

JOURNAL OF **SWINE** HEALTH & PRODUCTION

Feeder space allowance for
growing-finishing pigs

Li YZ, McDonald KA, Gonyou HW

Modelling contamination of trucks
used for pigs infected with PRRSV

Thakur KK, Revie CW, Hurnik D, et al

In vitro fertility of cryopreserved
spermatozoa from boars
supplemented with selenium

Estienne MJ, Whitaker BD

Microcystin toxicity in nursery piglets

Classen DM, Schwartz KJ, Madson D, et al



Journal of Swine Health and Production

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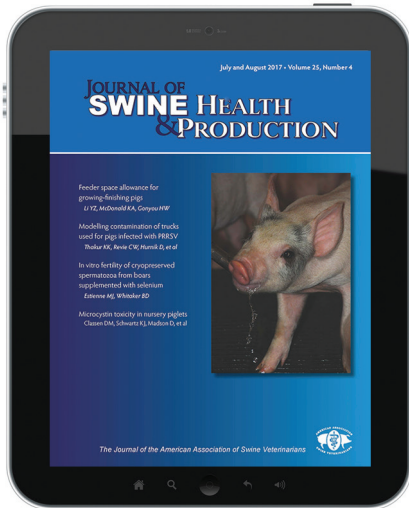
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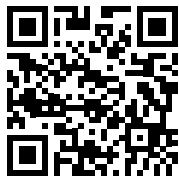
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About the cover...

A refreshing drink for an Iowa nursery pig

Photo courtesy of Tina Smith

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Upcoming meetings

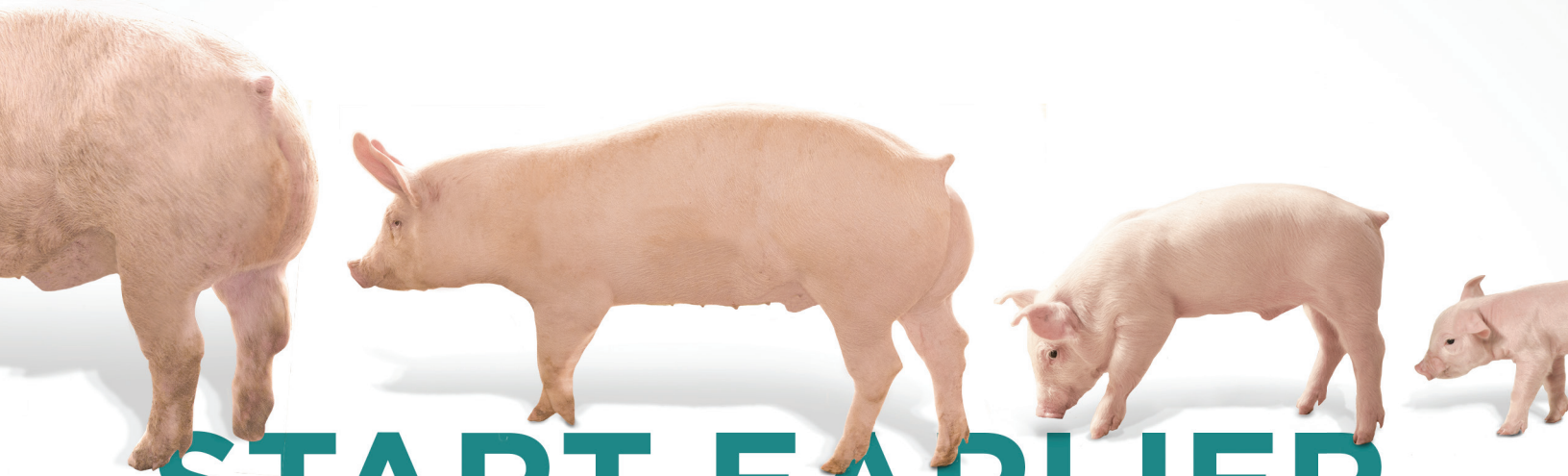
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“Our journal is ‘strong and vibrant’ today because of the work of our former leader, Bob Morrison.”

quoted from the Executive Editor's message, page 173



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9/16 SW-55269-2



Understanding generational differences

It is always interesting to hear veterinarians seeking to employ new graduates talk about “these young kids ...” and how things are so different nowadays. I have heard in the hallways, “next time a prospective employee asks me about vacation time I will tell them” As our colleague, Larry Firkins, stated in his 2013 Business Management AASV Seminar, “Every generation that enters the workforce causes stress, frustration, and criticism from the generation already employed.¹” This is not a unique situation or something “wrong” with the current generation of new graduates. This is simply part of the usual cycle of life.

The concept of generations is based on the fact that individuals born at a particular time frame are exposed to a unique mix of factors at a particular stage in life forming their general attitudes and behaviors. As a cohort, these generational groupings help us better understand differences in strengths and weaknesses between different individuals of different ages. As with any summary, when we try to generalize behaviors, we must recognize not all individuals in a cohort will have the same values or behaviors.

What is important to recognize is that these differences between generations are real; especially when it comes to values or how they

define success. Our own perspective and experience affect how we work with others. This often leads to two major mistakes. First, we assume that others define success or happiness the same way we do. We believe the best way to become successful is to work 70 to 80 hours a week, leading to more income for our clinic and thus higher profits, just like we have been doing. Millennials (born 1981 to 1997) value time off. It is not that they are lazy; their goals in life and how they define success are different.

Second, we assume that for others to achieve the same “learning” or “experience” that we have achieved they must go through the same painful process and mistakes we did. If we had to climb up a large mountain to get to the other side, we do not feel it is right for the newer generation to just be able to go through the newly constructed tunnel at the base of the mountain. If the goal is to get to the other side of the mountain, we should be happy that someone has figured out a different way to do it, or that technology today can help minimize obstacles for others rather than resent them having it “easy.”

Understanding generational differences is critical in allowing us to better communicate and move forward not only with our prospective employees, but also with our clients and consumers. We have learned the value of personality testing in the workplace.

“As a cohort, these generational groupings help us better understand differences in strengths and weaknesses between different individuals of different ages.”

Personality testing is not done to identify who is right and who is wrong. Personality testing is not done to decide whom you should hire. Personality testing is done to better understand how to better communicate and motivate others within a workplace. The same is true about different generations. It is not about one generation being better than the other, but rather simply recognizing they are different. As such, we must adapt our approaches to better connect and better stimulate them so we can all achieve our own goals. After all, since early 2015, Millennials have been the largest share of the American workforce.

Reference

1. Firkins LD. Managing generational expectations. *Proc AASV Pre-Conf Sem 7*. San Diego, California. 2013:3-4.

Alex Ramirez, DVM
AASV President

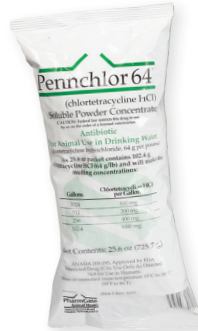




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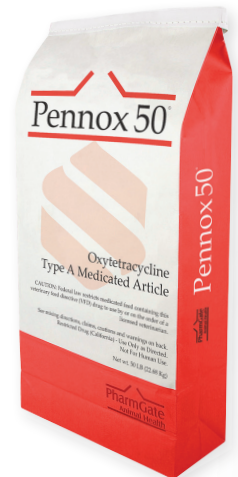
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Would it help?

In the movie “*Bridge of Spies*,” the character played by Tom Hanks, James Donovan, asks accused Russian spy Rudolph Abel “Do you ever worry?” To which Abel replies “Would it help?” Whether you liked this movie or not, this on-screen exchange lends perspective to whatever real concerns you might be facing. Personally and professionally, I try to not worry about the future and instead focus on the matters over which I might have some control. When considering an action, it is useful to ask the question “Would it help?”

As swine veterinarians, it seems like we never run out of concerns that require our attention and our action. In recognition of this perspective in 1989, a number of swine veterinarians decided to take action and form the American Association of Swine Practitioners (AASP) Foundation. These veterinarians recognized that rather than just worrying about issues, it made more sense to raise the necessary capital to take direct action. This recognition also provided a direct pathway for financial support by the members of the AASP (currently AASV).

Today, the AASV Foundation (AASVF) operates under the following mission:

To empower swine veterinarians to achieve a higher level of personal and professional effectiveness by

- *enhancing the image of the swine veterinary profession,*
- *supporting the development and scholarship of students and veterinarians interested in the swine industry,*
- *addressing long-range issues of the profession,*
- *supporting faculty and promoting excellence in the teaching of swine health and production, and*
- *funding research with direct application to the profession.*

“By concentrating on research with direct application to the profession, AASV members can have a say in what is important enough to warrant further study. There is no more direct route than that.”

Several years ago, concerns were raised over the number of veterinary graduates interested in food-animal practice. In response to those concerns, the foundation began to specifically focus on veterinary students as described in bullet #2. For many years now, funding has been provided for scholarships, externships, internships, and travel stipends to the AASV Annual Meeting. I am occasionally asked to predict the number of swine veterinarians we will need in the future. I could guess but I would almost certainly be wrong. I can, however, be confident in predicting that we can successfully educate, support, and recruit the best and brightest students who are highly motivated to become swine veterinarians. Since a low point in 1999, AASV student membership has tripled. This would not be possible without the help of the foundation.

