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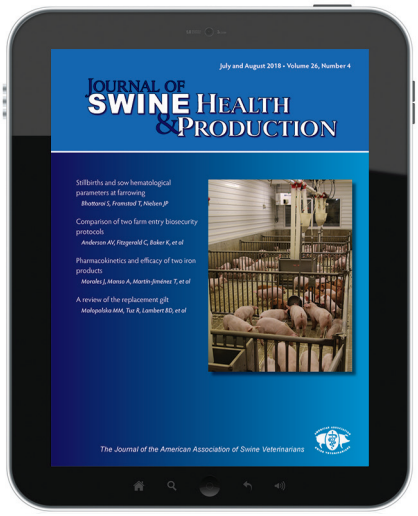

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Nursery pigs at University of Missouri Swine Teaching Center

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quoted from the Executive Director's message, page 189

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Are you taking care of yourself?

There's been a lot of talk lately about mental health awareness in our profession. I've heard a range of advice from "just tough it out" to more enlightened views. Nonetheless, this is not a new issue or one unique to our circumstances. Holmes and Rahe[1] hypothesized that stressful life events were correlated with risk of illness. They concluded that a strong positive correlation did indeed exist, which was confirmed again in a later study.[2]

What are the most stressful life events and how are they used to predict risk of illness? Stressful life events are assigned a life change score. For adults, the top ten most stressful life events and their Life Change Unit scores are as follows:

1. Death of a spouse: 100
2. Divorce: 73
3. Marital separation: 65
4. Imprisonment: 63
5. Death of a close family member: 63
6. Personal injury or illness: 53
7. Marriage: 50
8. Dismissal from work: 47
9. Marital reconciliation: 45
10. Retirement: 45

Stress can also occur due to an accumulation of several lesser events. Additional stressful life events and their Life Change Unit scores include:

- Change in health of a family member: 44
- Pregnancy: 40
- Sexual difficulties: 39
- Gaining a new family member: 39
- Business readjustment: 39
- Change in financial state: 38
- Death of a close friend: 37
- Change to a different line of work: 36
- Change in number of arguments with spouse: 35
- Having a mortgage over $150,000: 31
- Foreclosure on a mortgage or loan: 30
- Change in responsibilities at work: 29
- Son or daughter leaving home: 29
- Trouble with in-laws: 29
- Outstanding personal achievement: 28
- Spouse begins or stops work: 26
- Begin or end school: 26
- Change in living conditions: 25
- Revisions of personal habits: 24
- Trouble with a boss: 23
- Change in work hours or conditions: 20
- Change in residence: 20
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- Having a mortgage or loan less than $150,000: 17
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- Change in number of family get-togethers: 15
- Change in eating habits: 15
- Vacation: 13
- Major holidays: 12
- Minor violation of the law: 11

To calculate one's stress level, add each number for an event that has happened in the past year or is expected to occur in the future. If the event has happened more than once, add those additional instances to the total. According to the scale, there is an 80% likelihood of illness for scores over 300, a 50% likelihood of illness for scores between 150 and 299, and a 30% likelihood of illness for scores less than 150.

"Take stock of yourself now, assess your level of personal and social resources, and use the tools listed here to help cope."

So how do stressful life events create illness? Richard S. Lazarus created the modern definition of stress, which are the feelings we have when "demands exceed the personal and social resources the individual is able to mobilize." Stress is more than just our thoughts. It is a physical response to a perceived threat. In theory, once the stress is removed, our bodies return to a neutral state. Negative effects of chronic stress include:

- **Inability to unwind:** People experiencing chronic stress may feel jumpy and unable to settle down. They may feel like they always need to be doing something, or they may feel always behind in their daily tasks.
- **Changes in mood:** Chronic stress's major signalment may be the snappy irritability that often accompanies it. Previously patient people may find themselves snapping at those around them. Or they may find themselves overreacting to a situation. People with chronic stress may experience wild mood swings, elated one minute and furious the next.
- **Various physical changes:** Physical changes wrought by chronic stress are unique to everyone. They can include weight gain or loss, fatigue, dizziness, nausea, excitability or hyperactivity, heart palpitations, and nervousness. These symptoms can vary widely and are typically constant, not acute or episodic.

President's message continued on page 187

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President's message continued from page 185

- **Feelings lasting well past the stressful life event:** While a stressful life event may be challenging to process and let go of, stress becomes chronic when months or years later, it seems as if the stressful event happened yesterday. It is common to have the features of chronic stress as the stressful event is happening, but these features should not last well past the event.

While this seems intuitive, how can we deal with stressful situations to make them more bearable?

1. Acknowledge the stress. Start dealing with stress by acknowledging you are currently experiencing it. This may seem oversimplified, but it is an important first step. Especially for those of us who are used to coping with stress every day, it can be difficult to admit when stress has become overwhelming. Because stress levels can predict future illness, it is important to identify where you are on the scale so that you can move forward.

2. Don't do anything. While this advice may seem counter-intuitive, sometimes the best thing to do is nothing. Mindful meditation is gaining widespread popularity as a complementary stress treatment, and with good reason. Meditation reduces the perceived severity of stress. It also helps with depression and anxiety. Sometimes doing nothing, especially at the beginning, is the best way to understand and handle the top stressors.

3. Practice self-care. The most stressful life events can consume our lives and daily routines until there is no time for anything else. Once we do get time, we may tend to collapse on the couch in front of the TV and call it "relaxation." A better way to spend that time would be in self-care. Self-care can be indulging in a favorite hobby like gardening or painting. Regularly taking time out to do something you love can go a long way towards overall stress reduction.

4. Get support. Chronic stress can be a lonely, isolating condition. Too often even our loved ones don't truly understand what we are going through. Support groups for various life stressors (eg, divorce, family illness, etc) or individuals can make dealing with stressful life events easier. They can also provide some resources or local connections in the community. It may feel natural to withdraw when you are under stress but reaching out can actually help you cope with it better.

5. Clear the clutter. When stressors in life take over, our personal spaces may get cluttered and disorganized. Taking a few moments at the end of each day to put things away can help you wake up with a clear space and a calm mind.

6. Exercise. We have said it so often that it may begin to sound routine, but it is true. One of the best ways to manage the most stressful life events is with exercise. Level of intensity and duration do not matter. Just ten minutes of daily physical activity can be enough to reset your mental and emotional state. For those living with chronic stress, regular exercise is a crucial part of treatment. It keeps joints and muscles active and increases range of motion. On the most stressful days, you can try slow and soothing exercise.

7. Eat well. The most stressful life events can sometimes send us running to the kitchen for a snack. The quality of these snacks may add to the stress and the pain that is already there. Choose wisely and your "stress eating" can be good for stress busting and pain relief. There are plenty of delicious, easy foods that help lower stress. You must eat; you might as well take good care of yourself when you do.

8. Practice stress prevention. While certain amounts of stress are inevitable, it is possible to reduce stress in your life with a few simple steps. The most stressful events in life are often unpredictable and may occur all at once. Plan for the unknown as much as possible by putting systems into place that help you prevent what stress you can and cope better with what sneaks in.

The Holmes and Rahe Stress Scale[1] can be a helpful predictor of the risk of illness. Have you experienced an increased risk of illness because of one or more stressful life events? Take stock of yourself now, assess your level of personal and social resources, and use the tools listed here to help cope. And remember: It's a sign of strength to ask for help.

C. Scanlon Daniels, DVM
AASV President

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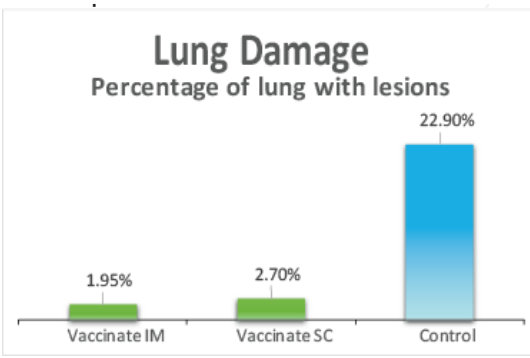

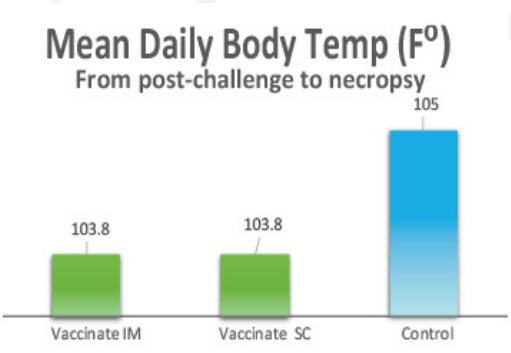

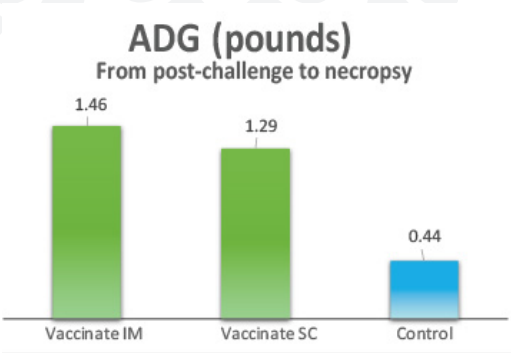

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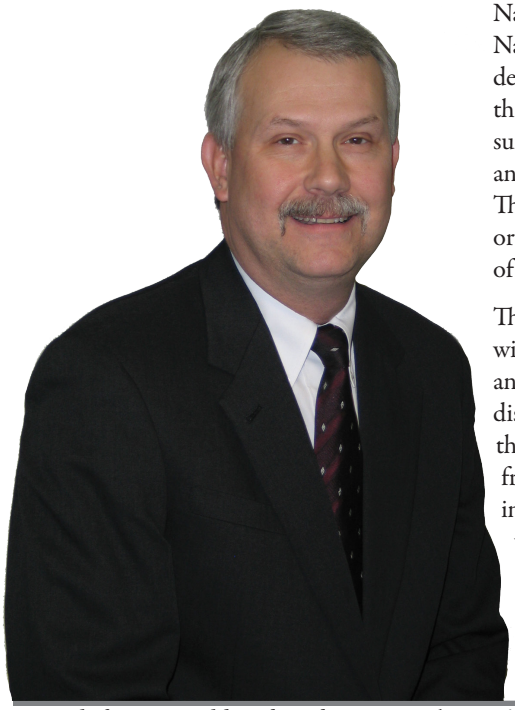
On the edges of knowledge

One of the aspects of traveling for my job is the downtime of waiting for flights and the time spent on airplanes. To pass the time, I usually have a book to read on my trips. I am reading a book entitled *Complications* by Atul Gawande.[1] It is nonfiction about the experiences of a surgeon as he and his colleagues practice human medicine and surgery. The stories he tells highlight just how inexact surgery can be and at the same time he reveals much about the advances being made. The descriptions in this book are occasionally alarming but the book is definitely an interesting and worthwhile read. If nothing else, this book has helped to inform my decision-making on healthcare.

There is a phrase in the book that leaped out at me: "I caught a glimpse of where the edges of knowledge were, the approachable frontiers." To me, the term "edges of knowledge" is very descriptive of where the AASV and its members need to be operating. The core mission of the AASV is to increase the knowledge of swine veterinarians. How we do that is a determinant of our relevancy for members and the pork industry. Relevancy is the currency of success for any organization that is based on attracting and retaining members while creating value for the profession and the industry. If we are to be relevant, then we need to be on the edges of knowledge.



If you were at the recent AASV Annual Meeting in San Diego, then you had the opportunity to see the edges of knowledge on display in the educational sessions as speakers gave presentations on a wide array of timely and topical subjects. There were seminars and sessions where you can get a sense of where that edge exists. You could see it in the technical show as companies provided information on new products and technologies. You could also see it in the hallways and in the private meetings as countless interactions occurred between and among colleagues. No matter what the venue or setting, there was a tremendous amount of knowledge being exchanged.

The edges of knowledge connote the finding of answers to perplexing questions. To find the answers, we must first ask the right questions. Then if answers are found, we must act. I am writing this in early May, exactly 5 years since porcine epidemic diarrhea virus (PEDV) was found to have entered the United States. In those early days of the outbreak there were a number of perplexing questions. The AASV, with support from the National Pork Producers Council and the National Pork Board, embarked on an epidemiological survey seeking answers about the introduction and spread of PEDV. The survey was not conducted to find a definitive answer but rather to find indicators of risk. The study found seven feed-related variables, or risk factors, associated with higher odds of PEDV.

These feed-related risk factors combined with the evidence of simultaneous appearances of PEDV in several geographically distinct locations were significant. Despite these implications, the response in 2013 from the US government and the feed industry was muted, to say the least. We were told that there was no way the virus would survive long enough to be transported in feedstuffs. As it turns out, that was not based on fact. Groundbreaking (at the edges of knowledge) research conducted by Dr Scott Dee has proven the hypothesis that viral agents, including PEDV, can survive in various feedstuffs long enough to make their way to the Midwest from overseas.[2] Armed with this knowledge, we are now faced with the fact that the door is still wide open for the entry of a foreign animal disease via feedstuffs.

> *"The edges of knowledge can be a scary place to operate, but this does not diminish the need to continue to seek answers."*

It is at this point that you would expect me to make an observation about what actions are needed. You will be sorely disappointed because I have no keen insight on actions that are any different from what has been done the last 5 years. The perplexing question is still the same: How do we keep those diseases out of the United States? The size and scale of the global feed system is daunting. It is unlikely that traditional actions like ingredient inspections, testing for contaminants, quality control, and quality assurance will be any more successful than they were prior to PEDV entering the United States.

The edges of knowledge can be a scary place to operate, but this does not diminish the need to continue to seek answers. We need to keep looking to the edges of knowledge to come up with better actions because that is perhaps the only place we will find them.

Tom Burkgren, DVM
Executive Director

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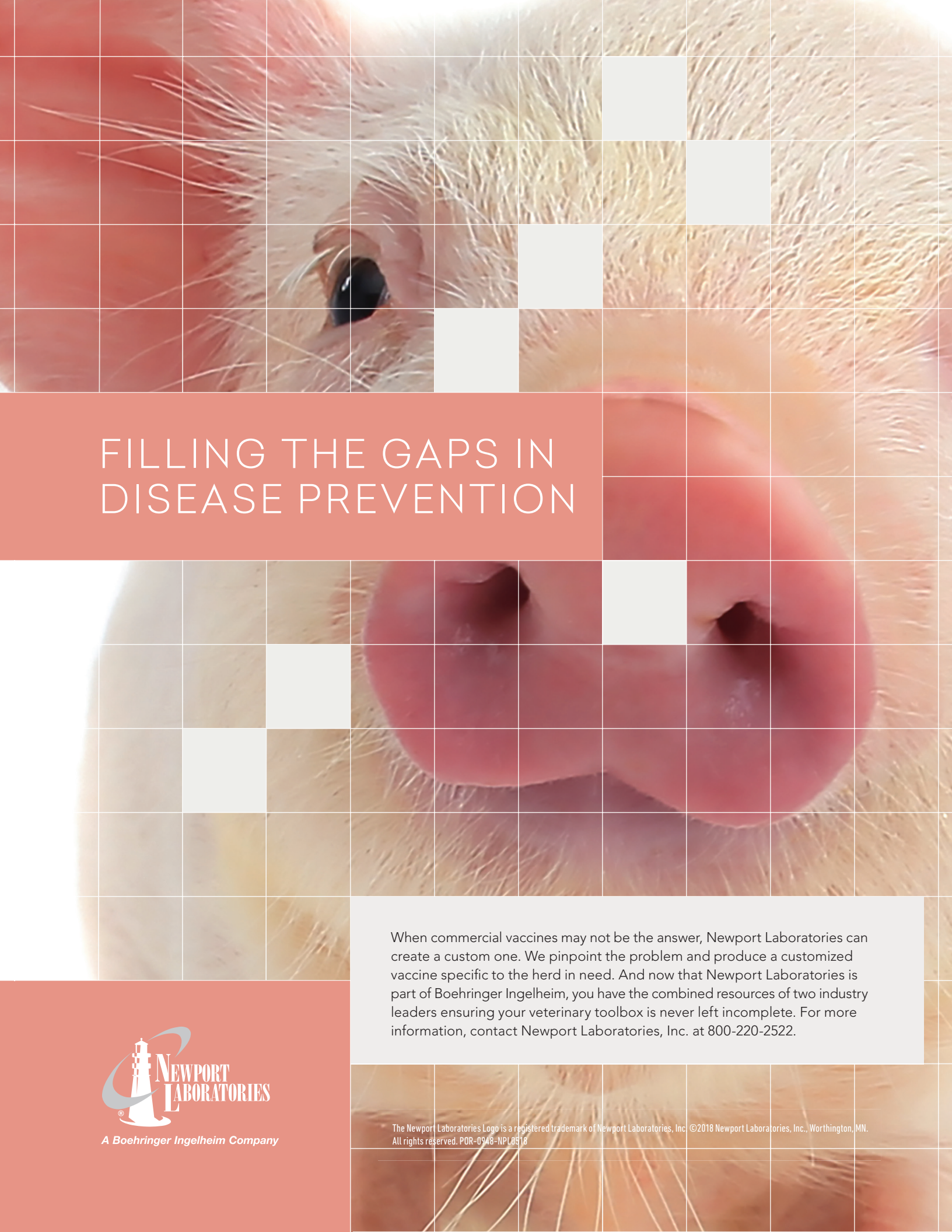

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The internet

How can we ensure that veterinary science continues to advance and flourish? In the fast-paced climate of information growth and dissemination that occurs today, how can we do our part as veterinarians, scientists, researchers, students, and allied industry to see veterinary medicine, science in general, and animal health continue to advance? This is a loaded question with many potential avenues to consider. I think one important avenue for constant improvement is through continuing education, which in my mind includes the continued sharing of ideas, expertise, experiences, and opinions. There are many ways to share ideas and expertise amongst experts and one way, of course, is the publication of peer-reviewed manuscripts. The publication of peer-reviewed information is becoming more and more timely and the internet has been instrumental in the distribution of information as it becomes available. It is probably safe to say that most of us are aware that the internet plays a vastly important role in the dissemination of information. If you are interested in seeing how much information is exchanged on the internet, visit the Internet Society's website and view their internet traffic report.[1]

Unfortunately, where there is information on the internet there is also misinformation. While I like to think that I would be savvy and critically reflective enough to identify misinformation on the internet, how do the general public and our clients sift through the information that bombards computer and phone screens and decide what is helpful, truthful, or fake news? The internet also seems to come with its own language that can be a challenge and constantly changing. Social media has proven to be this colloquial, double-edged sword where information and misinformation can be blogged, tweeted, liked, and apparently swiped right or left – I don't even know what that last one means! Do you have an internet presence? Are you on Facebook? Although, I am told by my students that I might as well have a rotary dial phone and that I need move from Facebook to Instagram.

How can we do our part to minimize internet misinformation about the swine industry? I recently attended a very interesting and large swine producer-focused meeting. A keynote speaker at this meeting, who was a representative from a large modern agriculture company, spoke about the importance of producers embracing the role of agriculture spokesperson and to accomplish this by establishing a strong internet presence. I felt like this was vague advice and I wasn't sure what the take home message was. However, I interpreted the message as advice to embrace the internet and as a gentle nudge to improve my internet and social media savvy-ness. Look out Instagram, here I come! I do think, however, there is some potential value in that advice. I encourage you to do the same so we can help our clients embrace the internet information exchange, aid in the interpretation of any information they read, and continue to ensure that veterinary science, animal health, and the swine industry continues to advance.

"How can we do our part to minimize internet misinformation about the swine industry?"

As I write this message I am packing my suitcase to travel to Chongqing, China to attend the International Pig Vet Society (IPVS) Congress. Call me old-school, but I prefer face-to-face meetings. Perhaps I will blog about my IPVS experiences or talk about them in my next message.

Terri O'Sullivan, DVM, PhD
Executive Editor

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ORIGINAL RESEARCH PEER REVIEWED

Comparison of shower-in and shower-in plus bench entry protocols for prevention of environmental contamination due to personnel entry in a commercial swine facility

Amanda V. Anderson; Cassandra Fitzgerald; Kimberlee Baker; Rachel Stika; Daniel Linhares, DVM, MBA, PhD; Derald J. Holtkamp, DVM, MS

Summary

Objective: To determine if the addition of a bench entry system in a commercial swine facility with a shower lowers the risk of personnel introducing environmental contamination.

Materials and methods: Fluorescent powder was used to assess the bench entry system by simulating environmental contamination carried on the footwear of personnel entering a commercial swine farm. On each of ten days, four female employees entered the premises, stepped through the fluorescent powder, performed bench entry procedures, and showered into the farm. For ten additional replicates, the bench was removed and regular farm protocols were followed. The fluorescent powder contamination was evaluated with a grid system at four sampling points including before the bench, after the bench, before the shower, and after the shower. Statistical analysis was conducted to determine if there was a difference in the number of contaminated grid cells found at each sampling between the treatment groups.

Results: Fluorescent powder was found after the shower on two study days in which the bench was removed but none when the bench was in place. There was a significant difference in contamination found directly after the bench between days with bench entry and days that the bench was removed, but this was not observed at any of the other sampling points.

Implications: A bench entry system may decrease the risk that pathogens reach the clean side of the shower, but improved protocols and additional layers of biosecurity are needed.

Keywords: swine, fluorescent powder, bench entry, swine pathogen, biosecurity

Received: November 29, 2017
Accepted: February 28, 2018

Resumen – Comparación entre regadera de entrada y regadera de entrada más el protocolo de entrada de banca para la prevención de contaminación medioambiental debido a la entrada de personal a un centro porcino comercial

Objetivo: Determinar si la adición de un sistema de banca de entrada con una regadera disminuye el riesgo de que el personal introduzca contaminación medioambiental a una granja porcina comercial.

