MD, Rault J-L, Coleman G. Arruda AG. Caretaker attitudes towards swine euthanasia. *Trans Anim Sci*. 2018;2:254-262.

*9. Matthis JS. Selected employee attributes and perceptions regarding methods and animal welfare concerns associated with swine euthanasia [PhD dissertation]. Raleigh: North Carolina State University; 1994.

10. Reeve CL, Spitzmuller C, Rogelberg SG, Walker A, Schultz L, Clark O. Employee reactions and adjustment to euthanasia-related work: identifying turning-point events through retrospective narratives. *J Appl Anim Welf Sci*. 2004;7:1-25.

11. McGee M, Parsons RL, O'Connor AM, Johnson AK, Anthony R, Ramirez A, Millman ST. A preliminary examination of swine caretakers' perspectives for euthanasia technology and training. *J Anim Sci*. 2016;94(Suppl 5):32.

12. Mullins CR, Pairis-Garcia MD, Campler MR, Anthony R, Johnson AK, Coleman GJ, Rault J-L. The development of an interactive computer-based training program for timely and humane on-farm pig euthanasia. *J Vet Med Educ*. 2018;5:405-412.

13. Rault JL, Holyoake T, Coleman G. Stockperson attitudes toward pig euthanasia. *J Anim Sci*. 2017;96:949-957.

*14. National Pork Board. Common Swine Industry Audit. https://d3fns0a45gcg1a.cloudfront.net/sites/all/files/documents/CommonSwineIndustryAudit/2019-csia-instructions-standards-tool.pdf . Published January 2015. Updated January 2019. Accessed September 28, 2019.

15. Coleman GJ, Rea T, Hall M, Sawyer A, Hemsworth, PH. Multimedia training in the pig industry. *Comp Ed*. 2001;37:257-271.

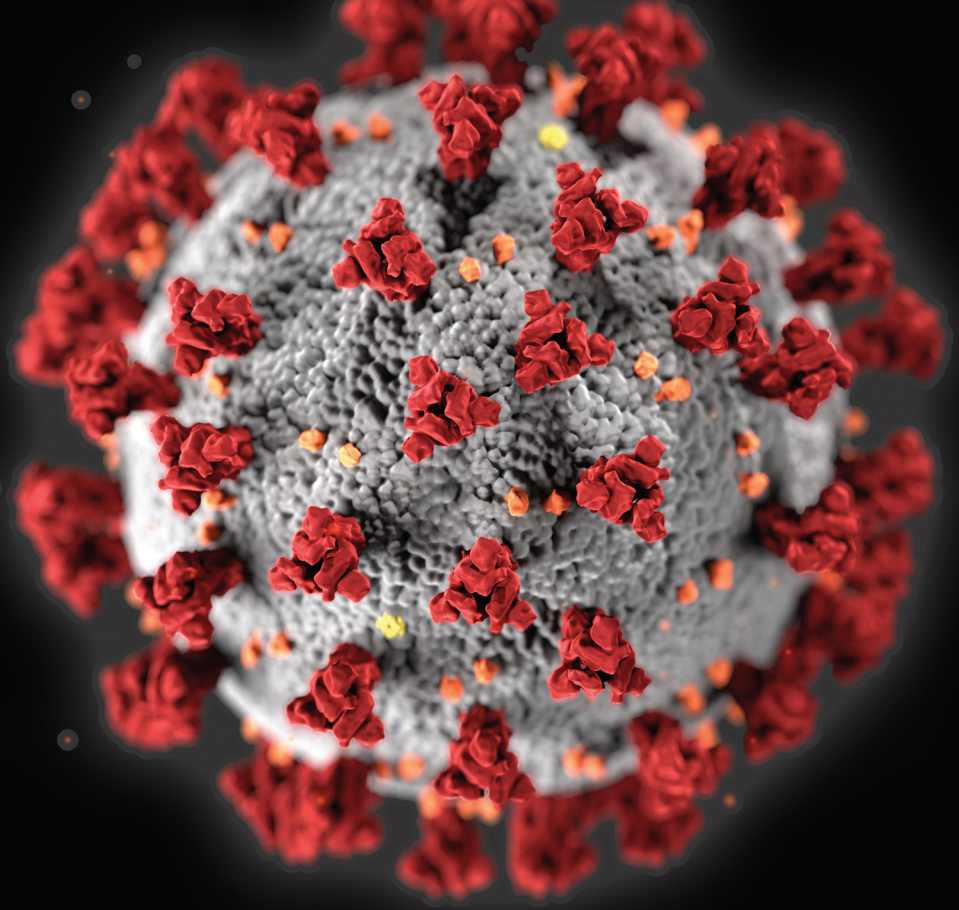
16. Klupiec C, Pope S, Taylor R, Carroll D, Ward MH, Celi P. Development and evaluation of online video teaching resources to enhance student knowledge of livestock handling. *Aust Vet J*. 2014;92:235-239.

17. Papastergiou M. Digital game-based learning in high school computer science education: impact on educational effectiveness and student motivation. *Comp Ed*. 2009;52:1-12.

18. Mehrabi A, Glückstein CH, Benner A, Hashemi B, Herfarth CH, Kallinowski F. A new way for surgical education – development and evaluation of a computer-based training module. *Comput Biol Med*. 2000;30:97-109.

19. Kalyuga S, Ayres P, Chandler P, Sweller J. The expertise reversal effect. *Educ Psychol*. 2003;38:23-31.

*Non-referred references.



COVID-19

AASV Resources for Swine Veterinarians

aasv.org/resources/publichealth/covid19

Swine veterinarians have an essential role in providing services that protect public health and swine health and welfare.