The foundation has also embarked on funding research with direct application to the profession (bullet #5). Although the funds are not a large amount, it is a start in the right direction. It is a brutal fact that public funding for research in animal agriculture is shrinking. If

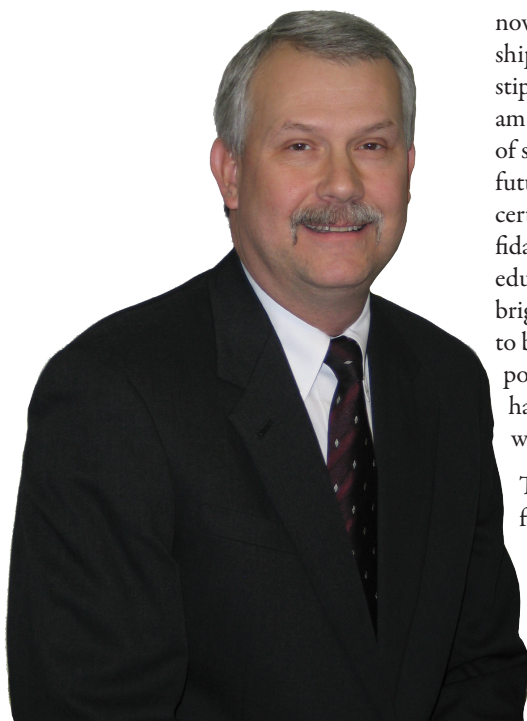
we cannot rely on a public resource then it is up to us to either fill that gap or be satisfied with less research and fewer derived benefits. By concentrating on research with direct application to the profession, AASV members can have a say in what is important enough to warrant further study. There is no more direct route than that.

An area of the AASVF mission that has not been energized yet, but has great potential, is addressing the long-range issues of the profession. The AASVF could provide a platform and needed support for the identification, discussion, and analysis of these issues. Examples could include the evolution of practice models, the effect of digital advancements, telemedicine-telehealth, and the role of the veterinarian in animal welfare. By concentrating on those issues with the most potential to “empower swine veterinarians to achieve a higher level of personal and professional effectiveness,” the AASVF can continue to fulfill its mission. The foundation is continually looking for new strategies that meet the needs of swine veterinarians. All ideas are welcome!

The AASVF has been blessed with tremendous support from AASV members as well as a number of industry partners. The endowment now stands at just over \$1 million. The board of directors has set a goal of a \$2 million endowment by the 2019 AASV Annual Meeting. We have a way to go to meet that goal, but it is certainly do-able with your help. There are currently three giving programs for individuals: Leman (\$1000), Heritage (\$5000), and Legacy (\$50,000). In addition, practices can participate in the Legacy program. Please call our office or contact one of the AASVF Board members for more information.

If you are considering a contribution to the AASVF, please ask yourself “Would it help?” I hope the track record and the commitment of the foundation will answer that question with a resounding YES!

Tom Burkgren, DVM
Executive Director



The evolution of the Journal of Swine Health and Production

Informing and speaking for swine veterinarians

Striving for excellence through the years

AASP Newsletter

Volume 1 • Number 1 July-August 1989



Control Measures for Pseudorabies

• Timothy J. Loufa

The question whether pseudorabies is a major, economically important swine disease has been hotly debated for years. This debate also has involved the issue of eradication. The availability of safe, effective, and economical vaccines has led to a national program to eradicate pseudorabies. As a practicing swine health consultant, it is my job to promote profitable swine production and to reduce the risk of economic loss. In many areas of the United States, including southern Minnesota where I practice, pseudorabies is endemic and control measures must be practiced routinely. The national program for pseudorabies eradication that began in January 1989 focuses not only on the control of pseudorabies but that practitioners be aware of methods to eradicate the disease from the client's premises eventually.

Prevention
The most important source of new infections is carrier swine brought into the susceptible herds. Most pigs brought onto farms are...

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1989

This newsletter is the effort of several members, including our Executive Secretary, Dr. Tomm Nantz, and continues on page 12.

ing companies have been used carefully for on-farm isolation. Neighboring dairy farms or retired livestock people often urge such

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AMERICAN ASSOCIATION OF SWINE PRACTITIONERS

NEWSLETTER

September-October, 1991 Vol. 3, No. 5

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1991

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Streptococcus suis meningitis in finishing pigs of a reproducted herd
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Volume 1, Number 1 January, 1993

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Swine Health and Production

Volume 2, Number 1 January and February, 1994

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Volume 3, Number 1 January and February, 1995

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What's your interpretation?

Inside back cover

1995

The Official Journal of the American Association of Swine Practitioners

What's your interpretation?
The graphic shows the distribution of weanings by day of week for a 215 sow continuous farrowing herd. Multiple mating is practiced. Lanes and gilts are mated with a boar on the first day of standing heat.

Swine Health and Production

JULY AND AUGUST, 2000

VOLUME 8, NUMBER 4

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JOURNAL OF Swine Health and Production

JANUARY AND FEBRUARY, 2001

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2001

The Journal of the American Association of Swine Veterinarians

The form manager of a new breeding herd stocked with PRRSV-negative animals began observing increased stillbirths and repeat service, as indicated by the "3-signals" on the still (stillbirth and having stage 3 shows down). What could be the possible cause, and how might you rule each in or out?

JOURNAL OF Swine Health and Production

JANUARY AND FEBRUARY, 2004

VOLUME 12, NUMBER 1

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2004

The Journal of the American Association of Swine Veterinarians

JOURNAL OF SWINE HEALTH & PRODUCTION

January and February 2009 - Volume 17, Number 1

Effectiveness and safety of two oral Salmonella vaccines

Hessa A. El-Har, BA, Wolcott DM, et al.

Phytosterols for PRDC
Fraile LJ, Crisci E, Weenberg J, et al.

The Journal of the American Association of Swine Veterinarians

2009

Recognizing the first executive editor of *Swine Health and Production*

It is with a heavy heart that I write this message after the untimely passing of Dr Bob Morrison. However, to recognize his leadership and positive influence in the early development of the *Journal of Swine Health and Production*, I wanted to share a few words. The journal would not be where it is today without his early guidance and vision.

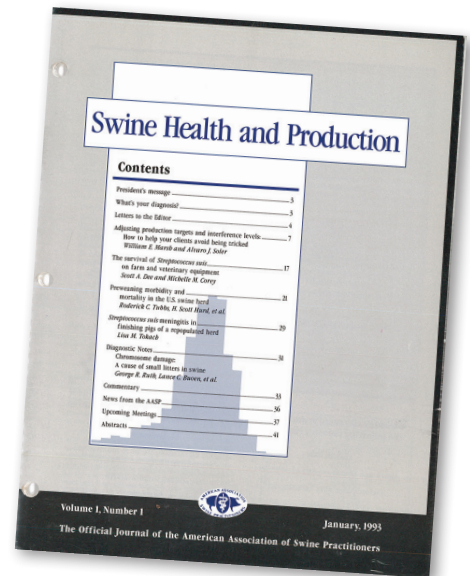
As many of you likely know, Dr Bob Morrison was the executive editor of the American Association of Swine Practitioners' (AASPs') Newsletter starting in 1991. It was in 1993, under Bob's leadership, that the AASP Newsletter became "*Swine Health and Production*" (SHAP), with Bob as first executive editor of this new journal. During Bob's tenure as editor, there was no regular "From the editor" column. However, he wrote a few messages as editor and while he was president of the AASP. I went to the first issue of SHAP, published in January-February, 1993, and there was no editor message in that inaugural issue. But I would like to quote from another letter that was published in this issue (Volume 1, Number 1, p1). In this first issue of SHAP, Dr Kent Kislisbury wrote a letter honoring Dr Al Lemman, and to summarize, he wrote "How do we honor this great man in a way that would preserve wonderful memories...how do we do something to further his quest for excellence in swine health and production?"

A short editor's message is by no means a satisfactory way to truly honor Dr Bob Morrison. But I wanted to share a few memories and quotes from his messages as editor of SHAP and president of AASV "to honor his tenure as editor of the journal" and to remember "his quest for excellence in swine health and production," as well as to help "preserve some wonderful memories."

Bob was editor of SHAP from 1991 to 1998. In 1997, under his guidance, 57 manuscripts were submitted to SHAP, representing the highest number of submissions the journal had ever reached. The annual number of submissions did not come close to that again until 2012. When Bob resigned as editor of SHAP in January-February 1998 (Volume 6, Number 1, p3) he wrote an "Editor's Note" and said "I want to take this opportunity to tell you that I have decided to 'retire' as the executive editor of *Swine Health and Production*. It is not without considerable mixed feelings that I have reached this decision. I have thoroughly enjoyed working with authors, our editorial board, reviewers, staff, and you, our readers... Being executive editor is a special privilege afforded to few individuals and I am very thankful to have had the opportunity."

Further along in this message he acknowledges the staff and AASP Executive Committee for their support and confidence to start the journal. "...the Executive Committee has been a constant source of support, giving us the ability to continue its (*Swine Health and Production's*) development into an internationally recognized forum for applied swine science." In the January-February 1999 issue of SHAP (Volume 7, Number 1, p3) the second appointed executive editor, Dr Cate Dewey, wrote an "Editor's Note" acknowledging Dr Bob Morrison's contributions to the journal.

"Under the guidance of Dr Bob Morrison, the journal has become a preeminent source of scientific knowledge for the swine industry. The journal has, since its inception, maintained a rigorous review and editorial process. It has become a journal selected by both swine researchers and practitioners as a forum for presenting research and case studies..."



The year after Bob turned the reins of the journal over to Dr Dewey, he was president of the association. And again during this time there were positive changes underway as the association changed its name from AASP to American Association of Swine Veterinarians (AASV) to be more inclusive. Bob recognized the need for this change and wrote in his president's message (2000, Volume 8, Number 4, p151): "As we know, there is great strength in diversity."

In one of Bob's messages as president, he said "Our association and profession is strong and vibrant because of the work of our former leaders, committee members, and members" (1999, Volume 9, Number 2, p51). Certainly, no truer words reflect the influence Bob has had on our journal and our association.

Our journal is "strong and vibrant" today because of the work of our former leader, Bob Morrison. As the third executive editor of JSHAP, I can only hope that we continue to respect the vision that he had for the journal. Thank you, Bob.