Materiales y métodos: Se utilizó polvo fluorescente para valorar el sistema de banca de entrada, simulando la contaminación medioambiental llevada en el calzado del personal que entra a una granja porcina comercial. En cada uno de los diez días, cuatro empleadas entraron a las instalaciones, pisaron el polvo fluorescente, llevaron a cabo los procedimientos de banca de entrada, y se bañaron para entrar a la granja. En diez repeticiones adicionales, se quitó la banca y se siguieron los protocolos regulares de granja. Se evaluó la contaminación con el polvo fluorescente con un sistema de cuadricula en cuatro puntos de muestreo, incluyendo antes de la banca, después de la banca, antes de la regadera, y después de la regadera. Se realizó un análisis estadístico para determinar si había una diferencia en el número de celdas de la cuadricula contaminadas que se encontraron en cada muestreo entre los grupos de tratamiento.

Resultados: Se encontró polvo fluorescente después de la regadera en dos días de estudio en los que se había quitado la banca pero no se encontró contaminación cuando la banca estuvo colocada. Hubo una diferencia significativa en la contaminación que se encontró directamente después de la banca entre los días con banca de entrada y los días en que la banca se quitó, esto no se observó en ninguno de los otros puntos de muestreo.

Implicaciones: Un sistema de banca de entrada puede disminuir el riesgo de que los patógenos lleguen al lado limpio de la regadera, pero también son necesarios protocolos mejorados y pasos adicionales de bioseguridad.

Résumé – Comparaison d'un protocole de douche à l'entrée et de douche à l'entrée plus utilisation d'un banc pour la prévention de contamination environnementale due à l'entrée du personnel dans une entreprise porcine commerciale

Objectif: Déterminer si l'ajout d'un système d'entrée avec banc dans une entreprise porcine commerciale utilisant la douche à l'entrée diminuait le risque que le personnel introduise une contamination environnementale.

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Corresponding Author: Dr Derald J. Holtkamp, Department of Veterinary Diagnostic and Production Animal Medicine, Iowa State University College of Veterinary Medicine, 1600 South 16th Street, Ames, IA 50011; Tel: 515-294-9611; Fax: 515-294-1072; E-mail: holtkamp@iastate.edu.

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

Anderson AV, Fitzgerald C, Baker K, et al. Comparison of shower-in and shower-in plus bench entry protocols for prevention of environmental contamination due to personnel entry in a commercial swine facility. *J Swine Health Prod.* 2018;26(4):192-199.

Matériels et méthodes: De la poudre fluorescente a été utilisée afin d'évaluer le système d'entrée avec banc en simulant de la contamination environnementale transportée sur les chaussures du personnel entrant sur une ferme porcine commerciale. À chaque jour pendant une période de 10 jours, quatre employées sont entrées sur les lieux, ont marché dans la poudre fluorescente, ont complété la procédure d'entrée avec banc, et pris une douche d'entrée sur la ferme. Pour dix réplications supplémentaires, le banc a été retiré et les protocoles d'entrée réguliers ont été suivis. La contamination par la poudre fluorescente a été évaluée à l'aide d'un système à grille à quatre points d'échantillonnage incluant avant le banc, après le banc, avant la douche, et après la douche. Une analyse statistique a été faite afin de déterminer s'il y avait une différence dans le nombre de cellules de la grille contaminées à chaque point d'échantillonnage entre les deux groupes.

Résultats: De la poudre fluorescente a été trouvée après la douche en deux occasions lorsque le banc avait été retiré mais jamais lorsque le banc était en place. Il y avait une différence significative dans la contamination trouvée directement après le banc entre les jours avec entrée avec le banc et les jours lorsque le banc était retiré, mais ceci n'a pas été observé aux autres points d'échantillonnage.

Implications: Un système d'entrée avec banc peut diminuer le risque que des agents pathogènes atteignent le côté propre de la douche, mais des protocoles améliorés et des mesures additionnelles de biosécurité sont nécessaires.

The United States swine industry accounts for many direct and indirect jobs and is worth approximately $22.5 billion.[1] The introduction of new pathogens into swine herds complicates disease management and puts the industry's profitability and capability to provide jobs at risk. In addition, the United States swine industry continues to struggle with the rapid spread of emerging infectious and transboundary production diseases following their introduction. This is evidenced by the rapid emergence of porcine circovirus type 2 in 2005 and the 2013 introduction of porcine epidemic diarrhea virus which spread to every region of the United States in less than one year. Despite three decades of research, approximately 20% to 40% of breeding herds in the United States undergo a new porcine reproductive and respiratory syndrome outbreak each year,[2] costing the industry $664 million dollars in lost productivity annually.[3] To prevent ongoing and future economic losses, the industry must identify biosecurity gaps and reduce risk factors to prevent introduction of pathogens, or new isolates of pathogens, into herds.

A risk event occurs when people, animals, or objects that may be contaminated or infected with a pathogen enter a farm. On-farm employee entry is one of the most frequent risk events that occurs on swine farms and can pose a significant threat for pathogen entry when specific biosecurity protocols are absent or poorly implemented.[4] Previous research on swine biosecurity protocols for porcine reproductive and respiratory syndrome virus (PRRSV) demonstrated that the virus can be transmitted to PRRSV-naïve pigs by personnel and fomites related to personnel, such as footwear, coveralls, and gloves.[5-8] Otake et al[5] demonstrated that if no biosecurity measures were taken, personnel that contacted PRRSV-positive pigs could transmit PRRSV to naïve pigs; but if contaminated personnel changed boots, coveralls, and washed hands prior to contacting sentinel animals, PRRSV was not transmitted. Another source of swine pathogen-contaminated material is personnel footwear. Dee et al[7] demonstrated that clean boots could be contaminated with PRRSV by contacting the same surface where boots carrying PRRSV contaminated material were placed. Therefore, employees could be carrying the virus on their footwear without ever contacting an infected herd themselves. In response, many breeding herds in the United States implemented shower-in-shower-out procedures. If properly constructed, the shower acts as a line of separation, since the "dirty" side is found before the shower and the "clean" side is found after the shower. All outside clothing and items remain on the dirty side and personnel are required to take a complete shower before stepping into the clean side. Farm dedicated boots and coveralls are provided inside the farm to decrease the risk of swine pathogen entry into farms. However, there is a potential risk of tracking PRRSV or other swine pathogens through the shower room and into the swine facility on farms where personnel take their footwear off in an ante-room and proceed to walk across that same surface in their stocking or bare feet to the showers.

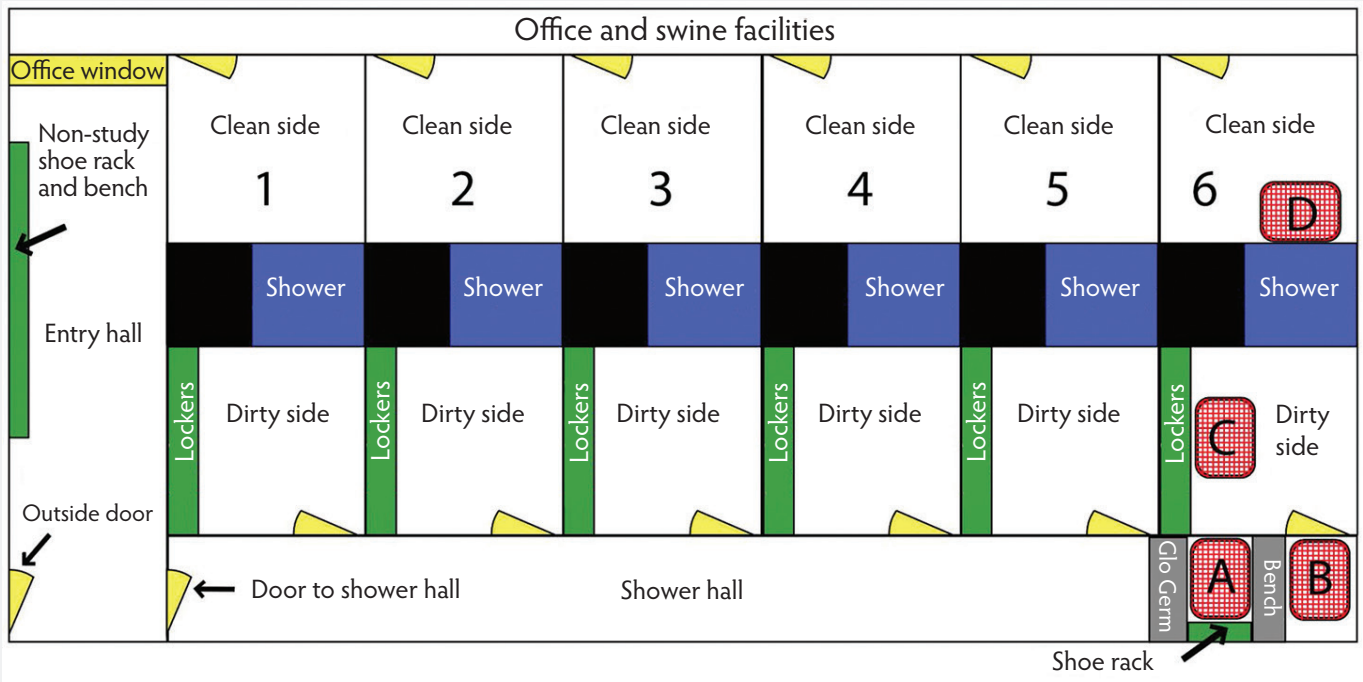
The bench entry system is an additional layer of biosecurity to lower the risk of pathogen transmission from contaminated footwear and ante-rooms. However, no research has been done to date to evaluate if the addition of a bench entry system to commercial swine facilities with a shower is effective at reducing the level of environmental contamination transferred to the clean side of the farm. In human medicine, fluorescing materials have been used to measure and compare environmental contamination with alternative protocols for removal of personal protective equipment.[9,10] The use of fluorescing materials may be useful for evaluating the efficacy of bio-exclusion practices to reduce the introduction of environmental contamination into swine farms. The objective of this study was to determine if the addition of a bench entry system at a commercial swine facility with a shower lowers the risk of personnel introducing environmental contamination, as simulated by use of a fluorescent powder.

Materials and methods

Facility and study area

The study was conducted at a Midwest commercial sow farm with 4,000 breeding females. The experimental protocol was approved by the Iowa State University Institutional Review Board and Use Committee (IRB ID: 16-231) prior to initiation of any experimental activity. Personnel were required to shower into and out of the facilities each day, but a bench entry system was not used. The layout of the facility and study area is shown in Figure 1. The showers were located so that personnel were required to pass through them to enter the facilities. The area prior to the showers was considered dirty and the area after the showers was considered clean. The first part of the dirty side was comprised of a doorway through which personnel entered from the outside. The employees would first walk down the hall and hand their lunches and personal items through the office window and then sit down to remove their shoes. The shoes were placed on a shoe rack next to the office window. Directly ahead of the outside door was another door, which lead to the shower hall. After the employees removed their shoes, they walked down the shower hall and entered their respective shower. Normal shower protocols for this farm included removing their clothes, placing all personal items inside a locker, and taking a thorough shower. Employees would then dry off and dress in clothing and boots provided on the clean side of the shower.

Figure 1: Diagram depicting the floor plan of the entry hall, shower hall, and shower rooms. Shower 6 was used to conduct the study. The location of the bench for the Bench treatment days and placement of the fluorescent powder (Glo Germ) are indicated. The location of each sampling point is designated with the letters A, B, C and D.



Study design

A control group (NoBench) and a treatment group (Bench) were evaluated in this study. The NoBench group was the farm's existing employee entry protocol as previously described. The Bench group included the addition of a bench entry procedure, used by employees for removal of their shoes, to the existing entry protocol. The design of this study was a randomized block design blocked by day of the week, Monday through Friday. Blocking by day was done to control for potential differences in compliance depending on the day of the week. Eight female employees participated in at least one replicate during the study. A single gender was enrolled in the study to avoid the potentially confounding effect of gender related to attention to detail and personal hygiene. On each day of the study, four employees would enter the farm through the study shower, shower 6, and other employees entered through one of the other five showers. The same four employees participated in the study whenever possible, however the other employees participated when scheduling conflicts resulted in the absence of one of the original employees. The experimental unit, therefore, was four employees entering the farm on a single day. The experimental units were blocked by day of week and then randomly assigned within each day of week to one of the two treatment groups (Table 1) using the RAND function in Microsoft Excel (version 2010; Microsoft Corporation, Redmond, Washington). The study was completed over twenty week days (4 weeks). Ten replicates of each treatment group were performed over the twenty study days.

Study materials

Fluorescent powder. The fluorescent powder (Glo Germ, Glo Germ Company, Moab, Utah) used to simulate the spread of environmental contamination throughout a farm contained particles that were approximately 5 microns or less in size, which is similar to the particle size of many bacteria. It appears white under natural lighting and fluoresces when exposed to ultraviolet (UV) light (Lights of America, Walnut, California).

Bench. The bench was constructed from pine wood and was painted with an oil-based primer (KILZ, Santa Ana, California) and a gloss oil-based porch and floor paint (Valspar paint, Salem, New Hampshire) to ensure that the fluorescent powder could be completely removed after each study day. The bench was 96.5 cm in length, 27.9 cm in width, and 50.8 cm in height. All sides of the bench reached the ground and were solid except for hand holes on each of the four sides that were used to remove the bench during the NoBench study days (Figure 2).

Contamination measurement grids. To evaluate the level of environmental contamination, 90 × 75 cm^2 grids were constructed and subdivided into 270 cells that measured 5 × 5 cm^2 (Figure 3). They were constructed with PVC pipes (Silver-Line Plastics; Lawton, Oklahoma), 0.48 × 5.08 cm^2 metal eyelets, and flat plastic string (Rexlace, Pepperell, Massachusetts). The grids were coated with a pink fluorescent paint (Krylon, Cleveland, Ohio) that showed up under UV light but was a different color than the fluorescent powder. One grid each was used for evaluating the clean and dirty sides of the shower and each grid remained on its respective side for the duration of the study.

Study procedures

Prior to the start of the trial, study investigators inspected the facilities and prepared for the first study day. The entire area in which the study took place was thoroughly cleaned. The locations where the bench, shoe rack, fluorescent powder, and measurement grids would be placed were marked. An in-person training session

Table 1: Randomly assigned treatments performed during a study comparing the efficacy of two protocols for entry onto a commercial sow farm

Study day	Date	Treatment*
Week 1		
Wednesday	6/8/2016	Bench
Thursday	6/9/2016	NoBench
Friday	6/10/2016	Bench
Monday	6/13/2016	Bench
Tuesday	6/14/2016	Bench
Week 2		
Wednesday	6/15/2016	NoBench
Thursday	6/16/2016	Bench
Friday	6/17/2016	NoBench
Monday	6/20/2016	NoBench
Tuesday	6/21/2016	NoBench
Week 3		
Wednesday	6/22/2016	NoBench
Thursday	6/23/2016	Bench
Friday	6/24/2016	NoBench
Monday	6/27/2016	NoBench
Tuesday	6/28/2016	Bench
Week 4		
Wednesday	6/29/2016	Bench
Thursday	6/30/2016	NoBench
Friday	7/1/2016	Bench
Monday	7/11/2016	Bench
Tuesday	7/12/2016	NoBench

* The NoBench treatment group was the farm's existing employee entry protocol, which included shower-in-shower-out procedure. The Bench treatment group included the addition of a bench entry procedure, used by employees for removal of their shoes, to the existing entry protocol.

lasting 30 minutes was conducted by the study investigators to teach the employees involved in the study how to use the bench and other study procedures. A poster, with instructions in English and Spanish on how to use the bench, was hung above the bench location for the duration of the study. Employees involved in the study were blinded to the purpose of the study and told that the powder was a novel disinfectant.

On each study day, two study investigators arrived at the site prior to the farm personnel. One investigator would shower in to the clean side of the farm using shower 5 and cross over to shower 6 to inspect for any residual fluorescent powder using a UV light. If any residual powder remained from the previous replicate, the researcher would clean the area using soap (Dawn Ultra, The Procter & Gamble Company, Cincinnati, Ohio), a sponge (Lysol, Reckitt Benckiser LLC, Parsippany, New Jersey), water taken from the clean side of the shower, and a clean towel. After cleaning, the researcher would re-inspect the area for any residual fluorescent powder. If any remained, the researcher would repeat the cleaning and inspecting process until no residual powder could be detected. The investigator would then shower out to the dirty side using shower 5 and prepare for the entry of employees. Simultaneously, the second study investigator would inspect the hall leading to the showers, the dirty side of the shower, and the surrounding area for residual fluorescent powder. If any fluorescent powder was detected using the UV light, the area was cleaned using water taken from the dirty side of the shower and the same procedure previously described.

On study days, 4 g of fluorescent powder, a simulated source of contamination, was spread uniformly on the floor of the hall approximately 118 cm prior to the entry of shower 6 (Figure 1). The concrete floor was covered with a non-porous coating, which allowed the researchers to remove all the fluorescent powder after each replicate. To ensure that the fluorescent powder was spread in the same location each day, a PVC pipe (Silver-Line Plastics; Lawton, Oklahoma) outline was built. The outline was 45×104.5 cm^2 and fit tightly between the two walls on either side of the hall leading

to the showers (Figure 4). Following setup, four female personnel entered the facility individually and walked down the hall to the showers in their outdoor footwear, instead of removing them in the entry hallway.

On NoBench study days, each employee had to step through the fluorescent powder to get to the shoe rack on which they would place their shoes. Once the employees had removed their shoes and placed them on the shoe rack (Figure 1), they would walk through the doorway into shower 6. Each employee would follow the swine facility's normal entry protocol following entrance into the shower.

On Bench treatment days, the researchers would set up the bench for employees to use in the designated location (Figure 1). When the employees arrived, they walked down the hall in their outside shoes and stepped through the fluorescent powder that had been sprinkled on the floor. The employees sat down on the bench with both their feet on the dirty side of the bench. They would remove their left shoe, place it on the shoe rack, and swing their left leg over to the clean side of the bench without touching their foot on the floor of the dirty side. Next, they would repeat this procedure with their right shoe. Employees were closely monitored to ensure that they did not touch their socked or bare feet on the floor of the dirty side of the bench. Finally, the employees would enter shower room 6 and follow the swine facility's normal shower protocol. Employees were monitored as they entered the facility each study day to ensure that procedures covered in the training were followed. If a deviation from the training occurred, the data from that replicate would not be included in the statistical analysis and that study day would be repeated on the same day of a different week.

After the four farm employees entered the swine facility, the level of contamination was measured at the four sampling points: A) hall before bench, B) hall after bench, C) dirty side of shower room, and D) clean side of shower room (Figure 1). Each of the four sampling points was marked inconspicuously on the floor to ensure that the placement of the grid and location measured would not vary between study days. The lights were turned off and the UV light was used to illuminate the grid and any fluorescent powder within the grid. The primary investigator would observe the grid and call out the grid coordinates of the cells that had visible

Figure 2: Bench used for the Bench treatment days during the study. The bench was 96.5 cm in length, 27.9 cm in width, and 50.8 cm in height. On treatment days, the bench was placed in the hallway just before the shower entry.

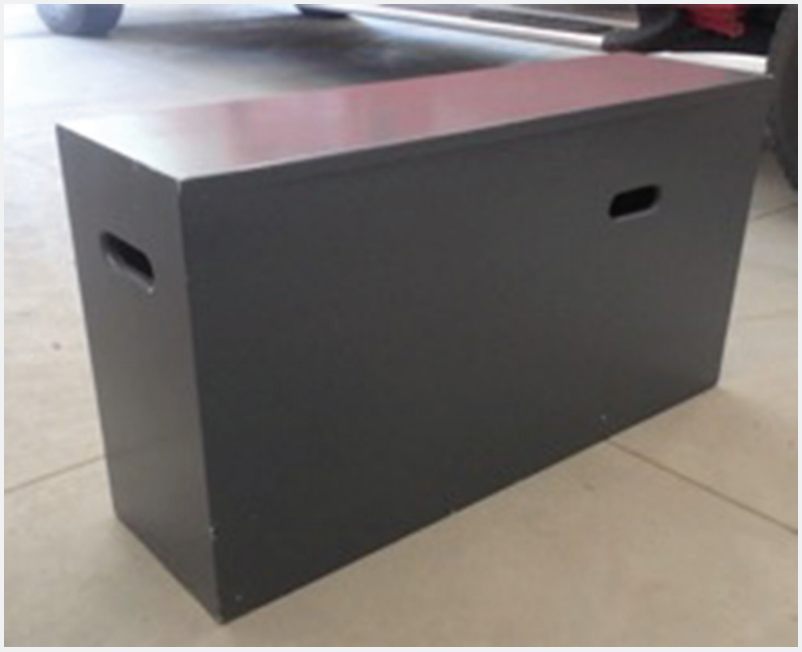
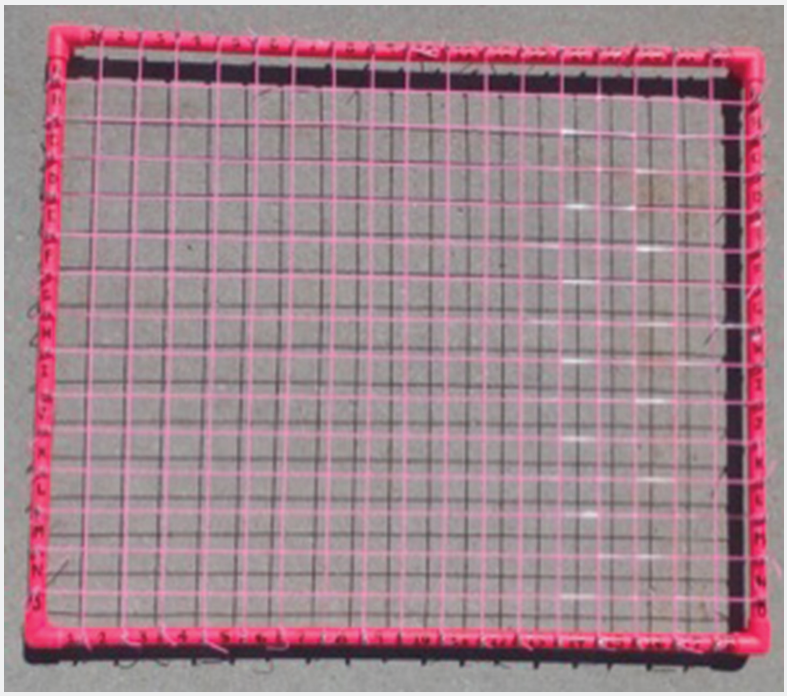


Figure 3: The grid that was constructed and used to quantify the amount of fluorescent powder transferred to each of the four sampling locations: 1) hall before bench, 2) hall after bench, 3) dirty side of shower room, and 4) clean side of shower room.



contamination with fluorescent powder. The secondary investigator would mark down the results on a pre-printed illustration of the grid for each sampling point. If there was any powder inside the cell of the grid, it was counted as contaminated. This was repeated for each sampling point. After taking measurements on the dirty side of the shower (sampling points A, B, and C), the primary investigator would shower through to the clean side of the farm using shower 5 and take measurements on the clean side of shower number 6 (sampling point D). The primary investigator identified contaminated cells at all sampling points (A, B, C, and D) on every day of the study to minimize variability.