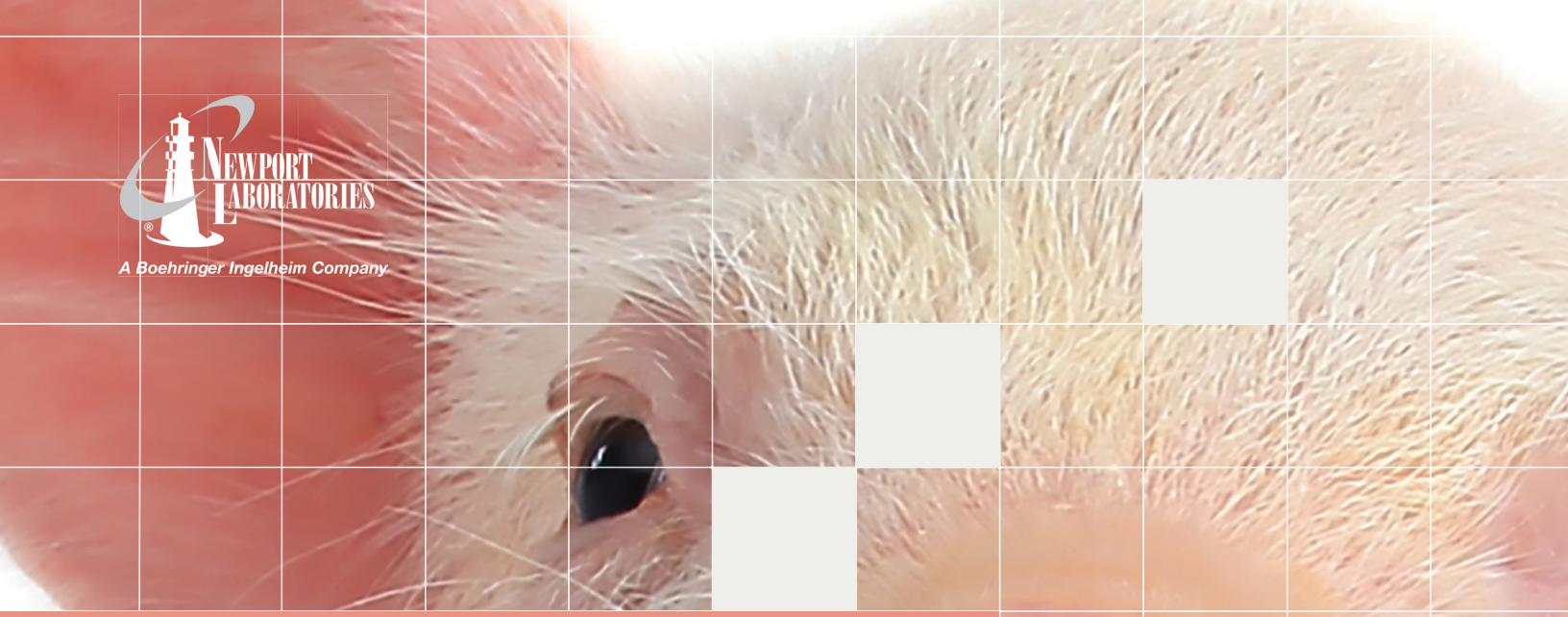
The COVID-19 pandemic is impacting our practices, communities, clients, and families. The AASV continues to ensure you have the information you need to stay healthy and continue meeting a critical need. Find resources for:

- Veterinary practice, business, legislation, and CE
- Producers
- Crisis planning and animal welfare
- Industry

The AASV is committed to providing members with resources to promote and enhance well-being – the state of being comfortable, healthy, and happy.

Visit AASV's Veterinarian Well-being webpage at **aasv.org/resources/wellbeing**

to find resources to assess and improve your own well-being and resources to help support colleagues, clients, friends, and family.



Newport Laboratories
A Boehringer Ingelheim Company

FILLING THE GAPS IN DISEASE PREVENTION

Commercial vaccines are a vital part of any swine health program, but sometimes disease prevention requires a different approach. Newport Laboratories, Inc., creates custom-made vaccines designed to help fight the specific pathogens challenging your herd, ensuring your veterinary toolbox is always complete.

Learn more about custom-made vaccines at **NewportLabs.com**.

PERFORM PARTNER PROTECT

Ingelvac PRRS®

FLEX

ENTERISOL® Ileitis

ENTERISOL® Salmonella T/C

Ingelvac MycoMAX™

Boehringer Ingelheim

National Pork Board names Kara Behlke as new Director of Nutrition and Dietetics

The National Pork Board recently announced Kara Behlke, of St Louis, Missouri, as director of nutrition and dietetics. Originally from Benkelman, Nebraska, Behlke holds a BS degree in dietetics from the University of Nebraska and completed her dietetic internship at Yale Medical Center. She is a member of the Academy of Nutrition and Dietetics and a previous member of the Retail Dietitian Business Alliance Advisory Board and CEOs Against Cancer.

Behlke comes to the Pork Board from Schnuck Markets, a 112-store supermarket chain operating in five Midwestern states, where she was the director of health and wellness strategy. In this role, she was responsible for creating an enterprise-wide health and well-being strategy in support of the company's mission for improving the quality of food in customers' baskets. She has held a variety of positions related to both brand marketing and nutrition in the retail food and commodity spaces, having worked for Schnucks, Hy-Vee, and the New York Beef Industry Council.

You can contact Kara Behlke at **kbehlke@pork.org**.

Industry gains keen insights for African swine fever preparation during COVID-19 pandemic

No one wants to go through tough times, but sometimes there is a silver lining. In the case of COVID-19, that upside is what the US pork industry learned over the past months that can be applicable and useful in preparing for a foreign animal disease (FAD) such as African swine fever (ASF).