Terri O'Sullivan, DVM, PhD
Executive Editor



Determining feeder space allowance across feed forms and water availability in the feeder for growing-finishing pigs

Yuzhi Z. Li, BSc, MSc, PhD; Kimberly A. McDonald, BSc; Harold W. Gonyou, BSc, MSc, PhD

Summary

Objectives: To evaluate a method of determining the optimal feeder space allowance for pigs.

Materials and methods: Trial 1 used eight pens of 12 pigs to determine total eating time in pigs to estimate occupancy rates of a single-space feeder. Feed was provided in four combinations of feed form (mash versus pelleted) and water availability in the feeder (dry versus wet-dry). Eating behavior of pigs was video-recorded during both growing and finishing phases. Trial 2 used 560 pigs for the growing phase and 454 pigs for the

finishing phase. Effects of feeder occupancy rate (< 80%, 95%, 110%, and 125% for the growing phase; 80%, 103%, and 125% for the finishing phase) on total eating time and growth performance were determined.

Results: Both feed form ($P < .01$) and water availability in the feeder ($P < .001$) affected total eating time and, consequently, feeder occupancy rate. Pigs spent more time eating a dry mash diet than any other diet by water combination during both growing ($P < .001$) and finishing ($P < .01$) phases. As feeder occupancy rate increased to above 80%, either eating time ($P < .05$) or growth performance ($P < .05$) decreased.

Implications: When testing levels of feeder space allowance and identifying the optimum, the designated number of pigs per feeder space should be determined according to feeder occupancy rates under different production settings. Optimal feeder space allowance should maintain both productivity and eating time of pigs.

Keywords: swine, eating behavior, feed form, feeder space

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Resumen - Determinar el espacio óptimo de comedero en base a las diferentes presentaciones de alimento y disponibilidad de agua del comedero para cerdos en crecimiento y finalización

Objetivos: Evaluar un método para determinar el espacio óptimo de comedero para cerdos.

Materiales y métodos: La prueba 1 utilizó ocho corrales de 12 cerdos para determinar el tiempo total de consumo de alimento en cerdos para valorar los índices de utilización de un comedero de una sola boca. El alimento se proveyó en cuatro combinaciones de forma de alimento (puré contra pellet) y la disponibilidad de agua en el comedero (seco contra seco-húmedo). Se video grabó la conducta de consumo de alimento de los

cerdos durante las fases de crecimiento y finalización. La prueba 2 utilizó 560 cerdos para la fase de crecimiento y 454 cerdos para la fase de finalización. Se determinaron los efectos del tiempo de ocupación del comedero (< 80%, 95%, 110%, y 125% para la fase de crecimiento; 80%, 103%, y 125% para la fase de finalización), se determinó el tiempo total de consumo de alimento y desempeño de crecimiento.

Resultados: Tanto la presentación del alimento ($P < .01$), como la disponibilidad de agua en el comedero ($P < .001$) afectaron el tiempo total de consumo de alimento y, consecuentemente, el índice de ocupación del comedero. Los cerdos pasaron más tiempo consumiendo una dieta seca en puré que cualquier otra dieta por combinación de agua durante las fases de crecimiento ($P < .001$) y

finalización ($P < .01$). Conforme aumentó el índice de ocupación del comedero a más de 80%, el tiempo de consumo de alimento ($P < .05$) o el desempeño del crecimiento ($P < .05$) disminuyeron.

Implicaciones: Cuando se prueben los niveles de disponibilidad de espacio del comedero para identificar el óptimo, el número de cerdos designados por comedero se debe determinar de acuerdo al tiempo de utilización y los escenarios de producción. El espacio óptimo de utilización debe mantener la productividad y el tiempo de consumo de alimento de los cerdos.

Résumé - Détermination de l'espace alloué à la mangeoire selon le type d'aliment et la disponibilité de l'eau dans la mangeoire pour des porcs en période de croissance-finition

Objectifs: Évaluer une méthode pour déterminer l'espace optimal à allouer aux porcs à la mangeoire.

Matériels et méthodes: Dans l'essai 1, huit enclos de 12 porcs ont été utilisés pour déterminer le temps total d'alimentation des porcs afin d'estimer les taux d'occupation de mangeoire à espace unique. L'aliment était fourni en quatre combinaisons de formes

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(en pâté versus en granules) et de disponibilité d'eau dans la mangeoire (sec versus mouillé-sec). Le comportement des porcs s'alimentant était enregistré sur vidéo durant les phases de croissance et de finition. L'essai 2 a utilisé 560 porcs dans la phase de croissance et 454 porcs dans la période de finition. Les effets des taux d'occupation à la mangeoire (< 80%, 95%, 110%, et 125% pour la phase de croissance; 80%, 103%, et 125% pour la période de finition) sur le temps total d'alimentation et les performances de croissance ont été déterminés.

Résultats: La forme de l'aliment ($P < 0,01$) et la disponibilité de l'eau dans la mangeoire ($P < 0,001$) ont affecté le temps total d'alimentation et, par conséquent, les taux d'occupation à la mangeoire. Les porcs ont passé plus de temps à consommer une diète sèche en pâté que n'importe quelle autre combinaison de diète et d'eau autant durant la période de croissance ($P < 0,001$) que de finition ($P < 0,01$). À mesure que le taux d'occupation à la mangeoire augmentait au-dessus de 80%, il y avait une diminution soit du temps d'alimentation ($P < 0,05$) ou des performances de croissance ($P < 0,05$).

Implications: Lors de l'évaluation de l'espace à allouer à la mangeoire pour identifier ce qui serait optimum, le nombre de porcs par espace de mangeoire devrait être déterminé en fonction des taux d'occupation à la mangeoire sous différents paramètres de production. L'espace optimal à allouer à la mangeoire devrait voir à maintenir la productivité et le temps d'alimentation des porcs.

Optimal feeder space allowance should not only maintain performance and welfare of pigs, but should also achieve the maximal potential of the feeder. When attempting to determine optimal feeder space allowance, researchers have opted to assign arbitrary pig-to-feeder space ratios and concluded their findings exclusively on the basis of these selected ratios.^{1,2} In fact, the maximum potential of a feeder, which is defined as the maximal number of pigs that can be fed from it, is primarily a reflection of the total amount of time that each pig needs to spend eating on a daily basis (total eating time). Many factors affect the amount of time needed for pigs to consume their feed,³ such as feed form (mash versus pelleted),⁴ availability of water in the feeder (dry versus wet-dry),^{5,6} body weight and age,⁷ and eating behavior^{8,9} of the pigs. The optimal feeder space allowance,

which is defined as the maximal number of pigs sharing one feeding space without reduction in performance and well-being of the pigs,^{4,5} may vary with these influencing factors. Consequently, it is difficult for researchers to arbitrarily select pig-to-feeder-space ratios in order to identify the ideal ratio and the optimal feeder space allowance for pigs at different production settings. The "ideal way" to determine how many pigs can be fed from a single-space feeder is to keep increasing the number of pigs until it results in a drop in productivity or eating time. This type of testing is expensive and time consuming. However, if a standard test could be developed, it would prove to be invaluable for both researchers and producers. That is, researchers could employ the test to investigate optimal feeder space allowance for pigs under different production settings, and producers could perform the test on farm to determine the maximal potential of existing feeders. The goal of this study was to develop and validate such a standard test. It was hypothesized that pigs might change their total eating time as they grow, and with feed form and water availability in the feeder provided, consequently changing feeder occupancy rate (percentage of the cumulated time period that a feeder is occupied by pigs over a 24-hour period)⁵ and optimal feeder space allowance. The objectives of this study were to determine total eating time in pigs fed mash or pelleted diets from feeders with or without a water source in the feeder (dry or wet-dry) during both growing and finishing phases; to estimate feeder occupancy rates on the basis of total eating time; and to evaluate effects of feeder occupancy rate on eating behavior and growth performance of pigs. Eventually, the optimal feeder space allowances that do not limit eating behavior, feed intake, or growth, while maintaining the maximum feeder occupancy rate, were estimated.

Materials and methods

The study was conducted on the 600-sow farrow-to-finish facility of the research farm of the Prairie Swine Center in Saskatoon, Saskatchewan, Canada. The University Committee of Animal Care and Supply of the University of Saskatchewan reviewed and approved the protocol for this study to ensure adherence to the guidelines of Canadian Council on Animal Care.¹⁰

Trial 1

The first trial was to determine the total amount of time that a single-space feeder

is in use by small groups of pigs fed diets in different forms (mash versus pelleted) from feeders with or without a water source in the feeder (dry versus wet-dry). The data were extrapolated to estimate feeder occupancy rate for pigs that were provided with each combination of feed form and water availability in the feeder. Ninety-six pigs (body weight mean \pm standard deviation [SD] 21.4 ± 2.40 kg; PIC Canada Ltd, Winnipeg, Manitoba) were weighed individually, sorted, and assigned to eight pens on fully slatted floors, each pen providing 12.2 m^2 (1.0 m^2 per pig), excluding space occupied by the feeder. Pigs were randomly allotted (by random number generator) within sex and weight categories such that each pen housed six barrows and six gilts, and the average weight and variation in weight within each pen were similar. Two pens were then randomly assigned (by random number generator) to each of four treatment combinations: mash diets fed from a dry feeder (DM), mash diets fed from a wet-dry feeder (WM), pelleted diets fed from a dry feeder (DP), and pelleted diets fed from a wet-dry feeder (WP). Both the dry and wet-dry feeders were single-space, shelf-type feeders (Crystal Spring, Model # F2000; St Agatha, Manitoba, Canada) for growing-finishing pigs, as described by Gonyou and Lou.^{5,11} The dry feeders had the same design as the wet-dry feeders except that there was no nipple drinker in the dry feeder. Both the dry and wet-dry feeders provided feed access, by means of gravity, on a shelf approximately 25 cm above the feeder pan. The area of the feeder pan measured $38 \text{ cm} \times 38 \text{ cm}$ for all feeders. Pigs had ad libitum access to a barley- and soybean-meal-based diet in a two-phase feeding program formulated according to National Research Council (NRC) standards.¹² For the initial 6 weeks of the trial (growing phase; initial weight [\pm SD] = 21.4 ± 2.40 kg, end weight = 59.4 ± 4.91 kg), the diet was formulated to contain 3.26 Mcal digestible energy (DE) per kg and 16.8% crude protein (CP). The diet for the second phase (finishing phase; initial weight = 59.4 ± 4.91 kg, final weight = 100.0 ± 9.66 kg) was formulated to contain 3.21 Mcal DE per kg and 16.1% CP. Pens with a dry feeder had one nipple drinker on the wall opposite the feeder. For pens with a wet-dry feeder, the only source of water was one water nipple located in the feeder, and no additional drinker was provided. Pigs were housed in the same mechanically ventilated room. Temperature in the room was controlled to the thermoneutral zones for

pigs.¹³ Light period was 12 hours daily. Room temperature, feeders, drinkers, and animal health were checked twice daily, in the morning and afternoon. Feed added to the feeders was recorded on a pen basis. Remaining feed and individual pigs in each pen were weighed every 2 weeks, from which average daily gain (ADG) and average daily feed intake (ADFI) were calculated. When pigs were removed from the trial, the date and reason for removal were recorded.