After all measurements of contamination were completed, the investigators used dishwashing soap, a sponge, and water to clean the entire study area. After cleaning, the areas were inspected with the UV light to ensure no residual fluorescent powder remained. If there was any residual fluorescent powder, the area was re-cleaned and inspected until none remained.

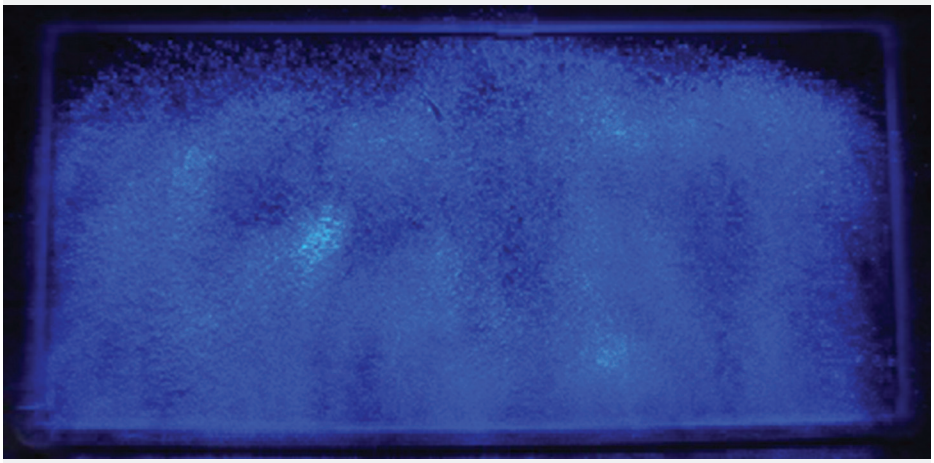
Statistical analysis

All data was analyzed using SAS 9.4 (SAS Institute, Cary, North Carolina). Differences in contamination at each of the sampling points between the Bench and NoBench groups were compared using a two-tailed Wilcoxon rank sum test when normality conditions were not satisfied. All reported differences were considered significant at $P < .05$ and there was no adjustment for repeated measures.

Results

The number of contaminated cells was significantly ($P < .05$) lower for the Bench treatment group at sampling point B (directly after bench) but not at any of the other sampling points (Figure 5). The mean number of contaminated cells declined as the employees progressed from the area closest to the contamination (sampling point A) to the clean side of the shower (sampling point D) for both treatment groups. Fluorescent powder was not found on the clean side of the shower on any Bench treatment days. However, it was found on the clean side of the shower on two NoBench days; 14 contaminated cells on a Wednesday and one on a Friday. No replicates had to be discarded and repeated due to deviations from procedures covered in the training.

Figure 4: Fluorescent powder, as seen under an ultraviolet light, was spread within a PVC pipe frame to ensure application in the same location each day.



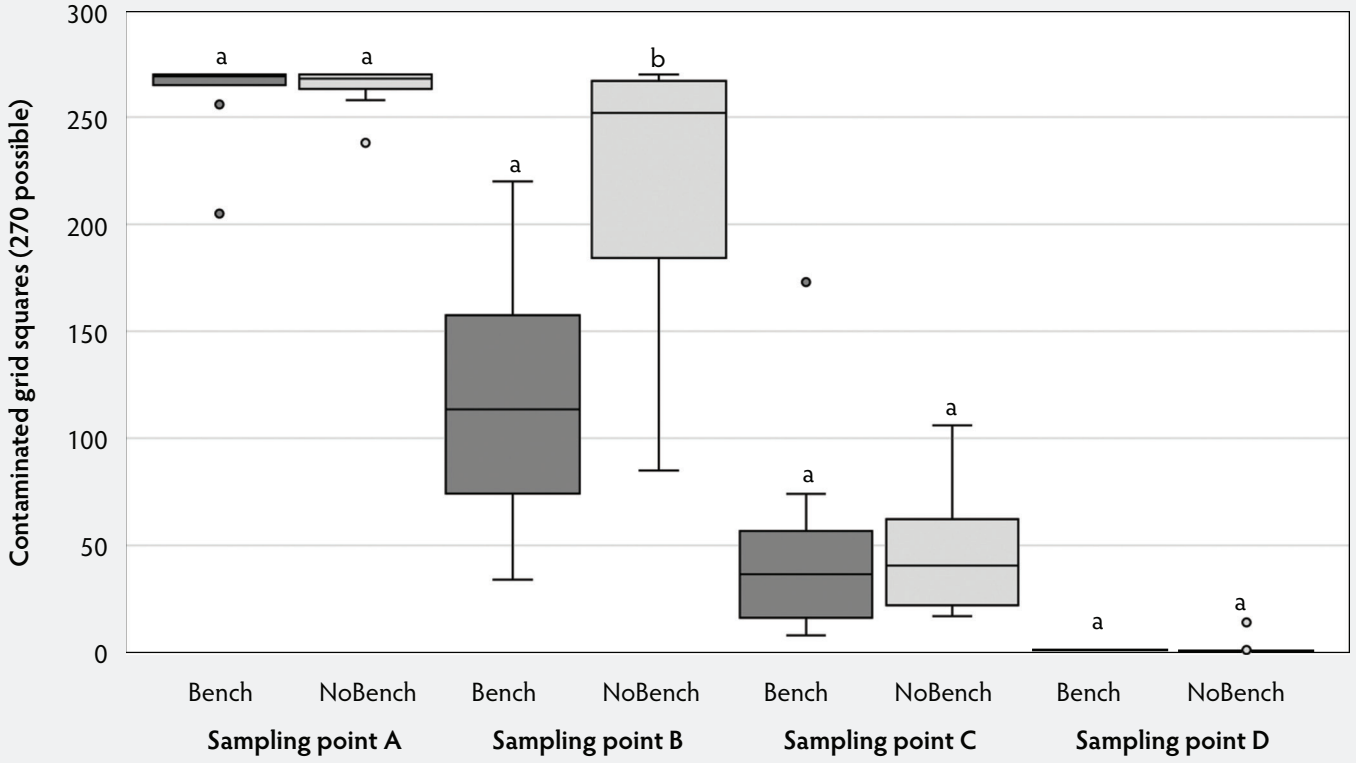
Discussion

The bench entry inconsistently reduced the level of contamination under experimental conditions, highlighting the need to focus on execution of entry and shower procedures. Before the study, employees were trained on proper use of the bench entry system and were monitored throughout the study for any deviations from procedures covered in the training. Study investigators were able to anticipate when a deviation might occur and were able to warn the employee. Consequently, no deviations occurred that would have necessitated a study day be repeated. Under field conditions where employees are not monitored, the level of contamination measured may be substantially different from this study. How employees should remove their shoes as they sat on the bench was not covered in the training and it was noted that they frequently touched the bottom of their shoes, transferring the contaminant to their hands and to anything their hands touched subsequently. It was commonly seen that the bench, walls, door handles, light switches, lockers, and shower curtains would have contaminant on them after the employees entered the farm through the Bench entry system, as well as during the NoBench entry system. Personnel clothing also needs to be considered. The investigators observed that pants worn by an employee during one study day were long enough to drag on the ground, which led to high levels of contamination on that study day. This was a Bench replicate, and although the employee used the correct procedure to remove her shoes and cross the bench, an unusual amount of fluorescent powder was transferred to sampling point C where 173 of the 270 grid cells contained fluorescent powder. The other nine Bench replicates had an average of 34 cells with contamination. These results emphasize the need to incorporate clothing and footwear choices, as well as footwear removal procedures, into personnel entry protocols to increase efficacy of the bench entry and shower systems.

A novel approach was used in this study to evaluate bio-exclusion practices designed to reduce the entry of pathogens into swine herds. Consequently, the sample size and study length were selected arbitrarily. The grid used to quantify the contamination was also novel. While the grid proved to be useful for quantifying contamination, some shortcomings were observed. The most notable was that a 5×5 cm^2 square was counted as contaminated whether contamination covered the entire area in the square or there was only a small speck. A method to measure the exact area of contamination would provide a more precise way of measuring contamination with a higher level of resolution. Additionally, in order to construct a bench that could be removed during NoBench days, the bench did not span the entire width of the hall and left a small gap on one side between the wall and the bench. Moreover, the height of the shoe rack placed beside the bench was greater than the height of the bench itself. The gap beside the bench, the height of the shoe rack, and the ability of the fluorescent powder to easily aerosolize may have contributed to some of the contamination on the clean side of the bench (sampling points B and C).

The results of this study also highlight the importance of layering biosecurity practices. Layering is accomplished by implementing

Figure 5: Distribution of the number of contaminated grid cells at sampling points A, B, C, and D for Bench and NoBench groups. The whiskers represent the minimum and maximum values recorded for each point excluding outliers (indicated by dots), and the upper and lower boxes represent the means of the 75th percentile and 25th percentile, respectively. Differing superscripts (a,b) within a sampling point indicate significant differences for Bench and NoBench groups ($P < .05$; two-tailed Wilcoxon rank sum test).



multiple biosecurity procedures, such as the shower and bench, to increase the number of failures that must occur for a pathogen to enter a herd. On two NoBench days, fluorescent powder was found on the clean side of the shower but was never found on Bench treatment days. While the differences in measured contamination on the clean side of the shower between the Bench and NoBench groups were not statistically significant, the results suggest that individual practices that are partially effective in isolation may reduce the risk of pathogen introduction when layered with other practices.

Implications

- This study provides a novel approach to evaluate the efficacy of bio-exclusion procedures on swine farms using a fluorescent powder to simulate environmental contamination.
- Provided the protocol is strictly followed, a bench entry system adds an additional layer of biosecurity and may decrease the risk of pathogens being spread by contaminated footwear to the clean side of the farm.
- Entry protocols should be improved to include detail about appropriate clothing and footwear choices and footwear removal techniques.

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Conflict of interest

None reported.

Disclaimer

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ORIGINAL RESEARCH PEER REVIEWED

Comparison of the pharmacokinetics and efficacy of two different iron supplementation products in suckling piglets

Joaquin Morales, DVM, PhD; Alberto Manso, DVM; Tomás Martín-Jiménez, DVM, PhD; Hamadi Karembe, DVM, MSc; Daniel Sperling, DVM, PhD

Summary

Objective: To evaluate and compare the efficacy and pharmacokinetics of two iron sources, gleptoferron (GLF) and iron dextran (DXT) in two-day old piglets.

Materials and methods: A total of 32 piglets from four litters were used in the study. On the second day of life, eight piglets were selected per litter and injected with one of two sources of iron, GLF or DXT (four piglets per treatment group in each litter). Blood samples were collected prior to treatment and 1, 2, 6, 10, and 12 hours after treatment. Additional samples were collected on days 1, 2, 3, 4, 7, 14, 19, and 24. Serum iron and ferritin concentrations were analyzed in all samples and the following pharmacokinetic parameters of iron were calculated: the peak concentration, time to peak concentration, half time, and extent of absorption. Hematological parameters were also analyzed to assess the iron status: hematocrit, hemoglobin, red blood cells, mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration. Piglets were individually weighed weekly.

Results: No significant differences in growth performance were observed between groups. Both products were efficient to prevent iron deficiency and anemia in the suckling period. The absorption and the bioavailability of iron were higher with GLF than DXT (overall iron serum concentration, $P < .001$).

Implications: Under the conditions of this study, both iron products are efficient to prevent iron deficiency and anemia in the suckling period. Absorption and bioavailability of GLF are significantly higher and have a confirmed different pharmacokinetic profile to DXT.

Keywords: swine, iron, suckling pigs, anemia, pharmacokinetics

Received: May 25, 2017
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Resumen – Comparación de la farmacocinética y la eficacia de dos productos de suplemento de hierro diferentes en lechones lactantes

Objetivo: Evaluar y comparar la eficacia y farmacocinética de dos fuentes de hierro, gleptoferron (GLF) y hierro dextrano (DXT) en lechones de dos días de edad.

Materiales y métodos: En el estudio se utilizaron un total de 32 lechones de cuatro camadas. En el segundo día de vida, se seleccionaron ocho lechones por camada y se inyectaron con una de dos fuentes de hierro, GLF o DXT (cuatro lechones por grupo de tratamiento en cada camada). Se tomaron muestras de sangre antes del tratamiento, y 1, 2, 6, 10, y 12 horas después del tratamiento. Se tomaron muestras adicionales en el día 1, 2, 3, 4, 7, 14, 19, y 24. Se analizaron concentraciones de ferritina y hierro sérico en todas las muestras, y se calcularon los siguientes parámetros farmacocinéticos de hierro: la concentración pico, tiempo para alcanzar la concentración pico, vida media, y extensión de absorción. También se analizaron los parámetros hematológicos para valorar el status del hierro: hematocrito, hemoglobina, glóbulos rojos, volumen corpuscular medio, hemoglobina corpuscular media, y concentraciones de hemoglobina corpuscular media. Se pesaron los lechones individualmente cada semana.

Resultados: No se observaron diferencias significativas en el desempeño del crecimiento entre grupos. Ambos productos fueron eficientes para prevenir la deficiencia de hierro y anemia durante el periodo de lactancia. La absorción y la biodisponibilidad de hierro fueron más altos con el GLF que con el DXT (concentración total de hierro sérico, $P < .001$).

Implicaciones: Bajo las condiciones de este estudio, ambos productos de hierro son eficientes para prevenir la deficiencia de hierro y anemia en el periodo de lactancia. La absorción y la biodisponibilidad de GLF son significativamente más altas y tiene un perfil confirmado farmacocinético diferente al DXT.

Résumé – Comparaison de la pharmacocinétique et de l'efficacité de deux produits de supplément de fer chez des porcelets à la mamelle

Objectif: Évaluer et comparer l'efficacité et la pharmacocinétique de deux sources de

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

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fer, le gleptoferron (GLF) et le fer dextran (DXT) chez des porcelets de deux jours d'âge.

Matériels et méthodes: Un total de 32 porcelets provenant de quatre portées a été utilisé dans la présente étude. À leur deuxième jour d'âge, huit porcelets ont été sélectionnés par portée et injectés avec une de deux sources de fer, GLF ou DXT (quatre porcelets par groupe de traitement dans chaque portée). Des échantillons de sang ont été prélevés avant le traitement et 1, 2, 6, 10 et 12 heures après le traitement. Des échantillons supplémentaires ont été prélevés aux jours 1, 2, 3, 4, 7, 14, 19, et 24. Les concentrations sériques de fer et de ferritine ont été analysées dans tous les échantillons et les paramètres pharmacocinétiques du fer suivants ont été calculés: le pic de concentration, le temps requis pour atteindre le pic de concentration, le demi-temps, et la quantité absorbée. Des paramètres hématologiques ont également été analysés pour évaluer le statut du fer: l'hématocrite, l'hémoglobine, la quantité de globules rouges, le volume corpusculaire moyen, l'hémoglobine corpusculaire moyenne, et la concentration moyenne d'hémoglobine corpusculaire. Les porcelets étaient pesés individuellement à chaque semaine.

Résultats: Aucune différence significative dans les performances de croissance n'a été observée entre les groupes. Les deux produits étaient efficaces pour la prévention d'une déficience en fer et d'anémie durant la période d'allaitement. L'absorption et la biodisponibilité du fer étaient supérieurs avec le GLF comparativement au DXT (concentration sérique globale du fer ($P < 0{,}001$).

Implications: Dans les conditions de la présente étude, les deux produits de fer sont efficaces pour prévenir une déficience en fer et l'anémie durant la période d'allaitement. L'absorption et la biodisponibilité de GLF sont significativement plus élevés et ont un profile pharmacocinétique confirmé comme différent par rapport au DXT.

It is well established that insufficient iron intake in suckling pigs results in iron deficiency or anemia. The pig is born with limited iron stores and the sow's milk is a poor source of iron, providing piglets with only 1 mg of iron a day.[1] This amount of iron is not sufficient to support the rapid growth and expansion of blood volume during the first days of life. Therefore, neonatal piglets require exogenous iron supplementation.[2] The practice most commonly used in field conditions is an intramuscular (IM) injection of 200 mg iron dextran (DXT) or gleptoferron (GLF) within the first 3 days of life. Gleptoferron is a macromolecular complex of beta-ferric oxyhydroxide and dextran glucoheptonic acid. It has been postulated that gleptoferron, is superior to iron dextran in preventing anemia for young pigs.[3] However, other authors concluded that iron dextran and gleptoferron can be used with similar effect.[4,5]

The growth potential of current genetic lines has improved in the last decades, while iron dosage remains the same. Therefore, it is important to verify if the routine iron supplementation protocols used today on commercial swine farms are still adequate to prevent iron deficiency and anemia in modern pigs.

In the present study, two iron products were compared: DXT and GLF. Serum iron and ferritin concentrations were measured after a single IM administration during the suckling period. Pharmacokinetic profiles and parameters of iron were evaluated to compare absorption and bioavailability of iron from both compounds. The poor responsiveness of neonatal piglets to oral iron therapy is now well documented. The immaturity of the duodenum to iron absorption may be the main cause[6] but studies about absorption and bioavailability of different injectable forms of iron are limited. The product should be rapidly and significantly absorbed from the IM injection site, otherwise iron is not available for hemoglobin synthesis and replenishment of iron stores in the liver. There is also the danger that the non-absorbed iron will deposit in the connective tissue stroma and associated macrophages, resulting in unacceptable muscle staining.[7] It is now well accepted that 90% of the injected iron should be absorbed within 72 hours post dosing to be effective.[8] Differences in absorption were reported for parenteral iron preparations.[7]

Materials and methods

Prior to the commencement of the study, the protocol was reviewed and approved by the investigators of PigCHAMP Pro Europa, a swine veterinary consultancy company. Animals were handled in compliance with both Spanish regulations and guidelines for the protection of animals in scientific research (Real Decreto Español 223/88 BOE 67: 8509-8511) and applicable European regulation.

Study facilities

The present study was conducted in Segovia, Spain on a commercial farrow-to-finish farm with a capacity of 500 sows. It involved one lactation room containing 12 farrowing pens. Each farrowing pen measured 2.5×2.0 m^2 (sow area: 2.0×0.6 m^2), and had a plastic slatted floor including a heated section for the piglets.

Study animals

Four litters were selected for the study. Only parity 3 to 5 sows (Danbred) were used. Within 24 h after birth, piglets were individually identified with ear tags and weighed. Litters were equalized at 12 piglets per litter by cross-fostering and no more changes in piglet allocation were then allowed. In each litter, eight piglets were randomly selected and allocated to two experimental groups. High quality digestible creep feed (2890 kcal NE/kg; 20.0% crude protein; 1.45% digestible lysine; 9.7% ether extract; 6.3% ash content) was offered from 10 days of age. Piglets were weaned at 28 days of age.

Experimental products

Two commercial iron supplements were evaluated: gleptoferron (Gleptosil, Ceva Santé Animale, Libourne, France) and an iron dextran product (Uniferon, Pharmacosmos A/S, Holbaek, Denmark). In both cases, 1 mL per piglet (200 mg of active compound) was administered by IM injection in the neck.

Experimental design

This study was a monocentric, blinded, randomized, 2-arm study, comparing two commercial iron preparations for prevention of anemia in neonatal piglets. In each litter, GLF was administered to four piglets and DXT was administered to another four piglets. Selection and allocation of piglets to treatment groups was done at random in each litter (computer-generated random allocation). Four different random lists were used in the study, one per litter. The sample size was calculated by power analysis with a power $(1 - \beta)$ higher than 80% for iron serum concentration, the main analysis variable.

Measurements and samples

Blood samples (3 mL) were collected from the vena cava prior to treatment (day 0) and 1, 2, 6, and 10 hours after treatment. Additional blood samples were collected on days 1, 2, 3, 4, 7, 14, 17, and 21. On day 0, each piglet was sampled only twice (0 and 6 hours, 1 and 10 hours, or 2 and 12 hours). Serum was collected immediately after centrifugation at 3500*g* for 5 min, and sent to a

laboratory (Facsis Consulting SL, Segovia, Spain). Serum iron and ferritin concentrations were measured spectrophotometrically with a Technicon RA-1000 automated system (Bayer, Tarrytown, New York).

Four additional piglets per treatment (1 per litter) were also sampled and blood collected into EDTA tubes for the determination of hematological parameters. Hematocrit (Hct), hemoglobin (Hb), red blood cells (RBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were measured using an automatic blood analyzer, Sysmex TX-1800i (Sysmex Corporation, Kobe, Japan). Blood samples for hematology were collected on day 0 before iron administration, and on days 1, 2, 3, 4, 14, 17, and 21 after treatment. Change in hematological variables between the baseline and the evaluation period were also calculated and compared.[9-12]

All piglets were individually weighed weekly from study day 0 until day 21. All deaths or clinical incidences were recorded.