"This event taught us pretty clearly that the US pork industry was not prepared for a large depopulation and disposal event," said Dr Dave Pyburn, chief veterinarian with the National Pork Board. "While the industry and government had plans on paper before COVID-19 temporarily shuttered many of our packing plants, it was the real-world need for immediate response that really gave us extremely valuable insights that we can use again if needed."

Specifically, Pyburn points to several key findings during COVID-19 that could help mitigate the negative effects of an FAD if it should strike.

- The National Veterinary Stockpile must have the right items and the quantity needed.
- Industry and government must have a clear plan and follow it from the start.
- State veterinarians should help lead and work with industry and the US Department of Agriculture as the situation develops over time, including locating resources.
- Farmers and veterinarians often have the best solutions because they are in the barns and fields.
- Allied-industry partners (eg, renderers) should be called upon to assist as needed for specific issues.
- Industry associations should continue to collaborate, communicate, and work for producer-focused solutions.

While COVID-19 provided its share of real-world lessons and pivots, some core industry tasks have gone relatively smoothly. These areas would remain a top priority should the industry face ASF or another critical issue.

For more information, contact Dr Dave Pyburn at **dpyburn@pork.org**.

NPB news continued on page 269

uniferon®200

Why A Higher Standard Is Worth Its Weight

Uniferon® is the only injectable iron supplement brand that meets both veterinary and human drug standards.[1] With demonstrated efficacy in preventing anemia and improving baby pig health, it ensures optimum average daily weight gain throughout the lactation period.[2] A second dose has demonstrated an additional weight-gain advantage throughout the feed-to-finish period.[3,4] Results like that carry the most weight of all.

Visit Uniferon.com to learn more.

[1] Radke, S.L., Olsen, C.W., Ensley, S.M., (2018) Elemental impurities in injectable iron products for swine. *The Journal of Swine Health and Production*, 26(3).

[2] Gaddy H et al. A review of recent supplemental iron industry practices and current usage of Uniferon® (iron dextran complex injection, 200 mg/mL) in baby pigs. *AASV*. 2012; 167–171.

[3] Haugegaard J et al. Effect of supplementing fast-growing, late-weaned piglets twice with 200 mg iron dextran intramuscularly. *The Pig Journal*. 2008. 61; 69–73.

[4] Olsen C and Fredericks L. Impact of iron dose and hemoglobin concentration on wean-finish weight gain. *IPVS*. 2018; 910.

PHARMACOSMOS

 PM-048-00

NPB news continued from page 267

AgView platform development continues

The Pork Checkoff continues to build out capabilities for AgView, its online animal health database and dashboard platform designed to help producers, veterinarians, and state and federal animal health officials communicate and make real-time decisions.

"We're excited to be drawing close to the launch of this user-friendly and valuable tool for sharing important animal health information to key collaborators," said Dr Patrick Webb, director of swine health at the National Pork Board. "We have spent much of 2020 testing the software and look forward to showing the world in November."

For more information, contact Dr Patrick Webb at **pwebb@pork.org**.

Pig farmers live out We Care during COVID-19

The National Pork Board started tracking how pig farmers were supporting their communities through COVID-19. As of late June, nearly 14.4 million pounds of pork had been donated across the country. These servings along with numerous donations of personal protective equipment to front-line workers and funds to local charities added up quickly.

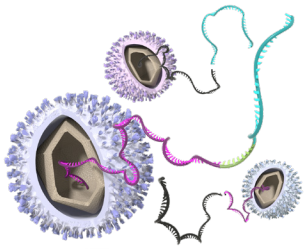
"Because these generous contributions are done behind the scenes, when no one is watching, I wanted to take a moment to highlight a few examples," said Dr Brett Kaysen, vice president of sustainability at the National Pork Board. He encourages everyone to visit **porkcares.org** to read more about these donations or to share more stories about how pig farmers are living out their We Care commitment.

Pharmgate
ANIMAL HEALTH

TAKE THE NEXT STEP IN PRRS PROTECTION

PRRSGard® is an innovative approach to modified-live vaccine construction.

- Chimeric structure combines a virulent "wild-type" strain (ORF3-7 MN1-8-4) with a non-virulent, attenuated lineage 1 strain
- Demonstrated efficacy against lung lesions and performance loss from pneumonia associated with the PRRS virus in growing pigs
- Unique genetic marker for use in diagnostic assays
- 1 mL dose



Take the next step to protect your pigs from the ever-changing PRRS challenge. Visit PRRSGard.com

AASV student abstracts due September 16

The American Association of Swine Veterinarians announces an opportunity for veterinary students to make a scientific presentation at the AASV Annual Meeting in San Francisco, California, on Sunday, February 28, 2021. Interested students are invited to submit a one-page abstract of a research paper, clinical case study, or literature review for consideration. The submitting student must be a current (2020-2021) student member of the AASV at the time of submission and must not have graduated from veterinary school prior to February 28, 2021. Submissions are limited to one (1) abstract per student.

Abstract submission

Abstracts and supporting information must be submitted online at **aasv2021.exordo.com**. Submissions must be completed before **11:59 PM Central Daylight Time on Wednesday, September 16, 2020** (firm deadline). Late submissions will not be considered.

Students will receive an email from Ex Ordo confirming receipt of their submission. If they do not receive this confirmation email, they must contact Dr Andrew Bowman (**bowman.214@osu.edu**) by Friday, September 18, 2020 with supporting evidence that the submission was made in time; otherwise the abstract will not be considered for judging.