When pigs weighed between 35 and 45 kg during the growing phase, the feeder area in each pen was video-recorded for two consecutive 24-hour periods. Within each pen, pigs' activities were video-recorded by two cameras (Panasonic WV-BP120; Osaka, Japan) installed above the feeder, a quad input device (Panasonic WJ-410), and a time-lapse recorder (Panasonic AG-6730; recording 10 images per second). A second set of video recordings was taken for two consecutive 24-hour periods in the finishing phase, when the pigs weighed between 90 and 100 kg, to determine the effect of pig size on time spent eating and to determine whether this effect was consistent across the treatments. During video-recording periods, the normal lighting schedule was maintained; however, supplemental low-level light (a 40-watt light bulb) was used to illuminate the feeder area to assist video-recording. The video-recordings were analyzed using instantaneous sampling at 5-minute intervals in order to determine time spent eating.¹³ All data were summarized and expressed as total eating time per day per pig.¹⁴ Eating was defined as a pig having its head in the feeder.⁵ Eating rate was calculated for each pen on the basis of ADFI and total eating time.

Trial 2

Using the behavior data collected from Trial 1 (Table 1), the number of pigs required to create various levels of feeder occupancy rate under each previously outlined feeding condition was calculated. Feeder occupancy rates were estimated using the equation

$$\text{Feeder occupancy rate (\%)} = \frac{\text{number of pigs in the pen} \times \text{total eating time (minutes per pig per day)}}{(24 \text{ hours} \times 60 \text{ minutes})} \times 100\%$$

The feeder occupancy rate was defined as 100% when the feeder was expected to be used 24 hours a day by the pigs. In other words, 100% feeder occupancy rate means that the single-space feeder was occupied by a pig at any given time over a 24-hour

Table 1 (Trial 1): Total eating time and estimated feeder occupancy rate of growing and finishing pigs when eating different forms of feed (mash versus pelleted) from single-space feeders with or without presence of water in the feeder (dry versus wet-dry feeders)*

	Mash		Pellets		SEM
	Dry	Wet-dry	Dry	Wet-dry	
No. pens	2	2	2	2	NA
No. pigs per pen	12	12	12	12	NA
Total eating time (min/pig/d)[†]					
Growing pigs [‡]	106.5	72.5	75.9	78.6	4.6
Finishing pigs [§]	105.7	63.5	65.2	64.6	4.6
Estimated feeder occupancy rate (%)[¶]					
Growing pigs [‡]	88.8	60.4	63.3	65.5	3.8
Finishing pigs [§]	88.1	52.9	54.3	53.8	3.8

* Pigs in each pen were video-recorded for two consecutive 24-hour periods.

† Total amount of time that a pig spent eating (defined as a pig having its head in the feeder) over a 24-hour period.

‡ Growing pigs weighed 35 to 45 kg.

§ Finishing pigs weighed 90 to 100 kg.

¶ Percent of the time that the feeder was expected to be used by pigs daily to consume the amount of feed that maximized growth performance, calculated using the equation $\text{feeder occupancy rate (\%)} = (\text{number of pigs} \times \text{total eating time (min/day/pig)}) \div (1440 \text{ min/d} \times 100\%)$.

SEM = standard error of the mean; NA = not applicable, descriptive variables; min = minute(s); d = day.

period. During the growing phase, the lowest level of feeder stocking capacity was maintained at 12 pigs per feeder (referred to as the "standard feeder occupancy rate" (Table 2) for all combinations of feed form and water availability in the feeder, in order to verify results from Trial 1. This standard occupancy rate was equivalent to approximately 88%, 60%, 63%, and 65% feeder occupancy rate for DM, WM, DP, and WP diet treatments, respectively. In addition to the standard occupancy rate, three feeder occupancy rates of approximately 95%, 110%, and 125% for each combination of feed form and water availability were included to evaluate the optimal feeder space allowance during the growing phase. During the finishing phase, feeder occupancy rates were reduced to approximately 80%, 103%, and 125% for the DM, WM, and DP treatments due to barn space restrictions. For the same reason, only feeder occupancy rates of 80% and 125% were represented in the WP treatment. Feeder occupancy rates exceeding 100% were tested in anticipation that pigs would, to some degree, adapt to feeder crowding by eating faster, and to ensure that the highest occupancy rates would result in reduced productivity. During the finishing phase, all

combinations of feed form and water availability in the feeder included a feeder occupancy rate of 80%, allowing a comparison of feed form and water availability in the feeder treatments under uncrowded feeding condition.⁵ Table 2 outlines the number of pigs used to generate estimated feeder occupancy rates for each combination of feed form and water availability in the feeder during both growing and finishing phases. Pigs were from the same source as for Trial 1.

To evaluate effect of feeder occupancy rate on eating behavior and growth performance of pigs, two identical grower-finisher rooms were used for Trial 2, with each treatment combination represented in both rooms. The rooms had fully slatted floors, were mechanically ventilated to achieve thermoneutral conditions, and were managed as in Trial 1. Pen size varied with the number of pigs in the pen such that each pig had the same floor space allowance. Floor space allowance was calculated on the basis of the predicted final weight of the pigs in that growth phase using this equation:

$$\text{Floor area (m}^2\text{)} = 0.035 \times \text{BW (kg)}^{0.667}$$

The resulting floor space allowance was 0.54 m² and 0.76 m² per pig for the growing

Table 2 (Trial 2): No. of pigs per single-space feeder for estimated feeder occupancy rate when feed was offered in different forms (mash versus pelleted) from feeders with or without presence of water in the feeder (dry versus wet-dry)

Estimated feeder occupancy rate (%)*	Mash		Pellets	
	Dry	Wet-dry	Dry	Wet-dry
Growing pigs (No. of pigs per pen)				
Standard†	12	12	12	12
95	13	19	18	17
110	15	22	21	20
125	17	25	24	23
Finishing pigs (No. of pigs per pen)				
80	11	18	18	18
103	14	23	23	ND
125	18	28	28	28

* Percent of the time that the feeder was expected to be used by pigs daily to consume the amount of feed that maximized growth performance was calculated using the equation occupancy rate (%) = (number of pigs × total eating time (min/d/pig) ÷ 1440 min/d × 100%), where total eating time was defined as the pig having its head in the feeder. The estimated feeder occupancy rate was defined as 100% when the feeder was expected to be used all the time by pigs in a pen under uncrowded feeding conditions or when feeder access was deemed to not be limiting.

† The standard group was designed to validate results of Trial 1 using group size of 12 pigs per single-space feeder. The estimated feeder occupancy rate was 88%, 60%, 63%, and 65% for pigs fed with dry mash, wet-dry mash, dry pelleted, and wet-dry pelleted diets, respectively. ND = Not done due to restrictions of barn space.

and finishing phases, respectively. Feeders were the same as those used in Trial 1. As in Trial 1, pens with a wet-dry feeder had one water nipple in the feeder as their only water source, while pens with a dry feeder were equipped with two nipple drinkers located on the opposite side of the pen from the feeder. Feed formulation was the same as in Trial 1 and remained consistent across treatments.

Five hundred and sixty pigs (21.3 ± 3.43 kg) without visible signs of compromised health were randomly assigned (by random number generator) within sex and weight categories, such that the average weight and variation in weight within each pen were similar at the beginning of the growing phase. The numbers of barrows and gilts within a pen were equal when total pig number was even, or differed by one when total number was odd. Two pens were randomly assigned (by random number generator) to each treatment combination (feeder occupancy rate × feed form × water availability in the feeder) for both growing and finishing phases. Pigs remained in the growing phase for 6 weeks. The pigs were then weighed individually and sorted by sex and weight. Among them, 454 pigs (60.6 ± 7.14 kg) without obvious signs of compromised health were selected for data collection in the finishing phase. These pigs were allocated randomly (using a random number generator) within sex and weight categories to

each treatment pen without consideration of previous treatment during the growing phase. The treatments for the finishing phase were continued for only 4 weeks (final weight of pigs = 92.8 ± 9.66 kg) due to restrictions of barn space. Feed was weighed as it was added to the feeders on a pen basis. Individual pigs and any remaining feed in each pen were weighed every 3 weeks during the growing phase and every 2 weeks during the finishing phase.

During the growing phase, when pigs reached between 35 and 45 kg, all feeders were video-recorded for two consecutive 24-hour periods, as in Trial 1. During the third week of the finishing phase, when the pigs weighed between 75 and 85 kg, feeders were again video-recorded for two consecutive 24-hour periods. As in Trial 1, video recordings were analyzed using instantaneous sampling at 5-minute intervals in order to determine total eating time.