Pharmacokinetic analysis

The serum pharmacokinetic parameters were determined using noncompartmental analysis with PK Software (Phoenix 6.0, Certara Inc, Princeton, New Jersey). The maximum serum concentration (Cmax) and the time to reach Cmax (tmax) for each animal were determined directly from the serum concentration data. The area under the curve (AUC) was calculated using the log-linear trapezoidal method. The decay phase of the iron concentration curve (T½) was calculated by a linear regression after logarithmic transformation of these concentrations.

Statistical analyses

SAS 9.0 (SAS Institute Inc, Cary, North Carolina) was used for statistical analysis. All treatment differences were assessed at the 2-sided .05 α level of significance and trends were reported for $\alpha = .10$.

For parameters measured only once (Cmax, tmax, T½, and AUC), group values were tabulated. Statistical analysis of iron and ferritin serum concentration and measures in plasma samples were conducted with a linear mixed effects model. The fixed effects were treatment group, litter (blocking variable), and body weight on day 0 (covariate), while time was the random effect. Average body weights on day 21 were analyzed using a general linear model (PROC GLM) including treatment, litter (blocking variable), and body weight on day 0 as covariates. The piglet was the experimental unit.

Results

No differences in growth performance were observed between groups during the suckling period, 6.1 kg versus 6.4 kg body weight on study day 21 in the GLF and in the DXT groups, respectively ($P = .29$). Only two deaths (crushed by the sow) occurred during the study, both were in the DXT group and were observed on days 1 and 3.

Serum iron and ferritin concentrations are presented in Table 1. The linear plots of the serum iron concentration-time profiles after IM administration of the two iron complexes are shown in Figure 1. The main pharmacokinetic parameters are summarized in Table 2. Serum iron concentration reached

Table 1: Least Square Means (standard deviation) of iron and ferritin serum concentrations in piglets at different time-points after treatment with gleptoferron or iron dextran*

	Iron (µg/dL)			Ferritin (ng/mL)		
Time	**GLF**	**DXT**	***P*†**	**GLF**	**DXT**	***P*†**
0 h‡	44.2 (13.6)	49.8 (20.1)	.62	8.31 (3.08)	9.69 (1.22)	.37
1 h‡	1294.8 (684.7)	1904.9 (818.0)	.15	9.79 (2.86)	8.71 (1.48)	.59
2 h‡	1881.0 (578.5)	1313.0 (331.4)	.05	9.03 (2.24)	12.72 (4.02)	.46
6 h‡	4212.8 (776.5)	1386.9 (695.1)	.02	10.46 (2.17)	9.54 (1.48)	.51
10 h‡	4204.7 (868.3)	2022.6 (237.0)	.13	9.94 (4.76)	3.31 (0.87)	.02
12 h‡	4677.0 (1471.0)	1306.7 (316.2)	.004	6.26 (2.77)	6.99 (1.41)	.82
24 h	3729.7 (842.8)	294.9 (132.1)	< .001	7.47 (1.85)	8.64 (3.96)	.31
48 h	1955.0 (534.4)	120.7 (89.7)	< .001	11.10 (2.98)	9.92 (2.59)	.38
72 h	684.3 (347.7)	121.7 (55.7)	< .001	12.76 (1.80)	12.21 (1.89)	.53
96 h	150.3 (61.1)	129.2 (38.1)	.30	14.42 (3.17)	15.27 (3.54)	.62
Day 14	161.8 (55.9)	143.1 (52.6)	.47	16.54 (6.08)	26.42 (43.07)	.49
Day 17	140.1 (40.7)	115.5 (50.2)	.27	13.45 (8.99)	11.55 (4.32)	.60
Day 21	146.7 (73.9)	100.2 (56.4)	.069	11.07 (4.96)	10.93 (3.26)	.95
Average	**1783.1 (1625.3)**	**684.02 (672.1)**	**< .001**	**10.68 (5.52)**	**11.36 (15.15)**	**< .001**

* A total of 24 two-day old piglets (day 0) from 4 litters (6 piglets per litter) were randomly allocated to two treatment groups resulting in 12 piglets per treatment (3 piglet per litter and treatment).

† A linear mixed effects model was used including the effects of treatment, litter (blocking variable) and time (random effect). Treatment × day interaction effect was $P < .001$ in iron serum concentration and $P = .15$ in ferritin serum concentration.

‡ On day 0, each piglet was sampled only twice (0h and 6h, 1h and 10h, or 2h and 12h) resulting in a total of 8 piglets sampled (1 piglet per litter and treatment) at each of these time points.

GLF = gleptoferron; DXT = iron dextran.

a peak at 12 h after administration of GLF and at 10 h after administration of DXT. The significantly different parameters between GLF and DXT were the Cmax (4695 µg/dL versus 2118 µg/dL respectively, $P < .001$) and the serum AUC (197.55 h · µg/dL versus 43.03 h · µg/dL respectively, $P < .001$). Overall, serum iron concentrations in the experimental period were higher in the GLF than in the DXT group ($P < .001$). The pharmacokinetic profile shows that serum iron concentrations were significantly higher in GLF piglets from 2 h to 72 h post treatment. Thereafter, no significant differences were observed between groups until weaning, when iron serum content in GLF piglets tended to be higher ($P < .10$). Ferritin serum concentration did not differ among treatment groups, except at 10 h post treatment when it was higher in GLF than in DXT piglets (9.94 ng/mL versus 3.31 ng/mL respectively; $P < .05$).

The hematological parameters are presented in Table 3. The Hct, Hb, and RBC decreased up to day 2 or 3 post treatment, before they again increased at day 4 to reach or supersede the day 0 level (Figures 2, 3, and 4). The Hct did not differ between groups except on day 17, when it was higher in GLF than in DXT piglets (45.1% versus 41.7%; $P < .05$). There was no significant difference between groups for Hb values (9.7 g/dL versus 9.4 g/dL; $P = .11$). The increase in Hb and Hct levels occurred sooner and were higher and more homogeneous in the GLF group (Figures 2 and 3). Two weeks after treatment, the mean increase in Hb from baseline was 3.10 g/dL for GLF and 2.25 g/dL for DXT (Figure 2). The mean increase in Hct two weeks after treatment was 12.9% for GLF and 7.45% for DXT (Figure 3). However, these differences were not statistically significant ($P > .05$). No differences were observed in RBC concentrations over time (Figure 4). On day 17, Hct was higher ($P < .05$) in the GLF than in the DXT group, indicating higher percentage of red blood cells around weaning age. In this sense, MCV was also higher in GLF than in DXT piglets on days 4 and 14 ($P < .05$), and numerically higher on day 17 ($P = .12$), which indicates more erythrocytes are being produced, as those new and immature erythrocytes are greater in size. The MCH, also associated with iron deficiencies, tended to be higher on days 4 and 14 ($P < .10$) and numerically higher on day 17 ($P = .17$) in GLF than in DXT piglets.

Discussion

The small number of the animals and samples tested in the present study needs to be taken into consideration when interpreting the results.

Pigs raised indoors lack access to soil, a rich source of iron, and therefore require exogenous supplementation within the first week of life to prevent iron deficiency and anemia. For many years on commercial farms, administration of 200 mg IM injection of DXT within the first 3 days of life has been performed on a routine basis.[2] However, iron requirements might be higher under current swine production conditions including higher prolificacy, lower birth weight, large variation of birth weight within litter, and higher growth performance.[13] Therefore, modern pigs likely require a higher dosage of iron or an exogenous source providing for higher absorption and bioavailability.

Figure 1: Mean concentration-time profiles (with standard error) of iron in serum after single intramuscular administration of 200 mg per piglet of gleptoferron or iron dextran. Data were analyzed using a linear mixed-effects model with treatment, group, and litter (blocking variable) as fixed effects and time as random effect. Treatment × day interaction effect was significant ($P < .001$).

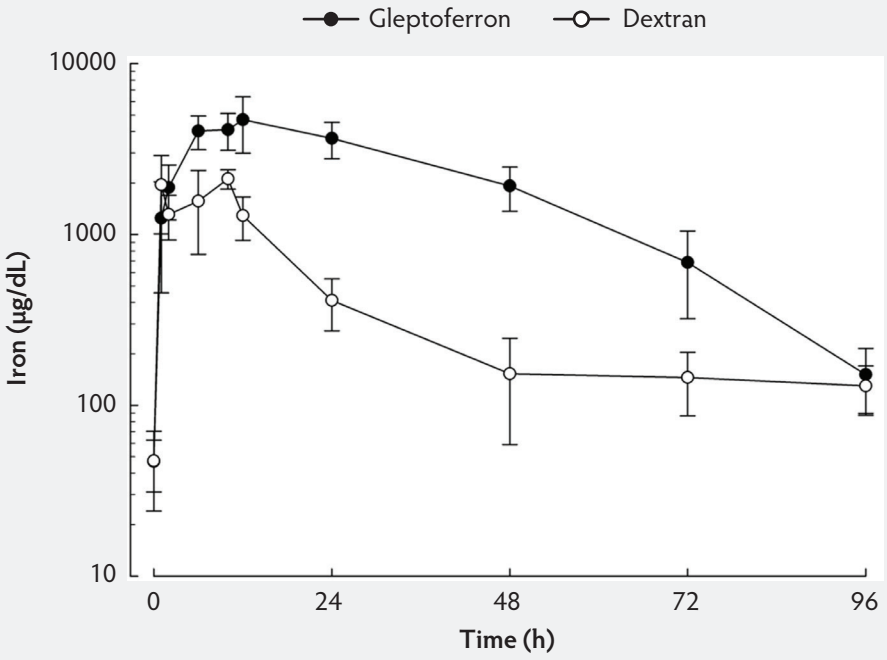


Table 2: Mean pharmacokinetic parameters of iron in serum after single intramuscular administration of 200 mg per piglet of gleptoferron or iron dextran.

Pharmacokinetic parameter	GLF	DXT
C_{max} (µg/dL)	4695	2118
T_{max} (h)	12.0	10.0
$T_{½}$ (h)	17.3	10.7
$AUC_{0\text{-}96h}$ (h · µg/dL)	197.55	43.03
Relative bioavailability*	4.6	1

* Relative bioavailability of GLF = $AUC_{0\text{-}96h}$ GLF/$AUC_{0\text{-}96h}$ DXT, assuming bioavailability of DXT = 1.

GLF = gleptoferron; DXT = iron dextran; Cmax = maximum serum concentration; Tmax = time to reach Cmax; T½ = decay phase of the iron concentration curve; $AUC_{0\text{-}96h}$ = area under the curve.

Table 3: Least Square Means (standard deviation) of hematological values in piglets treated with gleptoferron or iron dextran at different time points during the suckling period*

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 14	Day 17	Day 21	Average
Hct (volume % of red blood cells in blood)									
GLF	29.47 (0.68)	28.28 (1.18)	27.26 (1.18)	31.82 (2.75)	37.99 (1.43)	42.91 (2.59)	45.13 (1.13)	41.48 (3.09)	35.54 (6.79)
DXT	32.80 (3.48)	31.02 (1.43)	29.34 (1.31)	31.38 (1.13)	38.94 (3.23)	39.74 (2.67)	41.69 (1.14)	41.60 (3.19)	35.81 (5.58)
P†	.097	.14	.13	.84	.71	.33	.04	.97	.69
Hb (g/dL)									
GLF	8.27 (0.27)	7.47 (0.33)	7.32 (0.32)	8.00 (0.80)	9.53 (0.41)	11.57 (0.46)	11.75 (0.28)	11.35 (0.56)	9.41 (1.77)
DXT	9.13 (0.94)	8.30 (0.66)	8.26 (0.40)	8.00 (0.21)	10.19 (0.85)	11.18 (0.72)	11.20 (0.42)	11.35 (0.78)	9.70 (1.57)
P†	.15	.07	.04	.99	.34	.52	.13	.99	.11
RBC ($\times 10^{12}$/L)									
GLF	4.54 (0.18)	4.07 (0.15)	3.93 (0.27)	4.17 (0.45)	4.79 (0.17)	5.97 (0.17)	6.28 (0.13)	6.31 (0.30)	5.01 (0.96)
DXT	5.30 (0.57)	4.79 (0.48)	4.65 (0.29)	4.35 (0.23)	5.49 (0.48)	6.31 (0.37)	6.49 (0.21)	6.81 (0.41)	5.52 (0.97)
P†	.01	.14	.03	.53	.13	.32	.41	.26	< .001
MCV (fL)									
GLF	64.96 (1.55)	69.37 (0.42)	69.34 (3.13)	76.58 (4.92)	79.33 (1.63)	71.90 (2.68)	71.92 (2.89)	65.85 (4.91)	71.15 (5.70)
DXT	62.04 (3.20)	65.03 (3.88)	55.69 (14.70)	72.35 (3.14)	70.90 (1.03)	62.88 (0.77)	64.31 (2.73)	61.03 (2.43)	64.28 (7.58)
P†	.14	.15	.29	.51	.01	.046	.12	.30	< .001
MCH (pg)									
GLF	18.20 (0.33)	18.33 (0.59)	18.65 (0.57)	19.20 (0.90)	19.91 (0.40)	19.40 (0.53)	18.72 (0.81)	18.02 (1.12)	18.80 (0.95)
DXT	17.32 (0.84)	17.37 (1.01)	17.77 (0.71)	18.45 (0.61)	18.56 (0.65)	17.67 (0.47)	17.26 (0.59)	16.65 (0.61)	17.63 (0.90)
P†	.29	.30	.23	.48	.06	.06	.17	.29	< .001
MCHC (%)									
GLF	28.07 (0.74)	26.43 (0.78)	26.83 (0.66)	25.09 (0.94)	25.12 (0.19)	26.99 (0.58)	26.03 (0.39)	27.43 (0.86)	26.50 (1.21)
DXT	27.83 (0.36)	26.72 (1.08)	27.97 (0.54)	25.53 (0.53)	26.18 (0.59)	28.16 (0.54)	26.84 (0.54)	27.29 (0.23)	27.07 (1.05)
P†	.49	.61	.25	.67	.08	.15	.099	.86	.005

* A total of eight 2-day old piglets (day 0) from 4 litters (2 piglets per litter) were randomly allocated to two treatment groups resulting in 4 piglets per treatment (1 piglet per litter and treatment).

† A linear mixed effects model was used including the effects of treatment, litter (blocking variable), and time (random effect). In all variables (Hct, Hb, RBC, MCV, MCH, and MCHC), treatment × day interaction effect was $P < .001$.

Hct = hematocrit; Hb = hemoglobin; RBC = Red blood cells; MCV = Mean corpuscular volume; MCH = Mean corpuscular hemoglobin; MCHC = Mean corpuscular hemoglobin concentration; GLF = gleptoferron; DXT = iron dextran.

Figure 2: Mean change in hemoglobin (g/dL) from the baseline after single intramuscular administration of 200 mg per piglet of gleptoferron or iron dextran. Error bars represent the standard deviation.

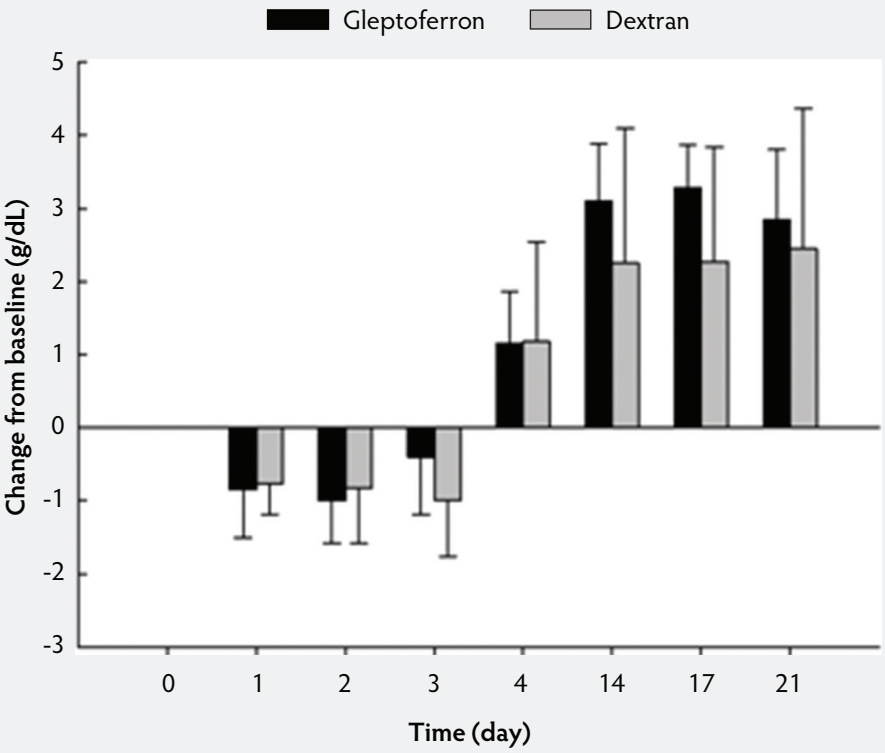
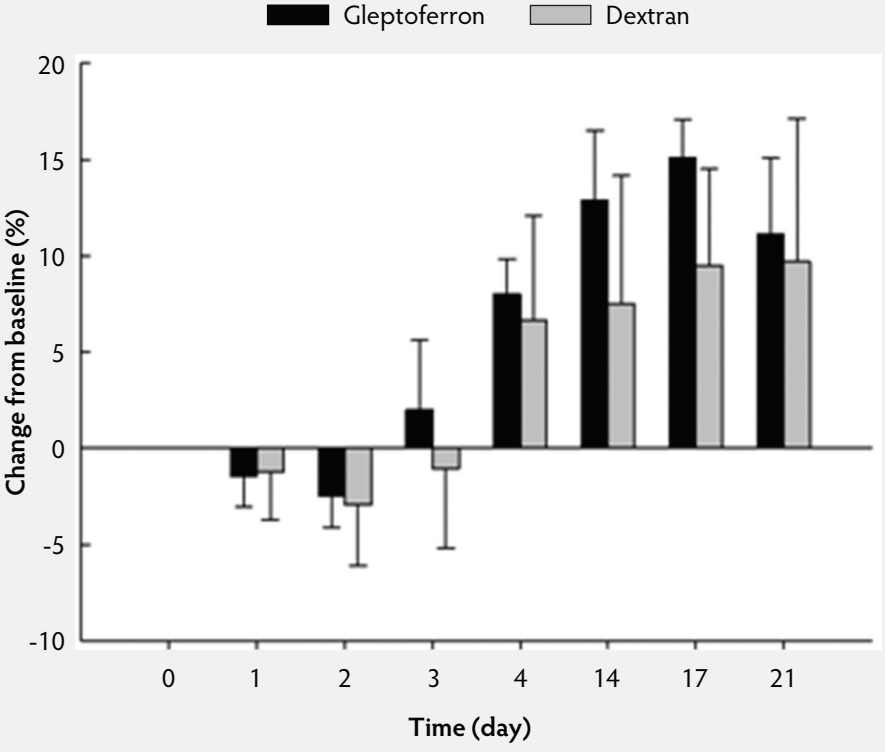


Figure 3: Mean change in hematocrit (%) from the baseline after single intramuscular administration of 200 mg per piglet of gleptoferron or iron dextran. Error bars represent the standard deviation.



In the present study, Cmax was 2.2 times higher in the GLF than in the DXT group, resulting in a much higher AUC in the GLF group. The AUC represents total iron exposure over time and consequently iron bioavailability. Assuming linear pharmacodynamics with a constant elimination rate, AUC is proportional to the total amount of iron absorbed by the body. Therefore, the present study confirms that GLF allows 4.6 times higher total iron absorption by the piglet than does DXT. Other authors did not observe differences in iron serum concentration from either iron sources, confirming that both are efficient for anemia prevention in young pigs compared with a negative control group.[4] However, in that study, blood samples were collected only at 10, 21, and 50 days post treatment. Considering that the peak iron concentrations are observed at 10 to 12 h post treatment, the absorption phase was missed.

Serum ferritin has been also used to evaluate iron levels in tissues of neonatal pigs, since it responds quickly to iron treatment or iron deficiency.[14] Smith et al[15] observed a marked increase in serum ferritin 10 to 21 days after treatment with GLF or DXT compared with untreated pigs. Similarly in the present study, no differences in serum ferritin were observed between GLF and DXT. Serum ferritin increased 2.0 to 2.7 times its concentration 14 days after iron treatment, confirming that both iron sources were efficient in preventing iron deficiency.