The abstracts will be reviewed by an unbiased, professional panel consisting of private practitioners, academicians, and industry veterinarians. Fifteen abstracts will be selected for oral presentation in the Student Seminar at the AASV Annual Meeting. Students will be notified by October 15, 2020, and those selected to participate will be expected to provide the complete paper or abstract, reformatted for publication, by November 12.

Student Seminar and Scholarships

As sponsor of the Student Seminar, **Zoetis** provides a total of $26,250 in support to fund travel stipends and the top student presenter scholarship. The student presenter of each paper selected for oral presentation receives a $750 stipend to help defray the costs of attending the AASV meeting. Veterinary students whose papers are selected for oral presentation also compete for one of several scholarships awarded through the AASV Foundation. The oral presentations will be judged to determine the amount of the scholarship awarded. Zoetis funds a $5000 scholarship for the student whose paper, oral presentation, and supporting information are judged best overall. **Elanco Animal Health** provides $20,000 in additional funding enabling the AASV Foundation to award scholarships of $2500 each for 2nd through 5th place, $1500 each for 6th through 10th place, and $500 each for 11th through 15th place.

Student Poster Session

Abstracts that are not selected for oral presentation in the Student Seminar will be considered for presentation in a poster session at the annual meeting. **Zoetis**, sponsor of the Student Poster Session, provides a $250 stipend for each student poster presenter who attends the meeting to participate in the session. Those selected for poster presentation will be expected to supply a brief paper, formatted for publication in the conference proceedings, by November 12. The guidelines for preparing posters for the display are available at **aasv.org/annmtg/2021/posters.php**.

Veterinary Student Poster Competition

The presenters of the top fifteen poster abstracts compete for scholarship awards ranging from $200 to $500 in the Veterinary Student Poster Competition, sponsored by **United Animal Health**. See **aasv.org/annmtg/2021/postercomp.htm** for poster judging details.

Complete information for preparing and submitting abstracts is available on the AASV website at **aasv.org/annmtg/2021/studentseminar.htm**. The rules for submission should be followed carefully. For more information, contact the AASV office by phone, 515-465-5255, or email, **aasv@aasv.org**.

The AASV is moving forward with plans for the 2021 AASV Annual Meeting with the understanding that guidelines associated with COVID-19 may necessitate changes yet to be determined. Please check **aasv.org/annmtg** regularly for updated information and revisions.

AASV news continued on page 273

Introducing

EASE™

Enhanced Antigen Surface Expression

by Phibro Animal Health

A new and improved bacterial growth procedure for Autogenous Vacccines

Phibro is implementing the use of EASE technology to grow bacteria such as *Salmonella spp.*, *E. coli* and other Gram-negative organisms for production of autogenous vaccines.

- EASE results in an upregulation of proteins on the bacterial surface in its natural form.
- EASE ensures a higher ratio of immunogenic proteins to other superficial proteins leading to a more focused immune response from the host animal.
- EASE implementation leads to a more defined vaccine product.

*Potency and efficacy of autogenous biologics have not been established.
Phibro Autogenous Vaccines are developed with MVP Adjuvants®

Phibro ANIMAL HEALTH CORPORATION™

AASV news continued from page 271

Call for abstracts – Industrial Partners sessions

The American Association of Swine Veterinarians invites submissions for the Industrial Partners oral and poster sessions at the 52nd AASV Annual Meeting. This is an opportunity for commercial companies to make brief presentations of a technical, educational nature to members of the AASV. The conference will be held February 27 - March 2, 2021 in San Francisco, California.

The oral sessions consist of a series of 15-minute presentations scheduled from 1:00 to 5:00 PM on Sunday afternoon, February 28th. A poster session takes place the same day. Poster authors will be required to be stationed with their poster from noon until 1:00 PM, and the posters will remain on display throughout the afternoon and the following day for viewing.

SUBMISSION PREREQUISITE: All companies submitting topics for presentation during the Industrial Partners sessions must register to participate in the AASV Technical Tables Exhibit before October 1st.

Restricted program space necessitates a limit on the number of presentations per company. Companies that are a member of the *Journal of Swine Health and Production* (JSHAP) Industry Support Council **and** sponsor the AASV e-Letter may submit three topics for oral presentation. Companies that are **either** a member of the JSHAP Industry Support Council **or** sponsor the AASV e-Letter may submit up to two topics. All other companies may submit one topic for oral presentation. In addition, every company may submit one topic for poster presentation, but the topic must not duplicate the oral presentation. All topics must represent information not previously presented at the AASV annual meeting or published in the meeting proceedings.

To participate, send the following information to **aasv@aasv.org** by October 1, 2020:

1. Company name
2. Presentation title
3. Brief description of the presentation content
4. Presenter name and contact details (mailing address, telephone number, and email address)
5. Whether the submission is intended for oral or poster presentation

Receipt of submissions will be confirmed by email. Presenters will be notified of their acceptance by October 15 and must submit a paper by November 12 for publication in the meeting proceedings. Failure to submit the paper in a timely manner will jeopardize the company's future participation in these sessions.

All presenters are required to register for the meeting, either as a Tech Table representative, or as an individual registrant (nonmember oral and poster presenters are eligible to register at the AASV regular member rate). AASV does not provide a speaking stipend or travel reimbursement to Industrial Partners presenters.

What's YOUR tip?

The dictionary defines a "tip" as a small but useful piece of practical advice. Synonyms include a hint, suggestion, pointer, clue, guideline, recommendation, word of warning, or counsel. Members of AASV have been offering useful pieces of practical advice to fellow members for many years as part of the AASV Annual Meeting. Now it is your turn! What suggestion, pointer, clue, or word of warning can you share?