Data analysis

All data were analyzed using mixed linear regression and using the Mixed and Glimmix procedures of SAS (SAS Institute Inc, Cary, North Carolina), with pen as the experimental unit. Two separate analyses were conducted. The first analysis examined effects of feed form and water availability in the feeder on

total eating time of pigs under the standard (growing phase) or 80% capacity (finishing phase). For this purpose, data from both Trial 1 and Trial 2 were used. For the growing phase, all pens containing 12 pigs were included in the analysis. For the finishing phase, the data from pens containing 12 pigs in Trial 1 and pens with 80% feeder stocking capacity in Trial 2 were used. Initial analyses were conducted to compare differences in eating behavior and growth performance between the two trials. No significant differences were detected (all $P > .10$), and the data from the two trials were combined. The model included feed form, water availability in the feeder, and their interaction as fixed effects, with trial and room serving as random effects. The second analysis was conducted to evaluate the effect of feeder occupancy rate on pigs under each combination of feed form and water availability in the feeder. In this case, only data from Trial 2 were used. The same model, but separate analyses, were conducted for the growing and finishing phases, respectively. The model included feeder occupancy rate, feed form, water availability in the feeder, and their interactions as fixed effects, with room as the random effect. Differences between means were tested by PDIF using a Tukey test with adjustment for multiple comparisons. Significant differences were identified at $P < .05$ and trends at $P < .10$.

Results

A total of three pigs from three pens were removed from Trial 1, and 15 pigs from 12 pens were removed from Trial 2 due to compromised health, with no more than two pigs removed per pen. There was no evidence that the number of pigs removed from the study was associated with feed form, water availability in the feeder, or feeder stocking-capacity treatments.

Effects of feed form and water availability in the feeder

Growing phase (body weight 20 to 60 kg).

There was an interactive effect of feed form by water availability in the feeder on ADG ($P < .01$; Table 3). Pigs fed DM diets gained less weight than pigs on any other treatment combination. Pigs using a wet-dry feeder had better gains than those using a dry feeder ($P < .001$). There was no effect of feed form on ADG. Both feed form and water availability in the feeder affected ADFI, with pigs fed mash diets having higher

ADFI ($P < .01$) than pigs fed pelleted diets, and pigs using wet-dry feeders having higher ADFI ($P < .01$) than pigs using dry feeders. There was an interactive effect between feed form and water availability in the feeder ($P < .05$) on ADFI, with pigs fed WM diets having higher intake than pigs on any other treatment. Pigs fed pelleted diets had better gain:feed than pigs fed mash diets ($P < .05$). Water availability in the feeder did not affect feed efficiency. In general, pigs fed mash diets spent more time eating than those fed pelleted diets ($P < .01$). Additionally, pigs using a dry versus wet-dry feeder had longer total eating time ($P < .001$). The primary source of variation was attributable to the interactive effect between feed form and water availability in the feeder ($P < .001$), with pigs fed DM diets spending more time eating than those on any other treatment combination. Pigs using a wet-dry feeder ate faster than those using a dry feeder ($P < .001$). Again, the primary source of variation was attributable to the interactive effect between feed form and water availability in the feeder ($P < .001$),

with pigs fed DM diets having the lowest eating rate and pigs fed WM diets having the highest eating rate.

Finishing phase (body weight 60 to 100 kg).

Pigs using a wet-dry feeder had higher ADG ($P < .01$; Table 3) than those using a dry feeder. Feed form did not affect ADG, and there was no interaction between feed form and water availability in the feeder. Pigs fed mash diets had greater ADFI ($P < .05$) than those fed pelleted diets. Additionally, pigs using a wet-dry feeder had greater ADFI ($P < .01$) than those using a dry feeder. Pigs fed pelleted diets had better gain:feed ($P < .05$) than pigs fed mash diets. Water availability in the feeder did not affect feed efficiency, and there were no interactive effects of feed form and water availability in the feeder on feed efficiency. Pigs fed DM diets had longer total eating time ($P < .001$) and ate more slowly ($P < .001$) than pigs on any other treatment. In general, pigs fed mash diets spent more time eating ($P < .001$) than those fed pelleted diets; and pigs using a dry feeder had longer total eating time

Table 3 (Trial 1 and Trial 2): Effect of feed form (mash versus pelleted) and water availability in the feeder (dry versus wet-dry) on performance and eating behavior of pigs using single-space feeders*

Parameter	Mash		Pellets		SEM	P		
	Dry	Wet-dry	Dry	Wet-dry		Form [†]	Water availability [‡]	Interaction
Growers								
No. pens	4	4	4	4	NA	NA	NA	NA
ADG (kg)	0.771 ^b	0.848 ^a	0.812 ^a	0.825 ^a	0.023	.35	< .001	< .01
ADFI (kg)	2.11 ^b	2.37 ^a	2.08 ^b	2.16 ^b	0.055	< .01	< .01	.04
Gain:feed	0.369 ^b	0.363 ^b	0.393 ^a	0.387 ^a	0.035	.02	.48	.98
TET (min/pig/day)	106.9 ^a	71.6 ^b	81.8 ^b	79.3 ^b	2.85	< .01	< .001	< .001
ER (g/pig/minute)	19.7 ^c	33.4 ^a	25.9 ^b	27.2 ^b	3.71	.99	< .001	< .001
Finishers								
No. pens	4	4	4	4	NA	NA	NA	NA
ADG (kg)	0.837 ^c	0.924 ^{ab}	0.882 ^b	0.957 ^a	0.047	.14	< .01	.81
ADFI (kg)	2.73 ^b	3.06 ^a	2.64 ^b	2.79 ^b	0.100	.03	< .01	.22
Gain:feed	0.307 ^b	0.303 ^b	0.334 ^a	0.346 ^a	0.025	.02	.79	.55
TET (min/pig/day)	106.5 ^a	66.6 ^b	67.0 ^b	65.1 ^b	2.98	< .001	< .001	< .001
ER (g/pig/min)	25.6 ^b	46.7 ^a	39.5 ^a	43.4 ^a	3.14	.06	< .001	< .01

* Data were derived from 12 pigs/feeder in both Trial 1 and Trial 2 for the growing phase, and 12 pigs/feeder in Trial 1 and 80% feeder occupancy rate in Trial 2 for the finishing phase.

[†] Mash versus pelleted feed.

[‡] Dry versus wet-dry feeders.

SEM = standard error of the mean; ADG = average daily gain; ADFI = average daily feed intake; gain:feed = weight gain per unit of feed intake; TET = total eating time of pigs, referring to total amount of time that pigs spent eating daily; ER = eating rate of pigs, based on ADFI and TET; min = minute(s); NA = not applicable, descriptive variables.

^{abcd} Means within a row with no common superscript differ (Tukey tests adjusted for multiple comparisons; $P < .05$).

($P < .001$) than those using a wet-dry feeder. Pigs using a wet-dry feeder ate faster ($P < .001$) than those using a dry feeder; and pigs fed pelleted diets tended ($P < .10$) to eat faster than pigs fed mash diets. The primary source of variation was attributable to the interactive effect between feed form and water availability in the feeder.

Effects of feeder occupancy rate, feed form, and water availability in the feeder

The P values for effects of feeder occupancy rate, feed form, and water availability in the feeder for both the growing and finishing phases are presented in Table 4.

Growing phase. Across feed form and water availability in the feeder combinations, an increase in feeder occupancy rate led to a decrease in ADG ($P < .001$; Table 5). Feeder occupancy rate interacted with water availability in the feeder to influence ADG ($P < .05$; Table 4). Pigs using wet-dry feeders had a larger decrease in ADG (from 0.812 kg at 80% feeder occupancy rate to 0.680 kg at 125% feeder occupancy rate, SEM (standard error of the mean) = 0.013; $P < .001$) than those using dry feeders (from 0.773 kg at 80% feeder occupancy rate to 0.707 kg at 125% feeder occupancy rate, SEM = 0.013;

$P < .05$) as feeder occupancy rate increased. There was no interactive effect of feeder occupancy rate and feed form on ADG.

Overall, ADFI decreased when feeder occupancy rate increased from 80% to 125% ($P < .001$; Table 5). There was no interactive effect of feeder occupancy rate and feed form or water availability in the feeder on ADFI. Feeder occupancy rate did not affect gain:feed, and there was no interactive effect of feeder occupancy rate and feed form or water availability in the feeder on feed efficiency.

As feeder occupancy rate increased, total eating time decreased ($P < .001$; Table 5). Feeder occupancy rate did not interact with feed form, but tended to interact with water availability in the feeder ($P < .10$; Table 4) with an effect on total eating time. Pigs using dry feeders tended to have a larger reduction in total eating time than pigs using wet-dry feeders as feeder occupancy rate increased. An increase in feeder occupancy rate tended ($P < .10$) to increase eating rate. There was no interaction of feeder occupancy rate with feed form or water availability in the feeder.

Finishing phase. Across feed forms and water availability in the feeder, ADG decreased when feeder occupancy rate increased ($P < .001$; Table 5). Feeder occupancy rate interacted with water availability in the feeder

($P < .01$; Table 4) to influence ADG. As feeder occupancy rate increased, pigs using wet-dry feeders had a larger reduction in ADG (0.989,^a 0.653,^b and 0.608^b kg at 80%, 103%, and 125% feeder occupancy rate, respectively, SEM = 0.029; $P < .001$) than those using dry feeders (0.893,^a 0.835,^{ab} and 0.726^b kg at 80%, 103%, and 125% feeder occupancy rate, respectively, SEM = 0.029; $P < .01$; means with no common superscript differ).

Across feed form and water availability in the feeder combinations, ADFI decreased ($P < .001$; Table 5) as feeder occupancy rate increased. Feeder occupancy rate tended ($P = .052$; Table 4) to interact with feed form to influence ADFI, with pigs fed mash diets tending to have a larger reduction in ADFI than pigs fed pelleted diets as feeder occupancy rate increased. Feed efficiency was not affected by feeder occupancy rate.