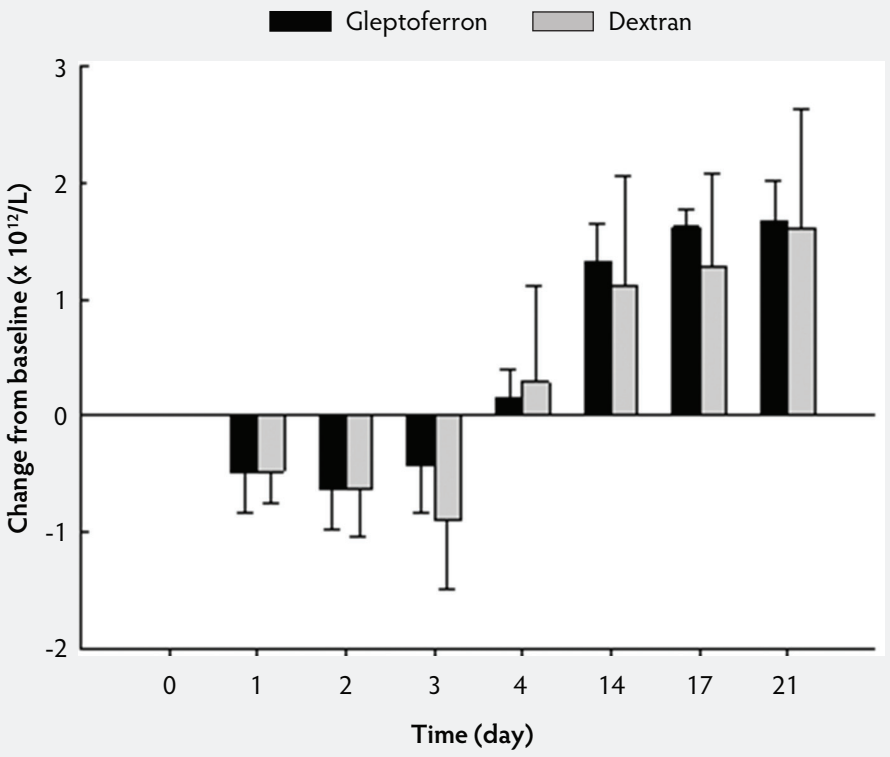
Despite iron treatment on day 0, Hct, Hb, and RBC decreased from day 0 to day 2 or 3 in both groups. This physiological anemia is explained by the rapid growth of the piglet and subsequent hemodilution.[16-18] Synthesis of new erythrocytes cannot occur fast enough to match the rapid increase in blood volume.

Hemoglobin concentration has been used to evaluate iron deficiency and anemia in the literature. Normal iron status is defined as a Hb concentration > 11 g/dL, iron deficiency as a Hb concentration > 9 g/dL but ≤ 11 g/dL, and anemia as a Hb concentration ≤ 9 g/dL.[13] Based on this Hb status classification, only two piglets (one in the GLF group and one in the DXT group) showed iron deficiency after day 14 with a Hb concentration of 10.4 g/dL. Iron status was normal in all other pigs (> 11 g/dL) indicating both iron products, GLF and DXT, were efficient in preventing iron deficiency and anemia. However, the increase in Hb levels occurred sooner and

was higher and more homogeneous in the GLF group. In a similar study, piglets that received GLF also had a higher level of Hb at weaning than the group receiving DXT indicating better bioavailability of GLF.[3] Efficacy of an exogenous iron source to prevent anemia was previously demonstrated by other authors,[4,19] who reported a decrease in Hb concentration and Hct percentage at 10 to 13 days of age in pigs receiving no supplemental iron compared with pigs receiving 200 mg IM injection of DXT at 1 d of age. However, these results are not in accordance with other studies where iron supplementation protocols used by participating farms, mainly 200 mg IM of DXT administration, were not sufficient to meet iron requirements in the suckling period.[20] The small number of pigs used in the present study and its main objective focusing on pharmacokinetics did not allow evaluation of individual effects which might affect iron deficiency such as birth weight.

No differences in Hb concentration were observed in the study of Bhattarai and Nielsen[13], concluding that using Hb as a diagnostic tool may underestimate the iron requirements for young piglets. Therefore, RBC, Hct, MCV, MCH and MCHC were used in this study as additional iron indicators. At the end of the suckling period, normal values of RBC, Hct, MCV, MCH, and MCHC are 5.4 × 10^{12}/L (± 0.50), 34% (± 3), 63.6 fL (± 6.4), 19.2 pg/cell (± 1.9), and 30.2% (± 0.9), respectively.[21] In anemic piglets, RBC, Hct, MCV, and MCH are significantly lower and MCHC is significantly higher than normal.[21] In the present study, all hematological parameters did not differ in pigs from both treatment groups, but RBC and Hct were higher and MCHC was lower compared with normal values observed by Egeli et al.[21]

Figure 4: Mean change in red blood cell count (× 10^{12}/L) from the baseline after single intramuscular administration of 200 mg per piglet of gleptoferron or iron dextran. Error bars represent the standard deviation.



Implications

- Under the conditions of this study, higher Cmax and AUC values are observed with GLF versus DXT.
- Both iron products are efficient to prevent iron deficiency and anemia in the suckling period.

Acknowledgments

Conflict of interest

Dr Daniel Sperling and Dr Hamadi Karembe are employees of Ceva Santé Animale, and Gleptosil is a product offered by Ceva.

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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

$^{\circ}F = (^{\circ}C \times 9/5) + 32$

$^{\circ}C = (^{\circ}F - 32) \times 5/9$

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

The replacement gilt: Current strategies for improvement of the breeding herd

Martyna M. Małopolska, MS; Ryszard Tuz, PhD; Barry D. Lambert, PhD; Jacek Nowicki, PhD; Tomasz Schwarz, PhD

Summary

The efficiency of swine production is affected by many factors. One of the most economically important factors is gilt reproductive performance. To achieve satisfactory results in breeding, both environmental and genetic factors must be monitored and constantly improved. For many years, intensive selection in the swine industry for increased carcass muscle to fat ratio has led to deterioration in some reproductive traits (eg, less favorable development of the reproductive system in gilts, problems with fertilization, large litters but tiny piglets). In recent years, many producers have focused on increasing litter size and weaning weights of piglets in addition to an emphasis on increasing sow productive life span. In replacement gilts, the systematic evaluation of both reproductive and structural soundness is of paramount importance. The main aim of this review is to summarize the current criteria for selecting replacement gilts.

Keywords: swine, gilt selection, reproductive efficiency, replacement gilts, breeding herd

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Resumen – La hembra de reemplazo: Estrategias actuales para la mejora del hato de cría

La eficiencia de la producción porcina es afectada por muchos factores. Uno de los factores económicamente más importantes es el desempeño reproductivo de la hembra de reemplazo. Para lograr resultados satisfactorios en las hembras de cría, se deben monitorear y mejorar constantemente, tanto los factores los medioambientales y genéticos. Por muchos años, la selección intensiva en la industria porcina para el aumento en la relación músculo grasa de la canal ha llevado al deterioro de algunas características reproductivas (vg, un desarrollo menos favorable del sistema reproductivo en hembras de reemplazo, problemas de fecundación, camadas grandes pero lechones pequeños). En años recientes, muchos productores se han enfocado en el aumento el tamaño de la camada y peso de destete de los lechones, además del énfasis en el aumento de la vida reproductiva de la hembra. En las hembras de reemplazo, la evaluación sistemática de la solidez reproductiva y estructural es de primordial importancia. El principal objetivo de esta revisión es resumir los criterios actuales para la selección de hembras de reemplazo.

Résumé – La cochette de remplacement: Stratégies actuelles pour l'amélioration du troupeau reproducteur

L'efficacité de la production porcine est affectée par plusieurs facteurs. Un des plus importants facteurs économiques est la performance reproductrice des cochettes. Afin d'obtenir des résultats satisfaisants en reproduction, les facteurs environnementaux et génétiques doivent être surveillés et constamment améliorés. Pendant plusieurs années la sélection intensive dans l'industrie porcine pour l'augmentation du ratio muscle de la carcasse/gras a mené à la détérioration de certaines caractéristiques liées à la reproduction (eg, développement moins favorable du système reproducteur des cochettes, problèmes de fertilisation, portées nombreuses mais petits porcelets). Au cours des dernières années plusieurs producteurs se sont concentrés à augmenter la taille des portées et sur le poids des porcelets au sevrage en plus de mettre une emphase sur l'augmentation de la vie reproductive des truies. Chez les cochettes de remplacement l'évaluation systématique des qualités reproductive et structurale sont d'importance primordiale. L'objectif principal de la présente revue est de résumer les critères courants pour sélectionner les cochettes de remplacement.

Reproduction is one of the most important factors influencing the efficiency of livestock production. In swine production systems, management and selection of replacement gilts is of great importance as these gilts represent the future production potential of the herd.[1] Unfortunately, heritability of most reproductive traits is low, and thus it may be difficult to improve reproductive traits through selection.[2,3] Those low heritable traits, such as fertility and piglet survival rate, are dependent on complex interactions between sow, boar, and embryo or piglet genotypes. Although, traits dependent on the female genotype (ie, ovulation rate and age at puberty) are possible to improve.[4] Proper selection of replacement gilts is based on many factors ranging from predicted reproductive ability to phenotypic production traits. The culmination of genetic factors, such as adequate growth and development, as well as

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environmental factors, such as management and selection, must be efficiently managed to maximize profit. This review article presents the current state of knowledge regarding selection of replacement gilts and the reproductive issues associated with gilts.

Herd management

The future production potential of a herd is closely related to replacement selection. Proper gilt selection is not a guarantee of profit, stability, or high business efficiency, but is a prerequisite for success. The number of sows culled annually by a farm depends on many factors such as health, climate, management, and breeding system. Annual sow culling rates have been reported to be 35% to 59%.[5-11] According to Früh,[12] in organic farms, more sows are culled in indoor (47.7%) than outdoor housing systems (45.8%). High replacement rates during the year may adversely affect the herd performance and production costs. The main reasons for culling sows are reproductive issues, such as return to service, failure to conceive, and anestrus, but production issues such as small litter size and lameness also contribute.[7,13] Reproductive issues comprise 27% to 34% of all culled sows,[5,7] while lameness disorders account for 22.5%.[14] The occurrence of reproductive failure increasing non-productive days in the herd can cause frequent replacement of females.[15] Early culling practices reduce profit from the investment while late culling practices for low performing individuals can affect herd profitability.[16]

Years of unilateral pig selection to achieve a high growth rate and faster rates of lean muscle gain has negatively impacted sow reproductive performance.[17,18] Szostak[19] showed that a high rate of growth negatively influences fertilization effectiveness and number of piglets born and reared in the first litter. According to Hermesch et al,[20] litter size was negatively correlated with growth rate, especially in the first parity (r_g = -0.30 for 3 to 18 weeks; r_g = -0.42 for 18 to 22 weeks). The results of other studies showed fast growing gilts were less likely to farrow (r = 0.52).[21] Additionally, rapid growth can lead to infantile development of the reproductive system[22] and has negative genetic associations with sow reproductive lifetime (r = -0.02 to -0.08).[23] Despite this, development of new methods for improving breeding herd and genomic knowledge provides an opportunity to improve rearing ability. Su et al[24] reported that selection for total number born between 1992 and 2004 led to an increase of 3.8 piglets per litter for Danish Landrace and 3.0 piglets for Danish Yorkshire, reaching 15.6 and 16.7 piglets per litter respectively in 2015.[25] Reproductive traits have a low to moderate heritability and are affected largely by external and internal environment.[26,27] Heritability estimates range from 0 to 0.73 for age at puberty, 0 to 0.76 for total number piglets born, 0 to 0.66 for number of piglets born alive, and 0 to 0.23 for prenatal survival rate.[4] Therefore, many factors can cause problems with reproduction including management, lack of or unsystematic production results, semen quality, poor estrus detection, length of lactation, health, feed quality, feeding management (especially during lactation), ineffective insemination, and other reproductive disorders.[15,26] Those factors lead to return to service, thereby decreasing reproductive efficiency and increasing non-productive days. It also negatively impacts farm economics because producers are not able to maintain production levels.[28] Research conducted by Iida and Koketsu[29] on Japanese herds showed 11.6% of gilts and 9% of sows returned to service. In the United States, the percentage of animals returning to service were 14% for gilts and 7% to 9% for sows.[15,30] Gilts were more likely to return to service than sows but occurrence of anestrus is higher in groups of multiparous sows when lactation duration is 15 to 19 days.[31] Moreover, incorrect detection of estrus reduces farrowing rate and causes a decreased number of litters per sow per year.[32]

Age at puberty

Onset of puberty in gilts is associated with the occurrence of first estrus. Age of first estrus and mating or insemination of gilts has an impact on subsequent reproductive performance and longevity.[33-36] Age at puberty is moderately heritable (r = 0.38), so potential opportunities for selection exist.[37] To decide when to start breeding gilts and how long they can be retained in the breeding herd, producers should consider the housing system to be used, herd management practices, longevity, and reproductive performance.[38] The onset of puberty is influenced by many factors including genotype, technique and effectiveness of estrus detection, season, environment, boar exposure, nutrition, and health.[11,39-41]

Both longevity and future reproductive efficiency are dependent on age at first mating.[35,42] Ovulation rate at first estrus is lower than in subsequent cycles,[43] indicating that artificial insemination (AI) or natural breeding should be carried out in the second or third estrus.[44] Le Cozler et al[34] and Young et al[11] demonstrated that the age of first farrowing affects herd management and showed that younger gilts (< 185 days of age) had more piglets over parities 1 to 3 than older gilts. Whereas, Tummaruk et al[45] showed that females whose dams were gilts grew slower, had less backfat at 100 days of age, and were mated later than their counterparts reared from multiparous sows. Moreover, it was observed that females from smaller litters reached sexual maturity earlier than gilts from larger litters. Lammers et al[46] reported that gilts reach sexual maturity between 160 and 190 days of age. Similarly, Tummaruk et al[36] reported that sexual maturity occurred at 180 to 210 days of age (6 to 7 months), while the results of previous studies indicate 200 to 220 days.[38] In tropical climates, the first estrus of gilts was observed from 188 to 251 days of age.[36,47] In Scandinavian countries, the reported average age for onset of sexual maturity was: 229 days in March and 245 in November (Sweden),[48] 210 to 270 days with 120 kg body weight (Sweden),[45] and 235 days (Finland).[49]

Delayed age of first mating in gilts increases the number of non-productive days and can negatively influence subsequent reproductive performance. According to Kapelańska et al,[50] it is possible to decrease the age of first mating to less than 6.5 months of age without negative consequences to their future productivity. Moreover, it would be beneficial for a farm's economic efficiency in pig production. On the other hand, the rapid development of a gilt's reproductive system starts from 6 months of age and is usually concurrent with the first estrus cycle. Therefore, mating gilts at this time may have negative effects on growth of the gilt and number of piglets born.

Weight and backfat thickness

Body weight and backfat thickness have an impact on gilt reproduction.[51] The proper body weight at breeding is necessary to protect females against excessive weight loss during their first lactation.[52] In a study conducted by Williams et al,[53] gilts with lower body weight (< 135 kg) had smaller litters their first three parities (31.1 total piglets born) than heavier females (32.3 to 33.1 total piglets born). Small litter size occurred

among gilts whose backfat thickness was more than 20 mm.[51] The studies conducted by Tummaruk et al[36] showed on average that Landrace × Yorkshire females had their first estrus at 195 days of age with 106 kg body weight and 13 mm backfat thickness. Recent research from the same laboratory showed that replacement gilts should be bred at 240 days of age, with 130 kg body weight and 17 mm backfat thickness.[47] It was confirmed by Amaral Filha et al[54] that the largest litters were from sows with backfat thickness 16 to 17 mm. Appropriate backfat thickness results in a positive effect on litter weight and consequently limits piglet losses in the rearing period. Kummer et al[55] suggested that AI in gilts between 185 and 209 days of age is possible without adverse effects if the growth rate of individuals exceeds 700 g/day.

Season and climate

Reproductive efficiency is significantly correlated with season due to seasonal infertility. Seasonal infertility is defined as the difference between the number of successful inseminations in the summer (weeks 25 to 42) and winter seasons (weeks 1 to 18) in the same year.[56] It has been shown that the farrowing rate is lower in spring and summer than in winter.[48] Additionally, gilts born in the spring reach puberty later than those born in autumn.[57] Jarczyk and Nogaj[58] found that birth in the spring and summer seasons, positively affected reproductive efficiency and lifetime performance. Moreover, sows born from September to February had smaller litters with a higher number of males than those sows born from March to August.[59] Kawęcka et al[60] found no effect of season on the effectiveness of AI. Additionally, they noted the beneficial effect of AI, especially in summer, on the fertilization rate and the number of piglets born alive per litter. These findings were confirmed by Rekiel et al[26] which showed that stabilization of the environment inside modern pig facilities eliminated the seasonal influence on reproduction efficiency.

Studies conducted in Thailand showed that reproductive efficiency is lower in tropical than in temperate zones. The factors negatively affecting reproduction, especially the delay of first estrus and decreased litter size, include high temperature and humidity.[61-65] Pigs are very sensitive to ambient temperatures, especially in the absence of proper ventilation and can quickly become overheated. Heat stress results in decreased ovulation rate, conception rate, decreased embryo survival, and abnormal development and mortality of embryos. Gilts are the most vulnerable to adverse environmental conditions.[65]

Selection criteria

Gilt selection criteria often vary based on production goals.[66] Routine selection of gilts provides the opportunity to choose the best female for breeding. First, pre-selection should be made on the day of weaning, choosing two or three more piglets than needed as replacements, and focused on the health of individuals and pre-weaning average daily gain.[67,68] Pre-weaning growth rate positively affected post weaning growth performance and subsequent reproductive performance of sows in later life.[68-70] Moreover, Vallet et al[70] reported that selection of gilts with high birth weight characterized by slow growth rate (0.05 kg/day) during the pre-weaning period reached puberty later than gilts with lower birth weight but with higher pre-weaning growth rate. Previous results showed a relationship between weaning age and a gilt's subsequent reproduction where an increased weaning age by one day resulted in an increase of 0.185 piglets per sow per year.[68] The author[68] suggested increasing weaning age to 25 days. Additionally, gilts selected for breeding should weigh at least 7.5 kg at weaning. Final selection should be carried out around 140 days of age and should include a visual evaluation of structure with respect to feet and legs, underline, and external genitalia.[67]

Another form of selection is a one-step selection, carried out at 5 to 6 months of age. During this time, traits such as body weight, body condition, structure, backfat thickness, number of estrus cycles, and growth rate[44,71,72] are used in selection. Some researchers expanded those criteria to include structural soundness, body condition, vulva size, number of nipples, body weight, and litter size at birth.[41,46]

Criterion 1: Structural soundness and condition

Hooves and legs indicate strength and durability. Desirable legs are strong, straight, set to pasterns, and wide apart. Legs with very soft pasterns, buck kneed, too steep hock joints, or with any other abnormalities are undesirable. Properly developed limbs will support the added weight of the boar during mating, maintain proper condition during pregnancy, and prevent piglet crushing during farrowing. The problems with poor feet and leg soundness and osteochondrosis are one of the main reasons to replace sows.[32,73] Those weaknesses are visible during locomotion and changes in leg position.[74] Osteochondrosis is caused by a few factors including rapid growth, inheritance, or nutrition.[75] According to Yazdi et al,[76] correlation between osteochondrosis and longevity was low ($r = 0.07$) but significant ($P < .01$). Consequently, higher risk of culling occurs, impacting sow longevity. Heritability estimates for leg structure traits, leg score, and locomotion are low to moderate depending on the population and favorably associated with sow longevity.[23,77,78] Direct selection for improved leg soundness provides an opportunity to increase sow lifetime productivity. The two types of scoring systems for leg confirmation traits are binary and linear.[79] Both types depend on observers' training and experience, which may cause wide variations.[80]

Criterion 2: Reproductive organs

The udder is a very important criterion for replacement gilts, especially when modern females can farrow more piglets than the number of functional nipples. The evaluation is based on the number, size, shape, and location of the nipples. The udder should be wide and properly developed. Gilts should have at least 12 to 16 nipples.[41,44,46,81] Regardless of the number, the nipples should be in a straight line and evenly spaced to provide free access to all piglets. The last 3 or 4 pairs of nipples tend to tilt, making it difficult for piglets to access them. It is important to avoid clogged nipples as this is a serious problem during farrowing.[81] The number of nipples is affected by the presence of males in the litter from which the gilt was born (more males in the litter results in gilts with fewer nipples).[27,82] The gilt should have a well-developed and well-shaped vulva, proportional in size, with the tip pointing downward.[41,81]

Criterion 3: Body weight and litter size at birth

Gilts are impacted by the dam's fertility, milk production, and reproductive history, which is based on performance in the same housing conditions of the dam, gilt offspring of the dam, and siblings to the gilt undergoing selection from previous litters.[32] Additionally, a dam's reproductive history is based on good maternal ability. This trait is very

individual, so elimination of sows with poor maternal responsiveness should be based on behavioral observations.[83,84] There are two main trends of choosing gilts based on litter size. First, replacement gilts should be chosen from the largest and heaviest litter and their dams should have a high fertility rate, at least 12 to 13 piglets per litter.[26] Moreover, gilts should be chosen from sows in their third parity, when it is possible to assess the fertility of the dam.[85] On the other hand, Jarczyk et al[86] showed that replacement gilts should be selected from smaller litters because they have more uterine space, and consequently had better conditions for development and growth during gestation. Additionally, research conducted by Flowers[87] showed positive effects of being raised in a small litter which consequently increased gilt longevity (to parity 6) and lifetime reproductive performance. Replacement gilts from litters with a larger number of females had more piglets than gilts from litters with more male siblings.[88] Litters with more than 12 piglets and a large number of males (67%) can cause problems with reproduction for gilts from this litter.[77,89] This is due to the occurrence of one-way blood flow in the uterus and because fetuses are exposed to hormones produced by the embryos that preceded them, which may be the other sex.[27,82]

Criterion 4: Growth rates

Gilts, which consume more feed, grow faster but tend to accumulate fat. Overweight gilts at breeding are a possible risk factor for reduced longevity and herd reproductive efficiency.[90] It is important to choose gilts with a good appetite but to prevent their excessive fattening.[46]