Please sign up to share a piece of advice, guideline, or recommendation at the 2021 AASV Annual Meeting in San Francisco! Presentations are only 10 minutes in length and no abstract is required! Prizes will be awarded to the top presenters. Contact Melissa Billing (**melissa.billing@boehringer-ingelheim.com**) or the AASV office (**aasv@aasv.org**) to sign up or suggest a colleague or topic.

The AASV is moving forward with plans for the 2021 AASV Annual Meeting with the understanding that guidelines associated with COVID-19 may necessitate changes yet to be determined. Please check **aasv.org/annmtg** regularly for updated information and revisions.

AASV promotes well-being, offers HEARD VET – a swine vet virtual social support group

AASV continues to offer resources to promote and enhance member well-being at **aasv.org/resources/wellbeing/**. During May 2020, AASV began offering HEARD VET, a confidential, virtual swine veterinarian peer social support group for AASV members to share or listen to experiences unique to swine veterinarians. The virtual support group sessions provide a venue for AASV members to connect with peers to discuss events associated with the COVID-19 pandemic or other emergency responses. Trained swine veterinarian peer mentors join University of Tennessee College of Veterinary Medicine's Dr Elizabeth Strand, a licensed clinical social worker, resiliency coach, and founding director of Veterinary Social Work, to moderate discussion.

Missed the 2020 AASV Annual Meeting? Catch up with an AASV Podcast or Video

Podcasts

During the AASV Annual Meetings, veterinary students research a presenter's topic, prepare questions, and interview conference speakers to gain additional information about their presentation topics. Each 5- to 15-minute audio interview is produced as an MP3 podcast. More than 300 AASV podcasts are available at no cost to AASV members on the website at **aasv.org/podcast/**. Did you miss this year's meeting? Do you wish you could listen to a talk from a past meeting? Hear from conference speakers from 2007-2020.

Also available to AASV members as MP3 podcasts are recordings from The Swine Medicine Talks. This swine medicine seminar series is hosted by the AASV student chapter and the Swine Medicine Education Center at Iowa State University and funded by the AASV Student Recruitment Committee. Find the free podcasts on the AASV website at **aasv.org/members/only/video/smecast/**.

Videos

Many resources, including videos, are available to AASV members in the Resources Library at **aasv.org/members/only/video/**.

- Annual Meeting Videos – AASV members can view keynote addresses, special 50th anniversary videos, and other selected presentations from 2005-2020 annual meetings.
- Webinars – Members have exclusive access to AASV webinar recordings. Recent topics include the management of tracheitis and viral myelitis, co-hosted by the Swine Health Information Center, and depopulation methods for swine.
- The Swine Medicine Talks – Free video recordings from the 2015-2019 Swine Medicine Talks seminar series are available to AASV members.
- Heritage Videos – To preserve some of the personal histories and capture the human element of swine veterinary medicine, distinguished AASV members recollect their experiences in the Heritage video series. Listen to the life stories of 23 distinguished AASV members.

Nominate exceptional colleagues for AASV awards

Thank you! Well done! We often take many things for granted. It is time to step up to the plate and thank an AASV member who has done so much for our AASV association and the swine industry. Please take the time to nominate deserving members. Now is the time! The AASV Awards Committee would like your help in identifying members who are well deserving of this public recognition. We would love to hear from you if you have nominations for the following five awards to be presented at the AASV Annual Meeting in San Francisco.

Howard Dunne Memorial Award – Given annually to an AASV member who has made a significant contribution and rendered outstanding service to the AASV and the swine industry.

Meritorious Service Award – Given annually to an individual who has consistently given time and effort to the association in the area of service to the AASV members, AASV officers, and the AASV staff.

Swine Practitioner of the Year – Given annually to the swine practitioner (AASV member) who has demonstrated an unusual degree of proficiency in the delivery of veterinary service to his or her clients.

Technical Services/Allied Industry Veterinarian of the Year – Given annually to the technical services or allied industry veterinarian who has demonstrated an unusual degree of proficiency and effectiveness in the delivery of veterinary service to his or her company and its clients as well as given tirelessly in service to the AASV and the swine industry.

Young Swine Veterinarian of the Year – Given annually to a swine veterinarian who is an AASV member, 5 years or less post-graduation, who has demonstrated the ideals of exemplary service and proficiency early in his or her career. DVM/VMD graduates of 2015 through 2019 will be considered for the 2021 award.

Nominations are due December 15th. The nomination letter should specify the award and cite the qualifications of the candidate for the award. Submit to: AASV, 830 26th Street, Perry, Iowa 50220, email: **aasv@aasv.org**.

AASV Annual Meeting

NAVIGATING THE FUTURE

...Together

February 27 - March 2, 2021
San Francisco, California
MARRIOTT MARQUIS

The AASV is moving forward with plans for the 2021 AASV Annual Meeting. Guidelines associated with COVID-19 may necessitate changes yet to be determined. Please check aasv.org/annmtg frequently for updated information and revisions.

Innovate. Investigate. Invigorate.

The numbers are in your favor with PROMOTE®. You can count on PROMOTE for research-based feed additive solutions. Supported by the vast global network of research from Cargill Animal Nutrition; PROMOTE offers non-medicated products that help you meet your goals – and satisfy our growing world's demand for more protein.

600
RESEARCHERS

16
GLOBAL LABS

5 INNOVATION CENTERS

FEEDPROMOTE.COM | 866-202-9889

AOX™ | CINERGY | DEFUSION® | ENZAE® | FORAGE-MATE® | TRASIC® | VALIDO®

provimi Cargill

FOUNDATION NEWS

Swine externship opportunities and $500 grants available

Veterinary students, are you planning a swine-based externship experience? The AASV Foundation provides grants of up to $500 to students who complete an externship of at least two (2) weeks in a swine practice or a mixed practice with a considerable swine component. Any AASV student member in veterinary school who fulfills the requirements is eligible to apply. More information can be found at: **aasv.org/students/externgrant.htm**.