Total eating time decreased ($P < .001$; Table 5) as feeder occupancy rate increased across feed forms and water availability in the feeder. Feeder occupancy rate interacted ($P < .05$; Table 4) with feed form. Pigs fed mash diets had a larger decrease in total eating time than pigs fed pelleted diets as feeder occupancy rate increased. Feeder occupancy rate tended ($P = .051$) to interact with water availability in the feeder to influence total eating time. As feeder occupancy rate increased,

Table 4 (Trial 2): P values derived from data analyzed using mixed linear regression for effects of feeder occupancy rate, feed form, and water availability in the feeder on performance and eating behavior of pigs using single-space feeders

Parameter	Occupancy*	Form†	Water availability‡	Occupancy × form	Occupancy × water availability
Growing pigs					
ADG (kg)	< .001	.25	.06	.95	.04
ADFI (kg)	< .001	.08	< .01	.71	.89
Gain:feed	.60	< .01	.053	.74	.13
TET (min/pig/day)	< .001	< .001	< .001	.16	.09
ER (g/pig/min)	.08	.07	< .001	.24	.73
Finishing pigs					
ADG (kg)	< .001	< .01	.16	.14	< .01
ADFI (kg)	< .001	.42	.31	.052	.12
Gain:feed	.57	.12	.39	.44	.29
TET (min/pig/day)	< .01	< .001	< .001	.04	.051
ER (g/pig/minute)	.55	< .001	< .01	.06	.16

* Percent of the time that the feeder was expected to be used by pigs according to total eating time under uncrowded conditions.

† Mash versus pelleted feed.

‡ Dry versus wet-dry feeders.

ADG = average daily gain; ADFI = average daily feed intake; gain:feed = weight gain per unit of feed intake; TET = total eating time of pigs, which refers to total amount of time that pigs spent eating daily; ER = eating rate of pigs, which was based on ADFI and TET; min = minute(s); d = day.

Table 5 (Trial 2): Effect of feeder occupancy rate across feed form and water availability in the feeder on performance and eating behavior of pigs using single-space feeders

Parameter	Feeder occupancy rate (%) [*]				SEM	P
	STD	95	110	125		
Growing pigs						
No. pens [†]	8	8	8	8	NA	NA
ADG (kg)	0.793 ^a	0.775 ^a	0.737 ^b	0.693 ^c	0.013	< .001
ADFI (kg)	1.92 ^a	1.83 ^{ab}	1.76 ^{bc}	1.65 ^c	0.045	< .001
Gain:feed	0.414	0.424	0.420	0.422	0.008	.60
TET (min/pig/day)	86.4 ^a	79.3 ^b	73.7 ^c	65.2 ^d	1.81	< .001
ER (g/pig/minute)	23.0 ^f	23.7 ^{ef}	24.5 ^{ef}	26.0 ^e	1.28	.08
Parameter	Feeder occupancy rate (%) [*]			NA	NA	
	80	103	125			
Finishing pigs						
No. pens [†]	8	6	8	NA	NA	
ADG (kg) [‡]	0.941 ± 0.039 ^a	0.778 ± 0.047 ^b	0.667 ± 0.039 ^b	NA	< .001	
ADFI (kg)	2.72 ± 0.14 ^a	2.30 ± 0.15 ^b	2.14 ± 0.14 ^b	NA	< .001	
Gain:feed	0.342 ± 0.027	0.341 ± 0.029	0.324 ± 0.027	NA	.57	
TET (min/pig/day)	77.8 ± 3.48 ^a	67.9 ± 4.16 ^{ab}	57.9 ± 3.48 ^b	NA	< .01	
ER (g/pig/minute)	36.4 ± 2.2	35.2 ± 2.5	38 ± 2.2	NA	.55	

* Percent of the time that the feeder was expected to be used by pigs according to total eating time under uncrowded conditions.

† No. of pigs per pen for each feeder stocking capacity; described in Table 2.

‡ Mean ± standard error of the mean (SEM).

NA = not applicable; STD = standard group size (12 pigs per single-space feeder, regardless of feed form or feeder design); ADG = average daily gain; ADFI = average daily feed intake; gain:feed = weight gain per unit of feed intake; TET = total eating time of pigs, referring to total amount of time that pigs spent eating daily; ER = eating rate of pigs, calculation based on ADFI and TET.

^{abcd} Means within a row with no common superscript differ (Tukey test adjusted for multiple comparisons; *P* < .05).

^{ef} Means within a row with no common superscript tend to differ (Tukey test adjusted for multiple comparisons; *P* < .10).

pigs using dry feeders tended to have a larger decrease in total eating time than pigs using wet-dry feeders. Feeder occupancy rate did not affect eating rate in finishing pigs.

Discussion

In this study, we explored a novel method of determination of feeder space allowance for pigs. This method emphasizes that, in order for researchers to identify the optimal feeder space allowance, the treatment levels of feeder space to be examined should be based on the eating behavior of the pigs, and then feeder occupancy rate can be determined. Eating behavior can be determined using small groups of pigs under uncrowded feeding conditions. On the basis of results of previous studies,^{1,5,7} 12 pigs eating from a single-space feeder were chosen for the uncrowded feeding condition. Gonyou and Lou⁵ demonstrated that there was no difference in growth performance when 12 pigs were fed from a single-space dry feeder versus

a single-space wet-dry feeder, or from a single-space feeder versus a double-space feeder. Likewise, Hyun and Ellis^{1,7} reported that there was no difference in growth performance between eight pigs and 12 pigs fed from a single-space feeder. Hyun and Ellis^{1,7} also demonstrated that when 12 pigs were fed mash diets from a dry feeder, they occupied the feeder 83% of the time during the growing period, and 74% of the time during the finishing period. Pigs may spend less time eating and have a lower occupancy rate of the feeder when provided pelleted wet-dry diets than when provided dry mash diets. As a result, the uncrowded feeding condition was designed at approximately 80% or lower feeder occupancy rate across feed form and feeder design treatments in this study. Accordingly, both 12 pigs per single-space feeder and 80% feeder occupancy rate were considered uncrowded feeding conditions.

The interactive effect of feed form and water availability in the feeder on eating behavior

and growth performance were determined during both growing and finishing phases. The performance data were consistent with previous findings^{3,6,15} that pigs fed from wet-dry feeders had higher ADG and ADFI than did those fed from dry feeders. By testing a wide variety of feeders, Gonyou and Lou⁵ found that wet-dry feeders consistently produced pigs with higher ADG and ADFI than dry feeders, indicating the improved productivity was likely due to the provision of water at the feeder. Bergstrom et al¹⁶ demonstrated that the benefit of wet-dry feeders to improve ADG in pigs was diminished when the same wet-dry feeders were used as dry feeders (water source removed). An interactive effect between feed form and water availability in the feeder on ADG and ADFI in growing pigs was observed in the current study, that is, wet-dry feeders increased ADG and ADFI when pigs were fed mash diets, but not when pigs were fed pelleted diets. This interaction could be attributable to several

factors. One factor could be the increased feed wastage by pigs fed a dry mash diet.¹⁷ When feeding a mash diet, water consumption is much higher than when feeding a pelleted diet from a dry feeder,⁴ and the pigs would have to interrupt feeding more often in order to drink.¹⁸ This interrupted feeding leads to an increase in the number of times the pig enters and exits the feeder, increasing the chance of more feed being wasted. In contrast, a wet-dry feeder allows pigs to either mix feed with water before eating (the water thereby acting as a lubricant) or drink while eating at the feeder because water is at the feed source.

Either way, this will decrease feed wastage and the number of times that the pig must exit the feeder.^{5,19} A pelleted diet, even fed from a dry feeder, presumably does not become as sticky, according to our on-farm observations, so the pig is more likely to eat without having to interrupt its meal with many drinks, decreasing the total time required for eating and decreasing feed wastage and the number of feeder exits.

The current study demonstrated that both feed form and water availability in the feeder affected total eating time, and consequently, feeder occupancy rate. Pigs fed mash diets spent more time eating than did pigs fed pelleted diets. The provision of water at the feeder reduced total eating time, especially in pigs fed mash diets. In agreement with our results, Laitat et al⁴ noted that pigs fed a dry pelleted diet had shorter total eating time than did those fed a dry mash diet. Gonyou and Lou⁵ reported a 17% decrease in total eating time when water was made available at the feeder and mash diets were fed. In agreement with Laitat et al,⁴ results of the current study suggested that water availability at the feeder had more impact on eating time when pigs were fed mash diets rather than pelleted diets. With this information and the data from the current study, it can be inferred that when pelleted diets are fed, eating behavior is less influenced by the presence of water within the feeder than when mash diets are fed. The possible reasons for this are similar to the rationale for changes in productivity. That is, the stickiness of the mash diet necessitates an increase in water consumption, thereby adding time to the meal by increasing the number of intra-meal intervals. When water is provided at the feeder, intra-meal intervals would be dramatically decreased when a mash diet is fed. The fact that consumption of pelleted diets requires less water likely shortens total eating time by

decreasing the number of visits to the feeder required to finish a single meal. It is also true that pigs can consume dry pelleted diets at a faster rate than dry mash diets, and these effects may be additive. So if pigs can eat pelleted diets faster without requiring frequent water breaks, it would seem to follow that the dramatic effect of a wet-dry feeder on mash diets would not be seen when a pelleted diet is fed.