Construction of reproductive organs and uterine capacity

The length of the vagina and cervix and uterine capacity are increasingly used as indicators of reproductive efficiency. Uterine capacity is defined as the ability of the uterus to provide the appropriate development of some number of embryos from implantation until birth.[91,92] Each incremental increase in uterine size increases the number of offspring obtained because the uterine horn length is correlated with ovulation rate.[91,93,94] Thus, uterine size is an important limiting factor affecting litter size at birth. Prenatal mortality is mostly caused by intrauterine crowding .[95] Fetuses that die in a crowded uterus are more likely to be male.[82] In addition to limited space in the uterus, another important conceptus survival factor is the appropriate transport of necessary nutrients.[96] It is observed that localization of an embryo within the uterine horn is correlated with its survival and growth.[26,27] Thus, longer uterine horns can interfere with the ability of the uterus to provide the necessary nutrients for all fetuses.[93] There are several scientific theories which try to explain this relationship. According to the theory from Mossman,[97] embryos implanted closest to the ovary demonstrate the greatest degree of development. In turn, Hammond[98] proposed that the rate of metabolic processes in different tissues influences the distribution of nutrients carried by the blood. Therefore, with limited nutrients, just the most important tissue may continue to grow at the expense of lower tissue metabolism.[27] Consequently, in numerous litters, the fetal development was delayed and reduced birth body weight occurred. It is caused by the rate of blood flow through the placenta, not by uterine mass.[26] A unidirectional flow of blood passes through the pig uterus washing all fetuses inside the uterine horns.[27] Another theory seeking to explain the relationship between the embryo growth and survival was formulated by Eckstein et al,[99] whereby the number of embryos in the uterine horns affects the weight of the fetus and mass of the placenta. Embryos are exposed to two impact factors: a larger number of embryos in the uterine horn results in lower blood pressure and reduced blood pressure indirectly impacts the size of the fetus.[27] Even in the early stage of pregnancy, the competition for nutrients and space is observed among fetuses.[100] The optimum space for each embryo in the uterine horn should be 20 to 35 cm.[27] Previous research suggested 36 cm as the minimal space for normal development for every fetus.[101] The uterine horn length can only be measured posthumously, so it leads to the search for correlations with other reproductive organs. Rillo et al[102] reported that for each centimeter the vagina increased in length, the uterine horns increased 8 to 9 cm. Furthermore, other research showed a relationship between vaginal and cervix length (VCL) and litter size.[9,103,104] It is confirmed by Dybała et al,[105] who also reported that sows with a longer VCL were from litters that had 0.98 more piglets when compared to gilts with a shorter VCL. On the other hand, Tarocco and Kirkwood[106] obtained opposite results. They suggested the measurement of VCL in the second estrus was not an indicator of litter size. Uterine size and VCL showed great diversity between females and increased with gilt age and subsequent litters.[93,107,108] Although, according to Dominguez et al,[109] the reproductive tract of gilts stabilized after the first litter, so gilts have a shorter VCL than sows after first parity. Therefore, the length of reproductive organs is not a significant factor for gilt selection and determination for their future potential. However, other researchers have reported correlations between: ovulation rate and length of uterine horn ($r = 0.38$), prenatal survival of fetuses and uterine capacity ($r = 0.95$), uterine length and capacity ($r = 0.51$), and VCL and litter size ($r = 0.36$).[9,93,108]

Boar exposure

Replacement gilts with body weights between 90 and 100 kg should be introduced into the breeding herd, as it is the optimal time to use boar exposure. The stimulation should be started around 140 days of age because age at puberty has been shown to be associated with age at onset of boar exposure.[110] On the other hand, van Wettere et al[42] suggested that first boar exposure should be delayed until 182 days of age because greater synchrony occurred within gilt groups. After stimulation, gilts achieved first estrus sooner and consequently their lifetime productivity was greater. Kaneko and Koketsu[111] noticed gilts in herds using boar exposure were around 13 days younger at first mating than those in herds using only indirect boar contact. It is assumed that gilts that experience estrus within 30 days of boar stimulation will have more piglets in their first litter and reach greater lifetime productivity.[33]

Longevity

High breeding herd productivity is associated with sow longevity. Many factors impact sow longevity, including genetics, nutrition, housing, disease, age at first mating, length of lactation, body condition, and growth rate.[32,112,113] The goal is for the first litter produced by a replacement gilt to recuperate the cost of her introduction into the herd. Subsequent litters will bring economic profit to producers.[46] To maximize profitability of sows, females are replaced after 4 to 5 parities[16] or longer on small farms and at 3 to 4 parities or earlier on large farms.[7,114] The decision to replace sows depends mostly on average herd productivity. The most productive parities are 2, 3 and 4[33,63,115] with a

reduction of 0.3 to 1 piglets beginning with parity 5. A high sow culling rate decreases farm productivity, especially in terms of the average number of piglets weaned per sow per year and increases the risk of introducing diseases into the herd by replacement gilts.

Summary

Over the last 20 to 30 years, the swine industry has undergone numerous changes. Despite those substantial technological and scientific changes, methodology involved in replacement gilt selection has remained largely the same as 20 years ago. The traditional selection of replacement gilts does not completely guarantee suitable reproductive efficiency. The greatest hopes are focused on genetic improvement, increased selection intensity, and the opportunity for producers to select animals with improved reproductive efficiency. Methods such as maternal responsiveness and VCL hold promise for such improvements, but more research and development is needed to perfect and disseminate these methodologies as selection tools.

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Conflict of interest

None reported.

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Peer reviewed

Original research

Stillbirths in relation to sow hematological parameters at farrowing: A cohort study

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Summary

Objective: To determine associations between stillbirths and sow hematological parameters at farrowing.

Materials and methods: A total of 160 sows from a high-performing Danish farrow-to-finish herd were chosen for the study. Standard hematological parameters were measured in sows within nine days before farrowing. At farrowing, dead piglets were collected and stillborns were identified using a lung floatation technique. The number of live-born piglets and parity of the sow was recorded after termination of farrowing. A generalized linear model was fitted to analyze the associations between each hematological parameter and the probability of stillbirth.

Results: The mean (standard deviation) sow hemoglobin concentration before farrowing was 108.5 (8.6) g/L. In total, 29 sows (18.1%) were anemic ie, hemoglobin concentration below 100 g/L. The mean number of total born and stillborn piglets per litter was 16.3 (4.1) and 1.2 (2.2), respectively. The average parity of sows was 2.8 (1.8). Piglet stillbirth was associated with several hematological parameters of the sow, namely hemoglobin concentration, mean cell hemoglobin concentration, mean corpuscular hemoglobin, red blood cell distribution width, hemoglobin distribution width, platelet distribution width, number of reticulocytes, reticulocyte hemoglobin content, and reticulocyte cellular volume. Parity of the sow and total number of piglets born per litter were also associated with stillbirths.

Implications: The probability of piglet stillbirth in this study is affected by several hematological parameters of the sow. There is also an association between probability of stillbirth and parity of the sow.

Keywords: swine, hemoglobin, stillbirth

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Resumen – Nacidos muertos en relación a los parámetros hematológicos al parto: Un estudio de cohorte

Objetivo: Determinar la asociación entre los nacidos muertos y los parámetros hematológicos de la hembra durante el parto.

Materiales y métodos: Para el estudio, se eligieron un total de 160 hembras de un hato de alto desempeño de parto a finalización Danés. Se midieron los parámetros hematológicos estándar en hembras nueve días antes del parto. En el parto, se recolectaron los lechones muertos, y se identificaron los fetos muertos utilizando una técnica de flotación de pulmón. Se registró el número de lechones nacidos vivos y la paridad de la hembra después de terminar el parto. Se ajustó un modelo linear generalizado para analizar la relación entre cada parámetro hematológico y la probabilidad de muerte fetal.

Resultados: La concentración media (desviación estándar) de hemoglobina de la hembra antes del parto fue de 108.5 (8.6) g/L. En total, 29 hembras (18.1%) estuvieron anémicas ie, concentración de hemoglobina por debajo de 100 g/L. El número medio del total de lechones nacidos y muertos por camada fue de 16.3 (4.1) y 1.2 (2.2), respectivamente. La paridad promedio de hembras fue de 2.8 (1.8). Los fetos muertos se relacionaron con varios parámetros hematológicos de la hembra, específicamente la concentración de hemoglobina, concentración media de hemoglobina celular, hemoglobina corpuscular media, amplitud de la distribución de glóbulos rojos, amplitud de la distribución de hemoglobina, amplitud de la distribución de plaquetas, número de reticulocitos, contenido de hemoglobina del reticulocito, y volumen celular del reticulocito. También se asociaron la paridad de la hembra y el número total de lechones nacidos por camada con los nacidos muertos.

Implicaciones: La probabilidad de muerte fetal del lechón en este estudio esta afectada por varios parámetros hematológicos de la hembra. También hay una relación entre la probabilidad de muerte fetal y la paridad de la hembra.

Résumé – Mortinatalités en relation avec les paramètres hématologiques des truies au moment de la mise-bas: Une étude de cohorte

Objectif: Déterminer les associations entre les mortinatalités et les paramètres hématologiques à la mise-bas.

Matériels et méthodes: Un total de 160 truies provenant d'un troupeau danois haute performance de type naisseur-finisseur a été choisi pour la présente étude. Les paramètres hématologiques standards ont été mesurés chez des truies dans un délai de neuf jours avant la mise-bas. À la mise-bas, les porcelets morts ont été ramassés et les mort-nés ont été identifiés à l'aide d'une

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technique de flottaison des poumons. Le nombre de porcelets nés vivants et la parité des truies ont été notés à la fin de la mise-bas. Un modèle linéaire généralisé a été ajusté pour analyser les associations entre chaque paramètre hématologique et la probabilité de porcelets mort-nés.

Résultats: La moyenne (écart-type) de la concentration en hémoglobine chez les truies avant la mise-bas était de 108,5 (8,6) g/L. Au total, 29 truies (18,1%) étaient anémiques ie, une concentration en hémoglobine inférieure à 100 g/L. Le nombre moyen de porcelets totaux nés et de porcelets mort-nés par portée était de 16,3 (4,1) et 1,2 (2,2), respectivement. La parité moyenne des truies était de 2,8 (1,8). La présence de porcelets mort-nés était associée avec de nombreux paramètres hématologiques de la truie, nommément la concentration en hémoglobine, la concentration moyenne d'hémoglobine cellulaire, la moyenne d'hémoglobine corpusculaire, l'étendue de la distribution des globules rouges, de l'hémoglobine, et des plaquettes, le nombre de réticulocytes, le contenu en hémoglobine des réticulocytes, et le volume cellulaire des réticulocytes. La parité des truies et le nombre total de porcelets nés par portée ont également été associés avec les mort-nés.

Implications: La probabilité de porcelets mort-nés dans la présente étude est affectée par plusieurs paramètres hématologiques de la truie. Il y a également une association entre la probabilité de mortinatalités et la parité de la truie.

In Denmark, stillbirth losses average 1.7 piglets per litter,[1] which is a serious economic and welfare issue in pig production. This problem has been increasing worldwide with the selection of sows for greater litter sizes.[2-4] Increased litter size results in decreased piglet birth weight and increased within-litter variability, which consequently may result in stillborn piglets.[5] Since 2004, Denmark's breeding strategy has been selection for piglets alive at day five instead of selection for large litter sizes. However, the number of stillborn piglets per litter has stayed constant since 2012.

Interventions to reduce the occurrence of stillbirth are very challenging in herds where stillbirths are not related to obvious infections or management factors. It has been suggested that pathogenic agents contribute to only 30% of stillbirths.[6] Several sow and piglet characteristics have been identified as potential risk factors for stillbirths. These risk factors include increased litter size, increased parity of the sow, prolonged duration of parturition, premature rupturing of the umbilical cord, birth in the last third of the birth order, and a sow hemoglobin concentration (Hb) of less than 90 g/L.[7-10] Stillbirths due to iron deficiency have been reported in older studies,[7,10-12] but the results are inconsistent or not representative of modern pig production.

Although sows get iron from the feed, the oral uptake is not always consistent and adequate.[13] Parenteral iron supplementation during pregnancy is uncommon. It has been shown that 75%[14,15] of stillborn piglets die during delivery and have lower Hb values than live-born piglets.[10,11,16] Furthermore, we have previously shown that Hb in the sow is associated to Hb in the piglets.[17] Studies of pregnant women have shown that anemia is associated with fetal mortality, spontaneous abortions, premature births, low birth weight, and immunosuppression.[18-24] It can be hypothesized that similar reproductive effects may be observed in sows. It is possible that anemia in sows may decrease the oxygen supply, decrease efficiency of uterine contractions, and cause hypoxia in piglets during parturition, thus increasing the number of stillborns. In this context, the main objective of our study was to investigate the associations between hematological parameters of the sow at farrowing and the probability of stillbirths in offspring. The secondary objectives were to determine the prevalence of anemia in sows and the effect of parity on hematological parameters.

Materials and methods

This was a cohort study using a Danish sow herd. It was carried out between July and October 2013. The study was conducted in accordance with the guidelines of the Danish Ministry of Justice with respect to animal experimentation and care of animals under study. Blood withdrawal was carried out by a skilled person with consideration to the welfare of the pigs.

Herd and sow selection

A high performing Danish farrow-to-finish sow herd was chosen for the study. The herd was selected for convenience and consisted of 1700 sows with 75 farrowings per week. The herd average for number of live-born piglets was 15.3 with 1.1 stillborn piglets per litter. A convenience sample of 160 sows from three consecutive farrowing batches were studied at the time of farrowing. In all selected sows, farrowings were induced with prostaglandin by the herd veterinarian. Farrowing induction was a routine procedure in the herd.

Hematology

Ten milliliters of blood were collected from the jugular vein of sows into EDTA tubes within nine days before farrowing and standard hematological measures were performed. The measured parameters were Hb, erythrocyte count, white blood cell count (both peroxidase method and basophil method), neutrophils (absolute count and percentage), lymphocytes (absolute count and percentage), monocytes (absolute count and percentage), eosinophils (absolute count and percentage), basophils (absolute count and percentage), platelets, mean platelet volume, platelet distribution width (PDW), red blood cell distribution width (RDW), hemoglobin distribution width (HDW), hematocrit, mean cell volume (MCV), mean corpuscular hemoglobin (MCH) and mean cell hemoglobin concentration (MCHC). Reticulocyte indices were also measured which included reticulocyte count (absolute and relative), reticulocyte hemoglobin content (Chr), mean reticulocyte corpuscular hemoglobin concentration, reticulocyte cellular volume (MCVr), reticulocyte red cell distribution width, and reticulocyte hemoglobin distribution width. Hemoglobin values received from the laboratory were multiplied by 16.11 to convert from mmol/L to g/L.[25] All laboratory analyses were done using the Advia 2120i Hematology System (Siemens Healthcare Diagnostics Inc, Tarrytown, New York) at the Veterinary Diagnostic Laboratory, Institute for Clinical Veterinary Medicine, University of Copenhagen. All methods were carried out following standard protocols of the manufacturer.

Recording stillborn pigs

Dead piglets collected during and immediately after farrowing were necropsied to determine whether they were stillborn. All fully developed piglets with uninflated lungs were considered stillborn whereas those with floating lungs were considered born alive. A piece of lung was removed using scissors and immersed in a cup of water. When the piece sank in the water, the piglet was categorized as a true stillborn assuming the piglet did not breathe. The number of live-born piglets and parity of sow was recorded after termination of farrowing. The total number of piglets born was calculated as the sum of stillborn and live-born piglets.

Statistical analysis

Data analysis was performed using SAS 9.4 (SAS Institute Inc, Cary, North Carolina). The sows were divided into two categories, anemic (Hb < 100 g/L) and non-anemic (Hb ≥ 100 g/L).[26] Additionally, anemia was categorized morphologically into three categories: microcytic (MCV ≤ 63 fL), normocytic (MCV > 63 fL ≤ 75 fL) and macrocytic (MCV > 75 fL). It was further categorized as normochromic (MCHC ≥ 18.62 mmol/L) and hypochromic (MCHC < 18.62 mmol/L). These morphological cut off values were chosen based on normal values for sows two weeks or less before parturition.[27] Similarly, three parity ranks were defined: parity rank 1 included first parity sows, parity rank 2 included sows between parities 2 and 4, and parity rank 3 included sows in parities higher than 4.

The difference in hematology between the parity categories was assessed by ANOVA using a general linear model (PROC GLM procedure) in case assumptions for the parametric test were met. Pairwise comparisons across parities were made using Least Square Means with Tukey-Kramer adjustment. Whenever assumptions of parametric test were not met, a Kruskal-Wallis test was used and in case of significance, pairwise comparisons were made using the Dwass-Steel-Critchlow-Fligner method.

A similar method was used to detect differences in the total number of piglets born and stillborn piglets between those categories, as the assumptions for the parametric test were not met.

To study associations between sow hematology and stillbirths, the probability of piglet stillbirth was modelled as the outcome variable. The explanatory variables of primary interest were the measured hematological parameters, which were tested separately. Other explanatory variables in each of the analyses were parity rank of the sow, total number of piglets born, and their interaction. A generalized linear model was fitted to analyze the associations between each measured hematological parameter and the probability of stillbirth. This was done with separate models for each hematological parameter using the PROC LOGISTIC procedure. The variables were removed from the model using backward elimination. Model fit was assessed using Deviance and Pearson Goodness-of-Fit statistics. Predicted probabilities of stillbirths were calculated for each level of Hb based on the final model. Statistical significance was set to $P < .05$.

Results

Altogether, 160 sows were included in the study. The average parity of the sows was 2.8 (± 1.8) with average total born of 16.3 (± 4.1), and stillborns of 1.2 (± 2.2). In total, 2610 piglets were born, of which 195 were stillborn (7.5%). Seventy-seven sows (48.1%) had no stillborn piglets, 41 sows (25.6%) had 1 stillborn piglet, and the remaining 42 sows (26.2%) had more than one stillborn piglet. Table 1 presents the descriptive summary of the study herd with respect to total number of piglets born, stillborn piglets, and mean Hb of sows within each parity distribution.

Prevalence of anemia in sows

Altogether, 29 sows (18.1%) were anemic with Hb values below 100 g/L. On average, these sows had 1.7 (± 2.6) stillborn piglets compared to 1.1 (± 2.1) stillborn piglets from non-anemic sows, which had Hb values equal to or greater than 100 g/L. Morphological characterization of anemia revealed that 39 sows had microcytic blood cells, whereas 121 sows had normocytic blood cells. Similarly, 32 sows had hypochromic blood cells, whereas 128 had normochromic blood cells. Only nine sows had both microcytic and hypochromic blood cells. Other sow hematological values are presented in Table 2.

Differences across parities

There were 41 parity rank 1 sows, 93 sows in parity rank 2, and 26 sows in parity rank 3. A significant difference in Hb levels among the three parity ranks was found ($P < .001$). Parity rank 1 sows had significantly higher Hb (113.0 ± 6.9 g/L) compared to parity rank 2 (107.4 ± 8.3 g/L) and parity rank 3 (105.8 ± 9.6 g/L) sows ($P = .001$ in both cases). There was no difference in Hb values between parity rank 2 and parity rank 3 sows ($P = .65$). The differences in other hematological parameters across parity ranks are presented in Table 2. The total number of piglets born was different among the three parity ranks ($P < .001$). Parity rank 1 sows had significantly fewer total born piglets (13.9 ± 3.4) compared to parity rank 2 (17.0 ± 3.7) and parity rank 3 (17.6 ± 4.6) sows ($P < .001$ and $P = .0025$, respectively). No difference was found in the total number of piglets born between parity rank 2 and parity rank 3 sows ($P = .92$). Similarly, there was no difference in the number of stillborn piglets among the parity ranks ($P = .14$).

Stillbirths in relation to sow hematological parameters

The results from the final generalized linear model measuring associations between hematology parameters and probability of stillbirth are shown in Table 3. Piglet stillbirths were associated with several hematological parameters, namely Hb (Figure 1), MCH, MCHC, RDW, HDW, PDW, the number of

Table 1: Descriptive farrowing data and sow hemoglobin by parity

Sow parity	Sows, n (%)	Hb, mean (SD), g/L	Total-Born Piglets, mean (SD)	Stillborn Piglets, mean (SD)
1	41 (25.6)	113.0 (7.0)	13.9 (3.4)	1.4 (2.9)
2	45 (28.1)	107.1 (8.8)	16.2 (3.3)	1.2 (2.6)
3	29 (18.1)	106.6 (8.0)	17.7 (3.2)	0.7 (1.1)
4	19 (11.9)	109.2 (8.0)	17.9 (5.0)	1.2 (1.2)
5	7 (4.4)	104.5 (4.9)	18.0 (4.3)	1.8 (1.6)
6	11 (6.9)	109.4 (12.7)	18.5 (3.8)	1.7 (1.6)
7	5 (3.1)	100.9 (5.2)	16.2 (5.2)	1.2 (1.6)
8	1 (0.6)	109.5	6.0	0.0
9	2 (1.3)	100.7 (10.2)	20.0 (1.4)	0.5 (0.7)
Herd total	160	108.6 (8.6)	16.3 (4.1)	1.2 (2.2)

Hb = hemoglobin; SD = standard deviation.