A database of swine-oriented internship and externship opportunities is available to student members at **aasv.org/internships/index.php**. Members of AASV who would like their internship and externship opportunities included in this directory are encouraged to contact Amanda Anderson, AASV alternate student delegate (**aasvstudentdelegate@gmail.com**), for more information.

Foundation seeks to support members pursuing ACAW board certification

Have you considered pursuing board certification in the American College of Animal Welfare? If so, you may qualify for financial support from the AASV Foundation.

Recognizing the need for swine veterinarians to be leaders in the field of animal welfare, the AASV Foundation continues to accept applications from AASV members seeking board certification in the American College of Animal Welfare (ACAW). Applicants must have a DVM or VMD degree and at least 5 years of continuous membership in the AASV.

To apply, the applicant must submit a curriculum vitae, an ACAW-approved program plan, and three (3) letters of reference (one of which must come from the applicant's mentor). There is no submission due date, but there is a limit to the amount of funding available each year. A selection committee reviews applications as they are received.

The scholarship will provide annual reimbursements for actual expenses related to the ACAW program, including travel, course fees, and textbooks, with a maximum reimbursement amount of $20,000. Reimbursement will not cover lost income. An incentive payment of $10,000 will be issued upon successful and timely completion of the ACAW Board Certification.

For more information, contact the AASV office by phone, 515-465-5255, or email, **aasv@aasv.org**.

Be Certain.

COMING SOON!

Larger wipes for larger surfaces.

Intervention™ Disinfectants kills the virus that causes COVID-19 in just 1 MINUTE.[1]

Be certain about the disinfectant you are using. During a time when disinfection has never been so critical, we have added a new size to our line-up to help you disinfect larger surfaces with ease & convenience. Get the peace of mind you deserve by creating a safe environment for your animals and the people you work with. Now that's something to be certain about.

InterventionDisinfectants.com

Powered by AHP®
ACCELERATED® HYDROGEN PEROXIDE
Patented

Proceed With Certainty.

[1] Intervention is approved under the EPA Emerging Pathogen Rule, refer to EPA List N: Disinfectants for use against SARS-CoV-2.

As the world turns

My perception of time passage has become very distorted during the coronavirus disease 2019 (COVID-19) pandemic as the days, weeks, and months have blended and blurred. Science would suggest that I am not alone in experiencing this phenomenon, as the novelty and emotional context of an experience can alter how we perceive the passage of time.[1] The phenomenon has resulted in clever memes proclaiming "For those who have lost track, today is Blursday the fortyteenth of Maprilay."

If you can remember life pre-COVID-19, the swine industry was intensely focused on prevention, preparation, and response efforts to the introduction of a foreign animal disease (FAD). The swine industry had collaborated closely with state and federal governments in FAD prevention and response preparation through several initiatives such as the Secure Pork Supply plan. Believe it or not, we are rapidly approaching 1 year from when the swine industry, along with federal, state, and local agencies, had the opportunity to exercise their response to an African swine fever outbreak during the Swine Fever Exercise for Agriculture Response (SFEAR).

It became evident throughout the course of the exercise which critical preparedness and response activities required additional resources to achieve the 3 primary goals of any FAD response: 1) detect, control, and contain the FAD as quickly as possible, 2) eradicate the FAD using strategies to stabilize animal agriculture, and 3) provide science- and risk-based approaches to facilitate continuity of business.[2] Two specific concerns identified during the SFEAR were:

- A limited proficiency of FAD diagnosticians (FADDs) when performing on-farm investigations.
- The number of diagnostic samples required to confirm the health status of premises within a given zone became a significant bottleneck.

With funding from the US Department of Agriculture's National Animal Disease Preparedness and Response Program, the American Association of Swine Veterinarians is collaborating with the Center for Food Security and Public Health and Swine Medicine Education Center at Iowa State University and the National Pork Board to develop training materials to address these 2 concerns.

An on-farm immersion course will be developed to provide hands-on training for FADDs and other animal agriculture sector responders to address the first concern. While the FADDs have been trained across all species, they may not have had the opportunity to gain hands-on experience with current swine medicine practices or modern pig production facilities. A better understanding of pig production, the movement of animals, biosecurity measures followed onsite, and increased proficiency at performing necropsies and sample collection will increase an FADD's ability and efficiency during an FAD investigation.

To address the second concern, a diagnostic sample collection training program will be developed to assure state and federal animal health officials that producers, caretakers, or other pig industry personnel have been trained by category II accredited veterinarians to correctly collect, handle, and submit samples. During an FAD outbreak, not only do sample collection requirements increase, but biosecurity and downtime requirements also increase. This training program will allow the production field staff, producers, barn managers, and others that many swine-focused veterinarians already rely on for diagnostic sample collection to become a great asset during an FAD response.

The collaborating team began working on these two training programs in January with priority given to the sample collection training and continue to make progress on the project objectives. Outreach to AASV members, category II accredited veterinarians, veterinary students, state and federal animal health officials, FADDs, and other animal agricultural sector responders to raise awareness of and participation in these two programs will begin in 2021.

Whether your world appears to be spinning faster or slower due to COVID-19, focus on key industry priorities remains and work to improve FAD prevention, preparedness, and response measures continues.