Due to these effects on total eating time, the number of pigs needed to generate a designated level of feeder space allowance differs depending on the feed form and water availability in the feeder. For example, according to results of this study, 11 finishing pigs will be needed to generate 80% feeder occupancy rate for a single-space feeder when DM diets are fed, whereas 18 pigs will be needed when WM diets are fed. In addition, since pigs spent more time eating DM diets, increasing the number of pigs per feeder space will result in a dramatic increase in feeder occupancy rate, compared with that when pigs are eating other diets. Using the traditional method of assigning fixed pig-to-feeder-space ratios to evaluate feeder space allowance when pigs are eating different forms of feed from feeders with or without presence of water in the feeder will result in differences in feeder occupancy rate, which consequently may change the eating behavior of the pigs and might result in misleading conclusions. In contrast, the method explored in this study suggests that different pig-to-feeder-space ratios should be based on the feed form and water availability in the feeder.

This study further confirmed that pigs eat faster as they grow.⁵ Although finishing pigs had higher ADFI, they spent a similar or shorter time eating, depending on the feed form and water availability in the feeder, than is spent by growing pigs. As a result, depending on feed form and water availability in the feeder, 17 to 25 pigs were needed during the growing phase, whereas 18 to 28 pigs were needed during the finishing phase, to design 125% feeder occupancy rate in the current study. By using designed levels of feeder occupancy rate instead of a set number of pigs per feeder space, the extent to which pigs could adapt their eating patterns to crowding at the feeder and the influence of feed form and water availability in the feeder on this ability could be examined.

Across all feed forms and water availability in the feeder treatments, ADG was greatly

reduced during both growing and finishing phases as feeder occupancy rate increased. However, pigs fed different forms of feed from feeders with or without water source in the feeder responded differently to the increase in feeder occupancy rate. In general, pigs fed WM diets showed the greatest response, followed by pigs fed WP diets during both growing and finishing phases. In contrast, pigs fed DM diets were not significantly affected by an increase in feeder occupancy. It is possible that, while the estimated feeder occupancy rate remained the same, small group sizes for the dry mash treatment allowed these pigs to be more flexible in modifying their eating behavior to maintain growth performance. This is supported by the fact that, in the current study, although total eating time decreased significantly regardless of feed form or water availability in the feeder, a pig fed a DM diet at 125% feeder occupancy rate still spent approximately 25 minutes per day longer eating than did pigs on any other treatment at the same feeder occupancy rate. Nielsen et al²⁰ found that pigs stocked at 5, 10, 15, or 20 per feeder space and fed a dry mash diet had remarkably different eating behaviors, such as the number of feeder visits, duration of feeder visits, and diurnal patterns of feeder visits, but they had similar growth performance, such as ADFI, ADG, and feed efficiency. These results suggest that pigs may be able to adapt their eating behavior to feeder occupancy rate and maintain growth performance when there are not many pigs for each feeder space. However, the number of pigs per feeder space may have been limited in the previous study²⁰ and larger numbers of pigs per feeder space may subject pigs to more limitations that restrict their adaptability to increased feeder occupancy. In other words, with a large number of pigs sharing a single feeding space, not all pigs may gain access to the feeder or achieve desired feed intake. That might be why a dramatic decrease in ADG was observed in pigs fed other diets, but not a DM diet. Regardless of the interaction between feed form and water availability in the feeder, pigs tended to perform better when feeder occupancy rate was maintained lower than 100%. In addition, in the current study, across all combinations of feed form and water availability in the feeder, total eating time tended to decrease when feeder occupancy rate reached above 80%, indicating that pigs were not given enough time to eat. These results suggest that pigs have limited ability to adapt their

eating behavior to high occupancy rates of the feeder in order to maintain feed intake and growth. This is further supported by the eating-rate data from the current study. As feeder occupancy rate increased, increases in eating rate were not significant, regardless of feed form or water availability in the feeder. Collectively, results of the current study suggest that an 80% feeder occupancy rate should be recommended to maintain both growth performance and welfare of pigs, regardless of the size of pigs, feed form, or feeder design.

Implications

- Under the conditions of this study, when testing levels of feeder space allowance and identifying the optimum, the designated number of pigs per feeder space should be determined according to the eating behavior of the pigs and the feeder occupancy rate under different production settings.
- Both feed form and water availability within the feeder affect eating behavior, and consequently, affect feeder occupancy rate.
- To maintain growth performance and allow enough time for pigs to eat their desired amount of feed, 80% feeder occupancy rate is recommended for pigs during both growing and finishing phases.

Conflict of interest

None reported.

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Modelling contamination of trucks used in the shipment of pigs infected with porcine reproductive and respiratory syndrome virus

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Summary

Objectives: To quantify the likelihood that a shared truck used to ship pigs will be contaminated with porcine reproductive and respiratory syndrome (PRRS) virus at the end of a given day, and to evaluate the efficacy of cleaning and washing protocols for trucks, using a Bayesian approach.

Materials and methods: PRRS virus-infected farms, from which trucks had shipped pigs, were deemed to be the source of contamination. A quantitative stochastic model was built using farm- and animal-level PRRS prevalence data, the number of times a truck is typically shared on any given day, shipment

size, travel time between farms, and the efficacy of three different cleaning and disinfection procedures.

Results: The model predicted a median probability of 0.525 that a truck would be contaminated at the end of any given day, without considering the number of previous shipments made by that truck or whether or not it had been washed and disinfected between shipments. Truck washing alone resulted in a negligible decrease in probability that a truck would be contaminated, while washing and disinfection followed by drying had the highest impact, with a greater than 99% reduction in probability of contamination.

Implications: Findings of this study suggest that under current biosecurity practices, a substantial risk exists for the spread of PRRS virus due to truck sharing. This model could also be utilized in understanding the risk of truck sharing on the spread of other swine diseases (such as porcine epidemic diarrhea) where transportation is believed to spread the virus.

Keywords: swine, Bayesian, porcine reproductive and respiratory syndrome virus, truck sharing, shipment

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Resumen - Modelando la contaminación de camiones utilizados en el embarque de cerdos infectados con el virus del síndrome reproductivo y respiratorio porcino

Objetivos: Cuantificar la probabilidad de que un camión compartido, utilizado para embarcar cerdos ese contamine con el virus del síndrome reproductivo y respiratorio porcino (PRRS) al final del día, y evaluar la eficacia de los protocolos de lavado y limpieza de camiones, utilizando un acercamiento Bayesiano.

Materials y métodos: Se consideró que las granjas infectadas con el virus del PRRS, de las cuales los camiones habían embarcado cerdos, eran la fuente de la contaminación. Se construyó un modelo estocástico cuantitativo utilizando datos de la prevalencia del PRRS a nivel animal y de granja, el número de veces que un camión se comparte típicamente en un

día, el tamaño del embarque, tiempo del viaje entre granjas, y la eficacia de tres procedimientos diferentes de limpieza y desinfección.

Resultados: El modelo predijo una probabilidad mediana de 0.525 para que un camión se contamine al final de un día dado, sin considerar el número de embarques previos hechos por el camión o si se había o no lavado y desinfectado entre embarques. El sólo lavado del camión resultó en una disminución insignificante en la probabilidad de que un camión se contaminara, mientras que el lavado y la desinfección seguidos de secado, tuvieron el impacto más alto, con una reducción mayor al 99% en la probabilidad de contaminación.

Implicaciones: Los hallazgos de este estudio sugieren que bajo las prácticas actuales de bioseguridad, existe un riesgo substancial para la propagación del virus del PRRS debido al

hecho de compartir el camión. Este modelo, también podría ser utilizado, para entender el riesgo de compartir camiones en la propagación de otras enfermedades porcinas (tales como la diarrea epidémica porcina) donde se cree que el transporte propaga el virus.

Résumé - Modélisation de la contamination des camions utilisés dans le transport de porcs infectés par le virus du syndrome reproducteur et respiratoire porcine

Objectifs: Quantifier la possibilité qu'un camion partagé utilisé pour le transport de porcs sera contaminé par le virus du syndrome reproducteur et respiratoire porcine (SRRP) à la fin d'une journée donnée, et évaluer l'efficacité des protocoles de nettoyage et de désinfection des camions, par une approche bayésienne.

Matériels et méthodes: Les fermes infectées par le virus du SRRP à partir desquelles des camions furent utilisés pour expédier des porcs étaient considérées comme étant la source de la contamination. Un modèle stochastique quantitatif a été construit en utilisant les données de prévalence du SRRP au niveau de la ferme et au niveau des animaux, le nombre de fois typique qu'un camion était partagé à chaque jour, la taille de l'expédition, le temps de transit entre les

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fermes, et l'efficacité de trois procédures différentes de nettoyage et désinfection.

Résultats: Le modèle a prédit une probabilité médiane de 0,525 qu'un camion serait contaminé à la fin d'une journée, sans prendre en considération le nombre de transports précédents effectués par ce camion ou s'il avait été ou non lavé et désinfecté entre les transports. Uniquement un lavage du camion a entraîné une diminution négligeable de la probabilité qu'un camion serait contaminé, alors que le lavage et la désinfection suivis par un séchage avaient le plus grand impact avec une réduction de plus de 99% de la probabilité de contamination.

Implications: Les résultats de cette étude suggèrent qu'en fonction des pratiques de biosécurité actuelles, un risque substantiel existe pour la dissémination du virus du SRRP dû au partage de camions. Ce modèle pourrait également être utilisé pour comprendre le risque de partage de camions dans la dissémination d'autres maladies porcines (telle que la diarrhée épidémique porcine) pour lesquelles le transport est considéré comme pouvant disséminer le virus.