Table 2: Mean (SD) sow hematological values for different parity ranks at farrowing

Hematological parameters	Unit	Parity rank*			*P*	Herd average
		1	2	3		
RBC	$\times 10^{12}$ cells/L	5.75 (0.39)[a]	5.38 (0.47)[b]	5.00 (0.45)[c]	< .001	5.41 (0.51)
Hct	L/L	0.36 (0.02)[a]	0.35 (0.02)[b]	0.34 (0.02)[b]	< .001	0.35 (0.02)
Hb	g/L	113.00 (6.95)[a]	107.38 (8.34)[b]	105.76 (9.63)[b]	< .001	108.56 (8.61)
MCV	fL	63.98 (2.47)[b]	65.10 (2.79)[b]	68.63 (2.57)[a]	< .001	65.39 (3.06)
MCHC	mmol/L	19.08 (0.77)	19.07 (0.58)	19.15 (0.46)	.83	19.08 (0.61)
MCH	fmol	1.22 (0.06)[b]	1.24 (0.06)[b]	1.31 (0.05)[a]	< .001	1.24 (0.07)
HDW	mmol/L	1.18 (0.09)	1.18 (0.17)	1.15 (0.13)	.36	1.18 (0.15)
Platelets	$\times 10^{9}$ cells/L	160.29 (55.23)	152.80 (64.29)	155.53 (55.72)	.80	155.16 (60.47)
MPV	fL	9.84 (1.85)	9.85 (1.86)	9.63 (1.75)	.88	9.81 (1.83)
PDW	%	59.77 (13.42)[a]	57.13 (12.23)[ab]	50.51 (6.48)[b]	.02	56.73 (12.14)
WBC	$\times 10^{9}$ cells/L	15.77 (3.10)[a]	12.95 (3.04)[b]	11.18 (2.10)[c]	< .001	13.38 (3.29)
RDW	%	16.70 (0.99)[a]	16.34 (1.43)[a]	15.53 (1.33)[b]	< .001	16.30 (1.36)
Mono, count	$\times 10^{9}$ cells/L	0.80 (0.22)[a]	0.56 (0.15)[b]	0.47 (0.12)[c]	< .001	0.61 (0.20)
Lymp, count	$\times 10^{9}$ cells/L	6.54 (1.23)[a]	4.54 (1.31)[bc]	4.23 (0.79)[c]	< .001	5.00 (1.52)
Neut, count	$\times 10^{9}$ cells/L	7.30 (3.02)	6.88 (3.04)	5.73 (2.07)	.06	6.80 (2.93)
Eos, count	$\times 10^{9}$ cells/L	0.92 (0.39)[a]	0.78 (0.42)[ab]	0.60 (0.25)[b]	.002	0.79 (0.40)
Baso, count	$\times 10^{9}$ cells/L	0.08 (0.06)[a]	0.05 (0.01)[b]	0.03 (0.01)[c]	< .001	0.05 (0.03)
Mono, diff	%	5.18 (1.39)[a]	4.46 (1.10)[b]	4.27 (1.06)[b]	.001	4.62 (1.22)
Lymp, diff	%	42.50 (8.84)[a]	36.39 (11.75)[b]	38.73 (8.90)[ab]	< .001	38.34 (10.90)
Neut, diff	%	45.13 (10.21)[a]	51.71 (12.49)[b]	50.10 (9.99)[ab]	< .001	49.76 (11.83)
Eos, diff	%	5.92 (2.49)	6.11 (3.03)	5.63 (2.65)	.69	5.98 (2.83)
Baso, diff	%	0.53 (0.33)[a]	0.39 (0.14)[b]	0.33 (0.10)[b]	< .001	0.41 (0.21)
Retic, count	$\times 10^{9}$ cells/L	87.06 (28.34)[a]	75.26 (35.59)[bc]	62.48 (28.48)[c]	< .001	76.21 (33.53)
Retic relative count	%	1.52 (0.54)	1.42 (0.80)	1.27 (0.66)	.09	1.42 (0.72)
MCVr	fL	84.20 (3.51)[b]	85.25 (3.84)[b]	87.66 (2.94)[a]	< .001	85.37 (3.77)
CHCMr	mmol/L	16.18 (0.41)	16.24 (0.47)	16.38 (0.40)	.20	16.25 (0.45)
Chr	fmol	1.35 (0.06)[b]	1.37 (0.06)[b]	1.42 (0.05)[a]	< .001	1.37 (0.06)
RDWr	%	15.24 (1.13)[a]	15.27 (1.67)[a]	14.64 (2.39)[b]	.01	15.16 (1.70)
HDWr	mmol/L	1.55 (0.13)	1.61 (0.21)	1.65 (0.30)	.30	1.60 (0.21)

* Parity rank1 included first parity sows, parity rank 2 included sows between parities 2 and 4, and parity rank 3 included sows in parities higher than 4.

[abc] Means within a row with different superscripts are significantly different ($P < .05$; ANOVA in case assumptions of parametric test were met, Kruskal-Wallis test in case assumptions of parametric test were not met).

SD = standard deviation; RBC = red blood cell count; Hct = hematocrit; Hb = hemoglobin; MCV = mean corpuscular volume; MCHC = mean cell hemoglobin concentration; MCH = mean corpuscular hemoglobin; HDW = hemoglobin distribution width; MPV = mean platelet volume; PDW = platelet distribution width; WBC = white blood cell count; RDW = red blood cell distribution width; Mono = monocytes; Lymp = lymphocytes; Neut = neutrophils; Eos = eosinophils; Baso = basophils; diff = differential; Rectic = reticulocyte; MCVr = reticulocyte cellular volume; CHCMr = mean reticulocyte corpuscular hemoglobin concentration; Chr = reticulocyte hemoglobin content; RDWr = reticulocyte distribution width; HDWr = reticulocyte hemoglobin distribution width.

reticulocytes, Chr, and MCVr. The probability of stillbirth in relation to these hematological parameters was dependent on parity of the sow and total number of piglets born per litter. No interaction was found between parity of the sow and total number of piglets born per litter in any of the analysis.

Discussion

The herd selected for this study had good health status and high productivity with 15.3 live-born and 1.1 stillborn piglets per litter. In this study, stillborn piglets were observed in 83 (51.9%) litters and the stillborn percentage was relatively low (7.4%) compared to the average in Denmark[1] (9.6%) which may be related to good farrowing surveillance and use of prostaglandin for farrowing induction. This is in agreement with other studies that have shown reduced stillborn piglets per litter in attended farrowings compared to non-attended farrowings.[28,29] Similarly, induced farrowings result in a decreased number of stillbirths compared to non-induced farrowings.[30] Furthermore, the stillborn piglets reported in this study are true stillborn piglets identified by lung floatation technique, whereas the national figures are based on numbers reported by workers at the farm using visual judgement. The stillbirth rate was similar or higher than reported in earlier international literature which lies between 5.6 to 7.5%.[31,32] In these studies, a smaller litter size was observed, 12.2 and 13.5, compared to 16.3 total born piglets in the present study.[31,33] Nevertheless, good farrowing surveillance and use of prostaglandin in our study may have influenced the effect of sow hematology on the stillbirth rate. Furthermore, different sow and piglet factors reported to be associated with piglet stillbirth,[33] such as farrowing duration, sow body condition, and piglet birth order, were not included in this study.

The mean sow Hb values from this study were below the normal reference interval (110 to 145 g/L) for sows two weeks or less before parturition.[27] However, Hb reference ranges vary greatly between breeds, age, season, physiological status, sample size, other management factors, and the laboratory measurement techniques. The Hb values in the study sows decreased after first parity, which is in agreement with other studies.[32]

This study indicates that stillbirths are negatively associated to Hb and other hematological values related to physiological performance of the sow at farrowing. The association between stillbirths and hematological values in the sow may be related to oxygen supply during farrowing or related to the nutritional iron deficiency in the sow. High hematological values of the sow may also reflect the efficiency of uterine contractions and the vigor of the litter at the onset of parturition. This might have a positive effect in reducing the number of stillborn piglets.

Both the indices of mature erythrocytes (Hb, MCH, MCHC, RDW, HDW) and indices of immature erythrocytes (reticulocytes, Chr, MCVr) showed an association with stillbirths. Indices of immature erythrocytes (eg, reticulocytes) show more recent bone marrow activity because of their short life span as compared to the indices of mature erythrocytes.[34,35] Therefore, the stillbirths associated with immature erythrocyte indices may be related to sow physiological characteristics during or shortly before farrowing, although blood samples were taken in this study within nine days before farrowing. However, changes in mature erythrocyte indices associated with stillbirths are also related to hematological changes long before farrowing. The change in mature erythrocyte indices could also be related to piglet development in the uterus before parturition. Further investigations are required to study this effect.

Considerably increased RDW, HDW, PDW, and reticulocytes in the sow can reflect iron deficiency and therefore, the probability of stillbirths would be expected to increase. However, this was not seen in our study because all these parameters showed a negative association with the proportion of stillbirths. The role of hematological parameters other than Hb in stillbirths has not been studied before and the exact role is therefore unknown.

In a Canadian study, an association between the probability of stillbirth and reduced Hb in piglets was found, but no association was observed between stillbirth and sow Hb in the final statistical model.[11] It has been reported that stillborn piglets have lower Hb values than live-born piglets.[10,16] We have previously shown that Hb values in newborn piglets are related to Hb values in the sow.[17] Therefore it seems that Hb levels of both the sow and piglets are important factors related to stillbirth.

Some sows in this herd had microcytic or hypochromic blood cells, though the number of sows that had both microcytic and hypochromic blood cells was very few. Microcytic-hypochromic anemia is one of the striking features of iron deficiency. Nevertheless, iron deficiency is the main cause of microcytic anemia in which the red blood cells appear smaller. Lead poisoning and vitamin B6 (pyridoxine) deficiency also cause microcytic anemia but these conditions are not reported in sows under commercial conditions.

This study shows an association between probability of stillborn piglets and parity of the sow. Stillbirth probability in parity rank 1 and 3 sows was higher compared to parity rank 2 sows. This result is consistent with the findings of Leenhouwers et al[15] who observed a greater number of stillbirths per litter in first parity sows than in second parity sows. The number of stillbirths then increased between the second and fifth parity. Canario et al[36] also found a greater probability of stillbirths in first parity sows compared to second parity sows. A larger number of stillbirths in first parity sows could be related to too narrow a birth canal or a small uterus.[15,36,37] The stillbirths in higher parity sows could be related to poor muscle tone, increased farrowing duration, and pathological changes in the reproductive tract.[38]

The probability of stillbirth was dependent on the total number of piglets born. This is in agreement with previous studies which report higher stillbirths with increased litter size.[2,3] Selection for increased litter size may result in decreased piglet birth weight and increased within-litter variability, which consequently results in more stillborn piglets.[5] Studies have also shown that increased litter size results in longer farrowing duration increasing the risk of piglet hypoxia due to detachment of the placenta or rupture of the umbilical cord.[11,33,36,39]

It has been estimated that of all stillborn piglets, most of them die during farrowing and only a few of them die either shortly before or immediately after farrowing. Such differentiation of stillborn piglets was not made in the current study. The role of hematological parameters in the farrowing process is obscure. A possible explanation for the association between Hb and other hematological parameters and stillbirths could be decreased oxygen supply in the piglets due to low iron status in the sow. This suggests the possibility of decreasing the number of stillborn piglets by improving the sow hematological status. The main limitation of this study is that only

Table 3: Effect of sow hematology at farrowing on the probability of stillborn piglets per litter

Hematological parameters	Probability estimate	Standard error	*P**
Hemoglobin (g/L)	-0.0330	0.0096	< .001
Intercept	0.0829	1.1498	.943
Parity rank 1†	0.5487	0.1363	< .001
Parity rank 2†	-0.3780	0.1025	< .001
Total born	0.05487	0.1363	.012
MCH (fmol)	-4.1942	1.1743	< .001
Intercept	1.4101	1.4651	.336
Parity rank 1	0.2988	0.1355	.027
Parity rank 2	-0.4481	0.1069	< .001
Total born	0.0822	0.0244	< .001
MCHC (mmol/L)	-0.6375	0.1313	< .001
Intercept	8.1094	2.4371	< .001
Parity rank 1	0.4604	0.1334	< .001
Parity rank 2	-0.4074	0.1037	<.001
Total born	0.0921	0.0249	< .001
RDW (%)	-0.2193	0.0648	< .001
Intercept	0.0229	1.1480	.984
Parity rank 1	0.5292	0.1351	< .001
Parity rank 2	-0.3208	0.1023	.002
Total born	0.0615	0.0231	.008
HDW (mmol/L)	-2.0607	0.6569	.002
Intercept	-1.2259	0.8637	.156
Parity rank 1	0.4655	0.1320	< .001
Parity rank 2	-0.3507	0.1022	< .001
Total born	0.0691	0.0233	.003
PDW (%)	-0.0166	0.00714	.012
Intercept	-2.6484	0.5857	< .001
Parity rank 1	0.4674	0.1313	< .001
Parity rank 2	-0.3226	0.1022	.002
Total born	0.0651	0.0234	.005
Reticulocytes ($\times 10^9$ cells/L)	-0.00540	0.00272	.047
Intercept	-3.2448	0.4536	< .001
Parity rank 1	0.4889	0.1347	< .001
Parity rank 2	-0.3561	0.1023	< .001
Total born	0.0701	0.0232	.003
Chr (fmol)	-3.8509	1.2227	.002
Intercept	1.4260	1.6451	.386
Parity rank 1	0.3322	0.1329	.012
Parity rank 2	-0.4156	0.1051	< .001
Total born	0.0880	0.0247	< .001

Table 3: Continued

Hematological parameters	Probability estimate	Standard error	*P**
MCVr (fL)	-0.0499	0.0215	.020
Intercept	0.5436	1.8341	.767
Parity rank 1	0.3540	0.1324	.008
Parity rank 2	-0.3812	0.1035	< .001
Total born	0.0751	0.0236	.001

* Statistical analysis was done using a generalized linear model. The probability of piglet stillbirth was modeled as the outcome variable with sow hematological parameters, sow parity rank, total number of piglets born, and their interaction as explanatory variables. Parity rank 3 is the reference group in each of the analysis.

† Parity rank1 included first parity sows, parity rank 2 included sows between parities 2 and 4, and parity rank 3 included sows in parities higher than 4.

MCH = mean corpuscular hemoglobin; MCHC = mean cell hemoglobin concentration; RDW = red blood cell distribution width; HDW = hemoglobin distribution width; PDW = platelet distribution width: Chr = reticulocyte hemoglobin content; MCVr = reticulocyte mean corpuscular volume.

one sow herd was investigated, therefore future studies on additional herds are warranted. Furthermore, studies are needed to investigate whether sow Hb values can be increased, which could serve as a herd intervention to reduce the number of stillborn piglets.

Implications

- In this study, the probability of piglet stillbirth is affected by several hematological parameters of the sow.
- Piglet stillbirths may be reduced by modifying hematological levels of the sow.
- Further studies are needed to investigate whether sow Hb can be increased (eg, iron supplementation) to have better oxygen carrying capacity.

Acknowledgements

The authors wish to thank Pharmacosmos A/S for funding the blood testing and transport during the study. Anna Kathrine Jensen is acknowledged for assistance in the herd.

Conflict of interest

Jens Peter Nielsen has consulted for Pharmacosmos A/S which financed the laboratory testing of samples in this study.

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.

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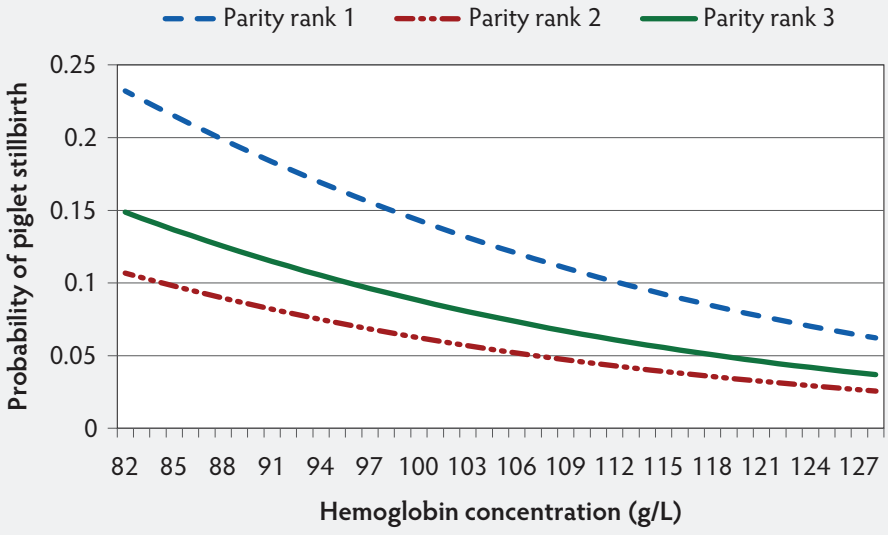
Figure 1: Probability of stillbirths in relation to sow hemoglobin concentration at farrowing. Parity rank1 included first parity sows, parity rank 2 included sows between parities 2 and 4, and parity rank 3 included sows in parities higher than 4. Probability was estimated with 16 total born piglets using the final generalized linear model ($P < .001$).



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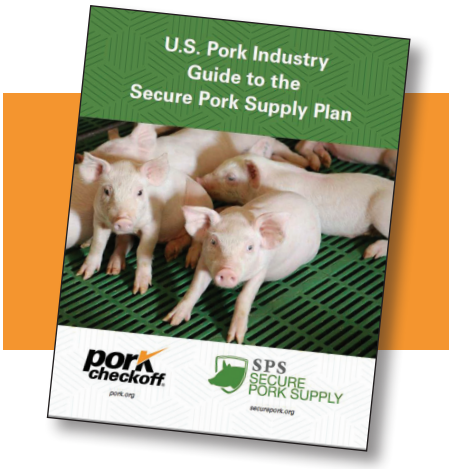
* Non-refereed references.

New guide provides overview of Secure Pork Supply plan

The Pork Checkoff continues to plan for the day when the US pork industry will get the bad news that foot-and-mouth disease, classical swine fever, or African swine fever has been diagnosed in the United States. While we understand that livestock movement restrictions will be put into place, what should each pork producer do to help mitigate losses and prove their site is disease-free? Answers to those questions and more are discussed in the National Pork Board's new Secure Pork Supply (SPS) plan guide. This 12-page booklet, created in collaboration with Iowa State University, covers the SPS plan's essentials and helps explain how the program will work as the industry will try to normalize itself post-outbreak and provide a better path to business continuity. The resource is available electronically online via the Checkoff's Pork Store and by searching on **pork.org**.

For more information, contact Patrick Webb, **PWebb@pork.org** or 515-223-3441.



Secure Pork Supply plan moves ahead

It's full steam ahead for the nation's Secure Pork Supply (SPS) plan. Work continues toward completing the necessary business continuity software that will share real-time industry data to animal health officials when every second will count during a foreign animal disease (FAD) outbreak.

The software and its associated dashboards will deliver data in a unique and practical way to allow users to make management decisions more quickly than before because of the ability to display data that is easily digestible. This will be invaluable in the face of a FAD outbreak where movement of low-risk pigs and a return to normal business will be of utmost importance.

While the threat posed by FADs is driving the SPS plan and software development, the system will be useful for more everyday disease-monitoring purposes and will allow users to share information and track any disease they may elect. This can serve as a great tool to help producers and their veterinarians make better disease management and production decisions.

The intent is to have the software developed in the first half of 2019, which is when producers can begin officially registering for the voluntary SPS program. The SPS plan is the result of ongoing collaboration between the US Department of Agriculture, the National Pork Board, the National Pork Producers Council, the American Association of Swine Veterinarians, academia, and other state and federal partners.

For more information, contact Patrick Webb, **PWebb@pork.org** or 515-223-3441.

New General Swine Disease booklet available

The National Pork Board announces that the new General Swine Disease Research 2004-2018 booklet is now available. This 84-page edition succeeds the 2012 edition and is aimed at providing producers, veterinarians and veterinary researchers an informational resource of Checkoff-funded research that focuses on endemic, domestic swine diseases.

The resource is available electronically online via the Checkoff's Pork Store and by searching on **pork.org**.

For more information, contact Lisa Becton, **LBecton@pork.org** or 515-223-2791.

NPB news continued on page 225

Go the extra yards
in your farrowing house with our convenient 250 mL vials of injectable iron in doses of either 200mg/mL or our new 100mg/mL.

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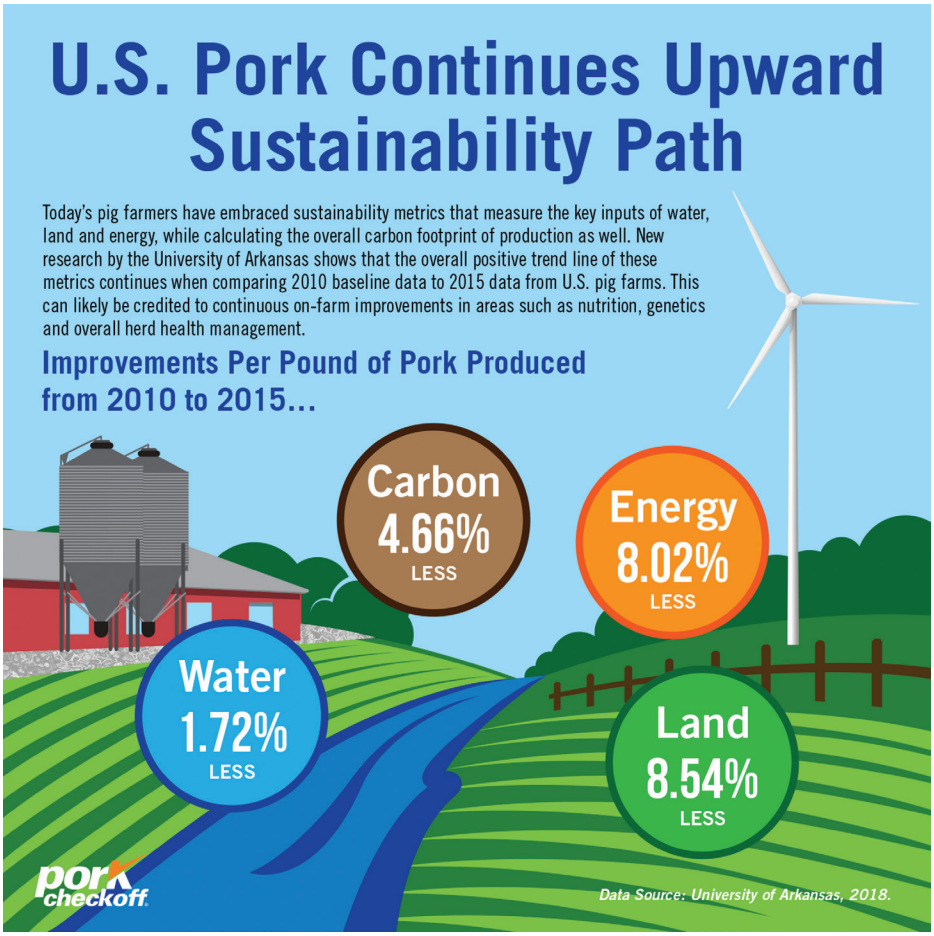
NPB news continued from page 223

Checkoff touts sustainability

Today's pig farmers have embraced sustainability metrics that measure key inputs of water, land, and energy, while calculating the overall carbon footprint of production as well. New research by the University of Arkansas shows that the overall positive trend line of these metrics continues when comparing 2010 baseline data to 2015 data from US pig farms. This can likely be credited to continuous on-farm improvements in areas such as nutrition, genetics, and overall herd health management.