References

*1. Schnalzer R. Is time flying by oddly quickly during COVID-19? Here's why you may feel that way. *Los Angeles Times*. May 1, 2020. Accessed July 23, 2020. **https://www.latimes.com/lifestyle/story/2020-05-01/does-it-feel-like-like-time-is-flying-by-during-coronavirus-quarantine-heres-why**.

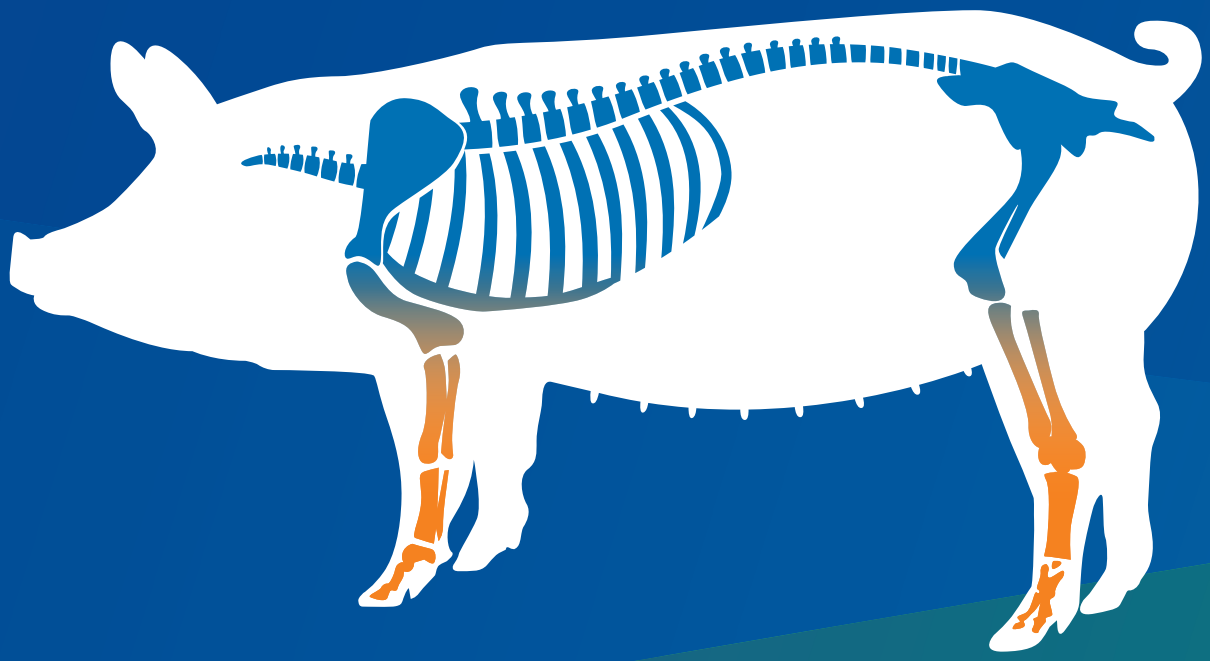
*2. Animal and Plant Health Inspection Service, US Department of Agriculture. Foreign Animal Disease Preparedness and Response Plan. APHIS Foreign Animal Disease Framework Response Strategies. FAD PReP Manual 2-0. **https://www.aphis.usda.gov/animal_health/emergency_management/downloads/documents_manuals/fadprep_manual_2.pdf**. Published October 2015. Accessed October 22, 2019.

* Non-refereed references.

Sherrie Webb, MSc
Director of Swine Welfare

Hy•D®

STAND STRONG
FOR A LIFETIME OF PRODUCTIVITY



Is your sow herd's vitamin D status high enough to ensure strong skeletal development, bone health and mobility? Hy•D®, a pure and proprietary vitamin D metabolite called 25-OH D3, works better than supplementing with vitamin D alone. Its unique mode of action eliminates the need for the conversion of D3 in the liver, allowing 25-OH D3 to be absorbed more quickly and consistently. Help your sows Stand Strong with Hy•D, your vitamin D solution for improving lifetime productivity.

See your DSM representative or visit dsm.com/hyd-swine

- Reduced bone lesions
- Improved gilt selection rates
- Reduced farrowing difficulties due to mobility issues
- Heavier birth and weaning weights

NUTRITION • HEALTH • SUSTAINABLE LIVING

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

SWINE DISEASE MANUAL

5TH EDITION

EJ Neumann, A Ramirez, KJ Schwartz

Fully revised!

An informative reference for students, instructors, practitioners, technicians, producers, and anyone working in the swine industry

Provides a concise overview of bacterial, viral, parasitic, nutritional, and other diseases and syndromes affecting swine

Information for each etiologic agent includes alternate names, definition, occurrence, history, etiology, epidemiology, pathogenesis, clinical signs, lesions, diagnosis, and control

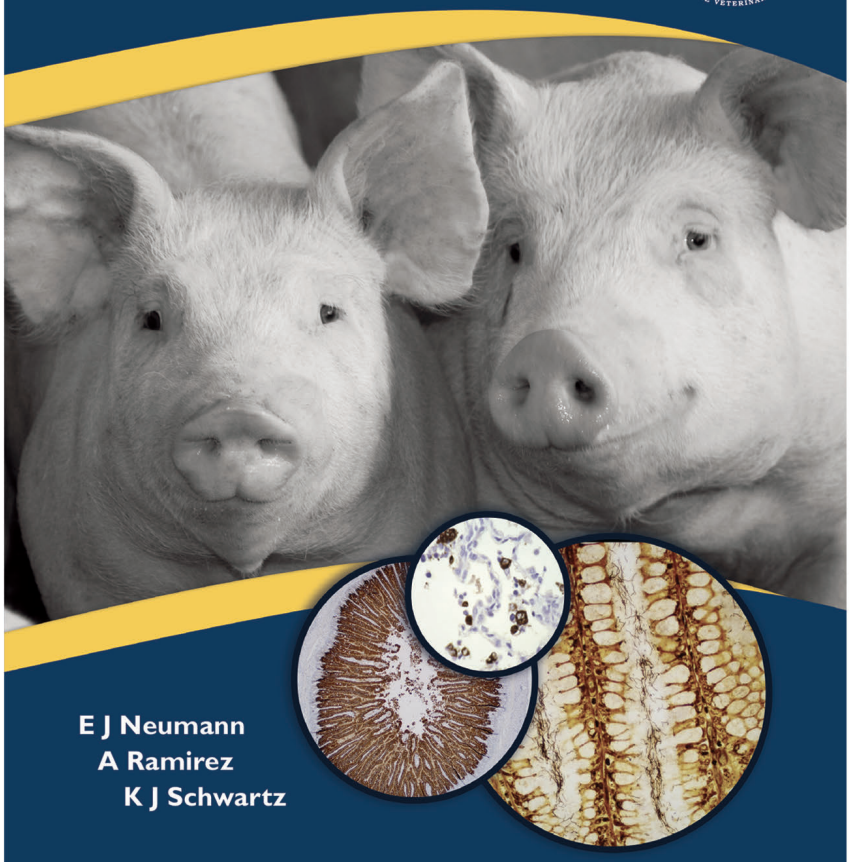
Includes a section on swine industry terminology and a handy chart of common abbreviations

Updated information on African swine fever, Senecavirus A, swine enteric coronavirus diseases, and more

191 pages of text; indexed

$30 plus shipping/handling

Order online:
ecom.aasv.org/sdm



Published by the
American Association of Swine Veterinarians

THE IMPACT OF RESPIRATORY COINFECTIONS could be greater than you think

Boehringer Ingelheim

Respiratory coinfections are a combination of infectious agents and environmental stressors and challenges that affect the health of the pig, reducing performance, increasing medication costs and mortality, and ultimately resulting in significant economic losses.[1]

RESPIRATORY COINFECTIONS MAY BE AFFECTING THE HEALTH OF YOUR HERD—AND YOUR BUSINESS. **SOLUTIONS FROM BOEHRINGER INGELHEIM CAN HELP.**

Ingelvac Provenza®

Ingelvac PRRS®

FLEX®

Newport Laboratories
A Boehringer Ingelheim Company

Reference: 1. Porcine respiratory disease complex. The Pig Site. https://thepigsite.com/articles/porcine-respiratory-disease-complex. Accessed January 30, 2020.

PARTNER. PROTECT. PERFORM.

Upcoming meetings

Allen D. Leman Swine Conference - VIRTUAL

September 19 - 22, 2020 (Sat-Tue)
Hosted by the University of Minnesota
The conference will be conducted online.

For more information:
Email: vetmedccaps@umn.edu
Web: ccaps.umn.edu/allen-d-leman-swine-conference

Emerging Animal Infectious Disease Conference - NEW DATE

October 5 - 7, 2020 (Mon-Wed)
State College, Pennsylvania

For more information:
Tel: 814-865-8301
Email: skuchipudi@psu.edu
Web: vbs.psu.edu/adl

United States Animal Health Association 124th Annual Meeting - VIRTUAL

October 15 - 21, 2020 (Thu-Wed)
The conference will be conducted online.

For more information:
Web: usaha.org/meetings

26th International Pig Veterinary Society Congress - CANCELLED

November 3 - 6, 2020 (Tue-Fri)
Rio de Janeiro, Brazil

Unfortunately, due to the Covid-19 pandemic, the congress in Brazil has been cancelled.

For more information:
Tel: +55 31 3360 3663
Email: ipvs2020@ipvs2020.com
Web: ipvs2020.com

ISU James D. McKean Swine Disease Conference

November 5 - 6, 2020 (Thu-Fri)
Scheman Building
Iowa State University
Ames, Iowa

For registration information:
Registration Services
Iowa State University
1601 Golden Aspen Drive #110
Ames, Iowa 50010
Tel: 515-294-6222
Email: registrations@iastate.edu

For questions about program content:
Dr Chris Rademacher
Conference Chair
Iowa State University
Email: cjrdvm@iastate.edu

American Association of Swine Veterinarians 52nd Annual Meeting

February 27 - March 2, 2021 (Sat-Tue)
San Francisco Marriott Marquis
San Francisco, California

For more information:
American Association of Swine Veterinarians
830 26th Street
Perry, IA 50220
Tel: 515-465-5255
Email: aasv@aasv.org
Web: aasv.org/annmtg

International Conference on Pig Survivability - POSTPONED UNTIL 2021

October 27 - 28, 2021 (Wed-Thu)
Hosted by: Iowa State University, Kansas State University, and Purdue University
Omaha, Nebraska

Conference contact:
Dr Joel DeRouchey
Email: jderouch@ksu.edu
Web: piglivability.org/conference

For additional information on upcoming meetings: aasv.org/meetings

AASV Industry Support Council

The *Journal of Swine Health and Production* is made possible by the generous support of these Industry Support Council members.

Elanco

Boehringer Ingelheim

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

MERCK Animal Health

Newport Laboratories

PHARMACOSMOS
Committed to Quality

Pharmgate
ANIMAL HEALTH

Phibro
ANIMAL HEALTH CORPORATION TM

provimi

UNITED
ANIMAL HEALTH

TechMix

VIROX
ANIMAL HEALTH

zoetis TM

Photo Corner

Photo courtesy of Barbara Molnar-Smith.