For more information, contact Allan Stokes, **AStokes@pork.org** or 515-223-3447.



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AASV NEWS

AASV adopts position on information technology

On January 3, 2018, an ad hoc group of representatives from the National Pork Board, National Pork Producers Council, Swine Health Information Center, and American Association of Swine Veterinarians met to discuss the role of information technology (IT) in swine health. Invitees included Drs Lisa Becton (NPB), Tom Burkgren (AASV), Maryn Ptaschinski (practitioners/producers), Harry Snelson (AASV), Paul Sundberg (SHIC), Liz Wagstrom (NPPC), and Patrick Webb (NPB). The group discussed the potential impact of improved IT on the swine health concerns facing the constituents of each organization.

Producers and veterinarians have recognized the need for herd health information at the farm, regional, and national level. Recent disease challenges have increased interest in data analysis and the capability to efficiently share data on a permissioned basis. Technology now exists to enable and enhance those capabilities. In addition, state and federal animal health officials concede the need for electronic data transfer to maintain business continuity during animal health emergencies and for routine disease control programs. Improved communication technologies facilitate efforts to monitor global emerging disease challenges and raise awareness of impending threats. The veterinary diagnostic laboratories have also responded to IT concerns by working to standardize the reporting of diagnostic results.

There was also recognition by the group that stakeholders utilize data differently. Some want access to data in a manner that allows them to perform their own analysis and answer specific questions. Others are content to have a third party collect and analyze the data and provide them with routine or specialized reports of the analysis. The industry's IT solution should effectively address both scenarios to promote widespread benefit.

The group identified several areas that would benefit from a robust IT infrastructure. While the group recognized the myriad of independent efforts to address IT challenges within the industry, it was evident that there is currently no unified strategy to promote IT advances and their adoption. It was the consensus of the group that an effective coordinated IT strategy is necessary to, among other things:

- promote continuous improvement;
- facilitate the identification of swine health trends and emerging diseases;
- enable business continuity during animal health emergencies;
- enhance disease prevention, response, and recovery;
- promote trade; and
- promote permissioned data sharing within the industry and to external stakeholders when appropriate.

To this end, it was the consensus of the participants representing all four allied groups that a structured, coordinated IT strategy should be a priority for the swine industry. The group formulated the following position statement, which has been adopted by all four organizations.

Position statement

The American Association of Swine Veterinarians, National Pork Board, National Pork Producers Council and Swine Health Information Center recognize the importance of information technology and its impact on all aspects of pork production, especially swine health, production, and well-being. The industry recognizes the need to prioritize the adoption of a strategy to coordinate and direct the development of information technologies to address current and future industry needs, with the goal of promoting continuous improvement within the industry.

AASV Annual Meeting call for abstracts – Research Topics Session

Plans are underway for the 50th Annual Meeting of the American Association of Swine Veterinarians (AASV), to take place March 9-12, 2019 in Lake Buena Vista, Florida. As part of the meeting, there will be a session highlighting research projects related to swine health and production. Abstracts are now being accepted for potential presentation during the Research Topics session, which will be held Sunday, March 10th.

Those interested in making a 15-minute oral presentation should submit a one-page abstract on applied research related to swine health and production issues (virology, bacteriology, parasitology, environment, food safety, odor, welfare, etc) to **aasv@aasv.org** by **August 15, 2018.** Include the presenting author's name, mailing address, phone number, and e-mail address with each submission.

Abstracts not selected for oral presentation will be considered for poster presentation. All submitting authors will be notified of the selection results in September. Authors of abstracts selected for oral or poster presentation must provide their formatted paper by November 15, 2018 for publication in the meeting proceedings.

PLEASE NOTE: Participation in the Research Topics oral and poster sessions is at the presenter's expense. The presenting author is required to register for the meeting (nonmember participants may register at the AASV regular member rate). No speaking stipend or travel expense reimbursement is paid by the AASV.

Call for submissions – Industrial Partners

The American Association of Swine Veterinarians invites submissions for the Industrial Partners oral and poster sessions at the 50th 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 March 9-12, 2019 in Lake Buena Vista, Florida.

The oral sessions consist of a series of 15-minute presentations scheduled from 1:00 to 5:00 PM on Sunday afternoon, March 10th. 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 posters will remain on display throughout the afternoon and the following day for viewing.

NEW THIS YEAR: All companies submitting topics for presentation during the Industrial Partners sessions must register to participate in the AASV Technical Tables Exhibit before October 1st (see **aasv.org/annmtg/2019/techinfo.htm**).

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* 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 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, 2018:

1) Company name
2) Presentation title
3) Brief description of presentation content
4) Presenter name and contact details (mailing address, telephone number, and e-mail)
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 15th and must submit a paper by November 15th 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 may register at the AASV regular member rate). AASV does not provide a speaking stipend or travel reimbursement to Industrial Partners presenters.

Call for abstracts – Student Seminar

The American Association of Swine Veterinarians announces an opportunity for veterinary students to make a scientific presentation at the 50th AASV Annual Meeting in Lake Buena Vista, Florida, on Sunday, March 10, 2019. 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 (2018-2019) student member of the AASV at the time of submission and must not have graduated from veterinary school prior to March 10, 2019. Submissions are limited to one (1) abstract per student.

Abstract submission process

Abstracts and supporting information must be submitted online at **aasv2019.exordo.com** (see **www.aasv.org/annmtg/2019/studentseminar.htm** for details). Submissions must be completed before 11:59 PM Central Daylight Time on Wednesday, September 19, 2018. 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 by Friday, September 21, 2018 with supporting evidence that the submission was made in time; otherwise the abstract will not be considered for judging.

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, 2018, and those selected to participate will be expected to provide the complete paper or abstract formatted for publication by November 15, 2018.

Student Seminar and Scholarships

As sponsor of the Student Seminar, Zoetis provides a total of $20,000 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, has joined with AASV to fund a $250 stipend for each student poster presenter who personally attends the meeting to participate in the session. Those selected for poster presentation will also be expected to supply a formatted paper by November 15 for publication in the conference proceedings.

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 Newport Laboratories.

Complete information for preparing and submitting abstracts is available on the AASV Web site at **www.aasv.org/annmtg/2019/studentseminar.htm**. The rules for submission should be followed carefully. For more information, contact the AASV office by phone, 515-465-5255, or e-mail, **aasv@aasv.org**.

FOUNDATION NEWS

Have you risen to the challenge?

In an effort to achieve $2 million in restricted funds by the 2019 AASV Annual Meeting, Dr John Waddell challenged his fellow past presidents to recruit new donors to the foundation endowment.

But the challenge is really for ***all*** AASV members. Yes, you.

Your contribution to the AASV Foundation endowment helps ensure a bright future for the swine veterinary profession. It supports research into the diseases you fight every day. It funds scholarships for exceptional veterinary students and for swine veterinarians seeking advanced degrees and certifications. It supports veterinary students seeking swine practice experience and provides travel stipends for students attending the annual meeting. It supports the annual meeting keynote lectures that inspire and motivate attendees every year.

Chances are that you've benefited from one or more of these foundation-funded programs. It's time for YOU to rise to the challenge! Help continue the legacy of support that has enabled the foundation to accomplish so much, donate to the AASV Foundation endowment. Endowed contributions are invested to produce income ensuring the availability of funding well into the future, so your donation will have a lasting impact on the profession.

Endowed giving programs

Leman

If you're not already a Leman Fellow, you should be! Named for the late industry leader and former AASV president, Dr Allen D. Leman, this giving program confers the title of Leman Fellow upon those who contribute $1000 or more to the foundation endowment.

Heritage

The Heritage Fellow program represents the next level of support for the foundation, recognizing contributions of $5000 or more. In addition to monetary donations, Heritage Fellows may select from additional contribution options, including life insurance policies, estate bequests, and retirement plan assets.

Legacy

The Legacy Fund provides an opportunity to recognize a principal donor or an honoree through a significant contribution to the endowment. A donor, multiple donors, or a veterinary practice may establish and name a Legacy Fund with a monetary gift of $50,000 or more. The fund may be named after the donor or another individual or group.

For more information about the AASVF endowment giving programs, or to make a contribution, see **aasv.org/foundation**, or contact the AASV Foundation by phone, 515-465-5255, or e-mail, **aasv@aasv.org**.

Recruit and register!

It's time to recruit your golf team! Registration is now open for the annual AASV Foundation Golf Outing, slated for **Thursday, August 23rd** at Landsmeer Golf Club in Orange City, Iowa.

AASV members, industry stakeholders, and their clients, family, and staff are invited to register a 4-person team for this fun, 18-hole best-ball tournament. Individual golfers and couples are also welcome and will be assigned to a team.

Golfer check-in begins at 11:00 AM on the 23rd, with practice balls available for warming up on the driving range before the contest begins. A shotgun start at noon kicks off the four-person team, best-ball competition. Golfers compete as a foursome against the challenges of the course (and the other teams) in addition to participating in individual contests along the way.

Boxed lunches, sponsored by **APC,** and beverages, courtesy of **Zoetis,** will be supplied on-course. Numerous golf hole sponsors, including **Aurora Pharmaceutical**, **Cambridge Technologies, Elanco Animal Health, GlobalVetLINK, Hog Slat, Huvepharma, Insight Wealth Group, Merck Animal Health, National Pork Producers Council, Pharmgate Animal Health,** and **Topigs Norsvin,** will offer games and giveaways to add to the fun. When the golfing is completed, team and individual contest winners will be recognized during the pork dinner sponsored by **Boehringer Ingelheim Animal Health**.

The registration fee includes 18 holes of best-ball golf, cart, lunch, beverages, awards dinner, and prizes. Funds raised by the event support AASV Foundation programs, including research grants, travel stipends for students attending the AASV annual meeting, swine externship grants, scholarships for veterinarians pursuing board certification in the American College of Animal Welfare, tuition grants at the Swine Medicine Education Center, and more.

For a sneak peek at the golf course, visit **www.landsmeergolfclub.com**. For more information about the outing, contact AASV by phone, 515-465-5255, or e-mail, **aasv@aasv.org**.

AASV Foundation
Golf Outing

Thursday, August 23, 2018 • 11:00 AM – 6:00 PM

It's tee time!

LANDSMEER GOLF CLUB
902 7th Street NE, Orange City, Iowa
landsmeergolfclub.com

REGISTRATION FORM

Please complete, detach, and return this form with payment to the AASV Foundation by August 6, 2018

☐ Single registration $125.00
(per person - includes 18 holes of golf, golf-cart rental, refreshments, box lunch, and closing dinner)

☐ Team registration $500.00
(group of four - list names below)

1. _____
2. _____
3. _____
4. _____

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AASV Goes to Washington

The AASV Executive Committee, Drs Scanlon Daniels, Nate Winkelman, Jeff Harker, and Alex Ramirez, joined Dr Harry Snelson, AASV Director of Communications, May 7 and 8 in Washington, DC. The group joined the American Association of Bovine Practitioners' leadership for an annual visit hosted at the American Veterinary Medical Association Government Relations Division headquarters.

The purpose of the trip was to provide AASV leadership an opportunity to interact with federal regulators, government agency personnel, legislators, and swine researchers to discuss issues of concern to swine veterinarians. In addition, the Executive Committee heard from the American Feed Industry Association (AFIA), National Cattleman's Beef Association (NCBA), Association of American Veterinary Medical Colleges (AAVMC) and representatives from the National Pork Producers Council (NPPC).

Drs Steve Solomon, Director for the Food and Drug Administration (FDA) Center for Veterinary Medicine, and Bill Flynn, Deputy Director for Science Policy, represented the FDA. The agency is beginning to transition from educational veterinary feed directive (VFD) inspections to regulatory enforcement. To date, few problems have been identified and adoption of the revised VFD rule has been largely uneventful. The agency plans to issue an updated Guidance for Industry #120 revising the Frequently Asked Questions resource to include additional questions and responses.

The FDA's overall goal with the revised VFD rule and targeted guidance has been to support antimicrobial stewardship and veterinary oversight. Drs Flynn and Solomon addressed the issue of establishing duration of use for drugs for when it is undefined on the product label. This effort is in the early stages with the agency as they try to understand the scope of the issue. Many of these products were initially labeled for over-the-counter (OTC) use and are now under veterinary oversight. The agency's intent is to retain the use of the products but to bring the labels in line with the goals of veterinary oversight. They plan to release an overarching plan in the next few months outlining what needs to be addressed and a timeline. Transition of OTC products to prescription status and addressing the duration of use issue are the two primary topics to be considered in the plan.

The group also discussed the need to better understand FDA's role in protecting animal agriculture from imported ingredients that could be harboring pathogenic organisms. FDA noted that the Food Safety Modernization Act will require importers to analyze products for specific hazards if a real risk can be determined. Currently, the agency concurs that there appears to be a theoretical risk, but the real-world significance has not been established. According to Dr Solomon, FDA has regulatory authority over all feed ingredients intended for use in animal feeds, but the United States Department of Agriculture (USDA) would probably provide the data to establish the risk.

When asked about the agency's position on the regulation of gene editing in animals, Dr Solomon indicated that the agency was looking for a flexible risk-based approach to allow for production animal use. He indicated that the agency recognizes gene editing is not the same as a new animal drug but believes the practice should be regulated to ensure it is safe for the animal, public, and environment. They plan to issue a final guidance highlighting FDA's direction later this year.

In an update regarding the status of carbadox, the agency continues to review the studies provided and has requested additional information. While the review process continues, it remains legal to market and use carbadox as labeled.

"Sellers indicated that the VFD transition had gone relatively smoothly for the swine industry and approximately 70% of the VFDs are submitted electronically."

The Executive Committee talked extensively with Richard Sellers, AFIA's Senior VP, about feed-related concerns such as imported ingredients and disease transmission risks via feed-associated sources as well as the feed industry's perspective of the recent VFD changes. Sellers indicated that the VFD transition had gone relatively smoothly for the swine industry and approximately 70% of the VFDs are submitted electronically.

This year's visit also included discussions with NCBA's Drs Kathy Simmons, Chief Veterinarian, and Jessica Watson, Manager Animal Health Policy. Antibiotic use is a key issue facing NCBA including monitoring on-farm antibiotic use to address resistance issues, maintaining therapeutic antibiotics for prevention, control, and treatment of disease, and the pending review of Guidance for Industry #152 which categorizes antibiotic status relative to human health uses. Other pertinent issues include preparation for foreign animal disease response and efforts to promote an industry-driven voluntary animal identification program.

Representatives from the AAVMC met with the group to discuss several programs designed to address issues of diversity and student debt. They discussed the REAL program designed to explore research, education, advocacy, and longevity issues and the fact

that in 2017 approximately 80% of graduates have veterinary student debt.

Dr Bruce Wagner, Director USDA Center for Epidemiology and Animal Health, joined the meeting by conference call. He described the Center's plans to address antimicrobial resistance by evaluating antimicrobial stewardship and use surveys distributed in 2017. The department was disappointed in the low response rate. It was suggested that the department work closely with the livestock industries and veterinary groups to encourage greater participation in future survey efforts. The proposed longitudinal studies assessing on-farm antimicrobial use were being delayed due to concerns regarding the ability to protect the confidentiality of the biological sample data. He will work with the livestock industries to determine how to proceed.

Dr Dan Kovich, NPPC Director of Science and Technology, discussed a number of issues of importance to swine producers and veterinarians including the Farm Bill (support for funding for a foot-and-mouth disease [FMD] vaccine bank and the Secretary's decision to allow non-infectious vaccine virus on the US mainland), trade (27% of US pork is exported; China, Canada, Mexico, and Korea make up about 60% of US pork exports), immigration reform, gene editing regulation, swine slaughter modernization,

AASV Officers (left to right): Drs Nate Winkelman (President-elect), Alex Ramirez (Past president), Scanlon Daniels (President), and Jeff Harker (Vice president)

the development of alternative meats, and a recent San Francisco ordinance requiring reporting of on-farm antibiotic use.

On Tuesday, the AASV Executive Committee visited the National Institutes for Food and Agriculture (NIFA) headquarters to meet with NIFA and Agriculture Research Service (ARS) swine researchers. The group discussed federal funding for swine research and the swine-related projects ongoing at NIFA and ARS.

The group traveled to Capitol Hill to meet with legislators on behalf of NPPC to educate lawmakers on the need for the FMD vaccine bank, the importance of opening trade with Thailand, and farm worker legislation.

Harry Snelson, DVM
Director of Communications

Pigs of #instaham

Share your best pig photos for JSHAP publication.

The *Journal of Swine Health and Production* would like to publish digital photographs submitted by our readers. Images used either on the front cover or in the photo corner on the back page are to represent healthy pigs and modern production facilities. Please ensure that the photos do not include people. Select the largest image size available on your camera (not cell phone) of the quality or compression that allows you to store the fewest images on a given memory card. Do not resize, crop, rotate, or color-correct the image prior to submission to the journal. Please send the images by e-mail attachment to **tina@aasv.org**. Also include your name, affiliation, and the approximate location of the image, or other details that you would like to submit which describe the image.

Upcoming meetings

11th Biennial Conference of the Association for Applied Animal Andrology

July 14-16, 2018 (Sat-Mon)
Hilton Riverside, New Orleans, Louisiana

For more information:
Dr Steven P. Lorton
E-mail: splorton04@tds.net
Web: animalandrology.org/futuremeetings.htm

Allen D. Leman Swine Conference

September 15-18, 2018 (Sat-Tue)
Saint Paul River Centre, Saint Paul, Minnesota

For more information:
Tel: 612-624-4754
E-mail: vetmedccaps@umn.edu
Web: ccaps.umn.edu/allen-d-leman-swine-conference

2018 ISU James D. McKean Swine Disease Conference

November 1-2, 2018 (Thu-Fri)
Scheman Building, Iowa State University, Ames, Iowa

For more information:
Registration Services
Iowa State University
1601 Golden Aspen Drive #110
Ames, Iowa 50010
Tel: 515-294-6222; Fax: 515-294-6223
E-mail: registrations@iastate.edu
Web: register.extension.iastate.edu/swinedisease

For questions about program content:
Dr Chris Rademacher, Conference Chair
Iowa State University
E-mail: cjrdvm@iastate.edu

Humane Endings Symposium

November 2-4, 2018 (Fri-Sun)
Westin O'Hare, Rosemont, Illinois
Hosted by American Veterinary Medical Association

For more information:
E-mail: humaneendings@avma.org

2018 North American PRRS Symposium

December 1-2, 2018 (Sat-Sun)
Chicago Marriott, Downtown Magnificent Mile

For more information:
Dr Bob Rowland, Executive Director
E-mail: naprrs@vet.k-state.edu
Web: www.vet.k-state.edu/na-prrs

American Association of Swine Veterinarians 50th Annual Meeting

March 9-12, 2019 (Sat-Tue)
Hilton Orlando Buena Vista Palace
Lake Buena Vista, Florida

For more information:
American Association of Swine Veterinarians
830 26th Street, Perry, Iowa
Tel: 515-465-5255
E-mail: aasv@aasv.org
Web: www.aasv.org/annmtg

Asian Pig Veterinary Society Congress 2019

August 26-28, 2019 (Mon-Wed)
BEXCO, Busan 55, APEC-ro, Haeundae-gu, Busan
Republic of Korea
Tel: +82 51-740-7300

For more information:
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E-mail: sue@innon.co.kr
Web: www.apvs2019.com

Pig Welfare Symposium

November 13-15, 2019 (Wed-Fri)
Hosted by the National Pork Board

For more information:
Web: www.pork.org/pws

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

AASV Industry Support Council

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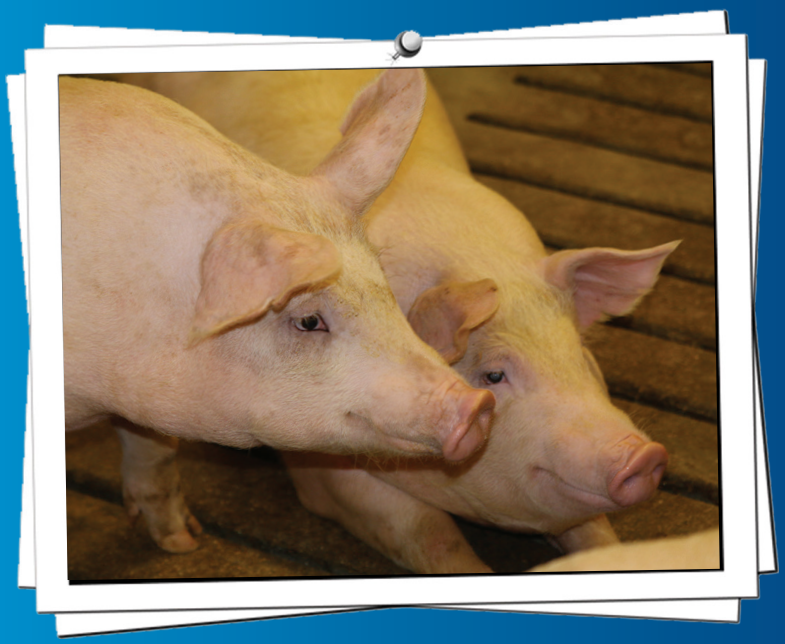

Photo Corner

Pigs at University of Missouri Swine Teaching Center.

Photo courtesy of Tina Smith