Porcine reproductive and respiratory syndrome (PRRS) is a major viral disease of swine with devastating economic consequences to the swine industry.^{1,2} Pigs of all ages are susceptible to PRRS virus, with highly variable clinical manifestations in different age groups of infected pigs, ranging from abortion, anorexia, and pyrexia in pregnant sows to respiratory signs, high mortality, and poor growth in young pigs.³ Several direct and indirect mechanisms have been identified for the spread of PRRS virus from one farm to another. Direct contact routes include movement of infected animals and use of contaminated semen. Indirect mechanisms involve sharing shipment trucks between farms^{4,5} and sharing of equipment and other fomites.⁶⁻⁸ Aerosol transmission has also been reported,^{9,10} and some studies have implicated the role of insects, such as mosquitoes and house flies, in mechanical transmission of the virus.^{11,12}

The swine industry in North America has become increasingly specialized and integrated, with the adoption of three-site production systems that require regular movement of pigs between sites.¹³ Canadian swine producers and experts in the swine industry have been concerned about the role of shared trucks in the farm-to-farm spread

of PRRS virus.¹⁴ In recent years, network analysis has elucidated contact patterns among animal holdings in specific livestock industries.¹⁵⁻¹⁸ A number of recent swine movement analysis studies in Denmark and France have identified the importance of shipment vehicles as a means to spread infectious agents between farms that are otherwise not directly connected.^{17,19,20} In a recent study characterizing swine movement in four Canadian regions,¹⁸ patterns of truck-sharing between farms, similar to those described in the United Kingdom,¹⁷ France,²⁰ and Denmark,¹⁹ were identified, with one truck, on average, being shared among four different farms. Similarly, for more than 50% of all shipments on any particular day, the same truck had been used in at least one additional shipment from a different farm.¹⁸ Thus, any inadequate cleaning and disinfection of vehicles is likely to increase the risk of spread of infectious agents, as has been implicated in the recent spread of porcine epidemic diarrhea (PED) virus across North America.²¹

The role of shipment vehicles in the spread of PRRS virus to susceptible pigs has also been demonstrated through experimental studies in which sentinel pigs became infected after being housed in an artificially contaminated trailer and in trailers that housed experimentally infected pigs.⁴ Similarly, mechanical transmission of PRRS virus via transportation during cold and warm weather has been documented by the same authors.^{22,23} Trucks contaminated with PRRS virus require rigorous cleaning, disinfection, and drying to eliminate the virus.^{4,24} The Canadian Swine Health Board has developed protocols to wash, disinfect, and dry such transport vehicles.²⁵ However, anecdotal evidence indicates a lack of consistency in the application of these standardized protocols, with some trucks being cleaned by washing only, while others are washed and disinfected, and others undergo the full protocol of washing, disinfection, and overnight drying. In these experiments, Dee et al⁴ also evaluated cleaning and disinfection protocols. PRRS virus from the trailers was detected in all combinations of cleaning and disinfection treatments except when bedding removal, washing, disinfecting, and drying were combined. Washing and fumigation with glutaraldehyde-quaternary ammonium chloride or washing and disinfection plus overnight drying were effective treatments.²⁴

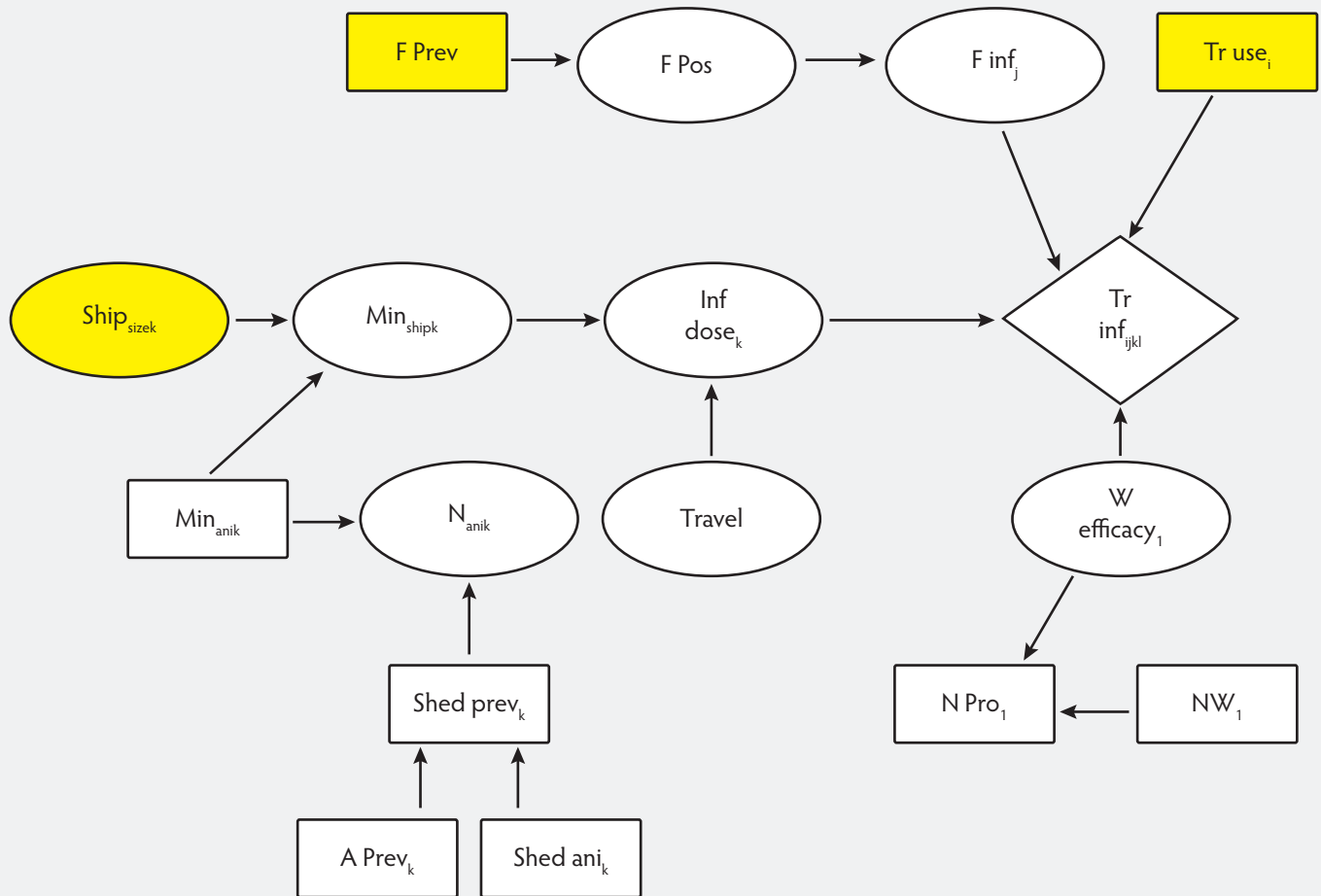
A Bayesian approach was selected for this study, as it supports a combination of different sources of information and the propagation of uncertainty in the model.²⁶ It also allows the assumption of conditional dependence between nodes required by classical risk assessment to be relaxed, supporting the estimation of joint probability distributions at nodes that are conditionally independent, through the use of Bayesian networks.²⁷ A Bayesian network is a probabilistic graphical model representing a network of nodes connected by directed links, where nodes represent a set of random variables, and the links, dependencies between these nodes. Bayesian networks have been used in veterinary epidemiology to aid in disease diagnosis²⁸⁻³⁰ or to study associations between biosecurity practices and disease outbreak.^{31,32}

The objectives of the analyses described here were to use a Bayesian approach to quantify the likelihood that a truck used for a shipment of pigs would be contaminated with PRRS virus at the end of any given day (as well as on subsequent days), and to evaluate the efficacy of cleaning and disinfection protocols in eliminating the virus from these trucks. The model estimates the probability that a truck will be contaminated with PRRS virus after it has been used by a number of farms on any given day, and provides estimates on the likelihood that the truck will remain contaminated on subsequent days. In addition, it provides insights into the likelihood that the PRRS virus will be eliminated from the trucks after one of a number of cleaning and disinfection protocols has been applied.

Materials and methods

Truck-use pattern for transportation of pigs between swine farms, informed by pig traceability data from a pilot study in Canada,¹⁸ suggests that a given truck may be used by two or more farms on any given day, and may or may not be cleaned between shipments. A schematic representation of the Bayesian model is presented in Figure 1. The baseline model estimates the probability that a truck "i" will be contaminated with PRRS virus at the end of Day 1, given it visited "j" farms on that day, and that at least one of those farms was infected with PRRS virus. It also estimates whether the truck had sufficient viral load to make it infectious, which is determined by the travel time of the truck during the shipment, the number of pigs in the shipment (ie, shipment size), the animal-level prevalence of the virus, and the probability of animals

Figure 1: Schematic representation of the Bayesian network used to estimate the likelihood that shipment trucks would be contaminated with porcine reproductive and respiratory syndrome (PRRS) virus and to evaluate the efficacy of various cleaning and disinfecting protocols for removal of PRRS virus from contaminated trucks. Fixed nodes are shown in rectangles, with stochastic nodes in ellipsoids. The diamond-shaped node represents an outcome that is estimated by the model. Nodes in yellow represent prior information. The model represents a truck_{*i*}, that can have visits_{*j*} (two, three, four, or more) on a day and can ship animals from production types_{*k*} (farrowing, nursery, or finishing) of swine farms and can be cleaned by using protocols_{*l*} (wash; wash and disinfect; or wash, disinfect, and dry).



shedding in the shipment group. The probability of shedding animals depends on the production type “k” of the infected farm.

The baseline model incorporated one of the three “l” cleaning and disinfection protocols and evaluated the efficacy of each of these protocols in eliminating the PRRS virus from contaminated trucks. This risk assessment considered the following five nodes as influencing the probability that a truck would be contaminated with PRRS virus at the end of a given day: farm-level prevalence of PRRS virus (proportion of PRRS farms with at least one PRRS-positive animal), number of farms using the same truck on that day, number of animals shipped on the truck, animal-level prevalence of PRRS virus in the group of shipped pigs, and proportion of animals shedding the virus in the group, which in turn depends on the stage of growth of the

pigs and the time of travel between two farms. A detailed description of the nodes is presented in Table 1, with a summary of the underlying assumptions, process models, and associated input values. Finally, we estimated the probability that a truck “i” would be contaminated with PRRS virus by multiplying the probability that at least one of the farms “j” that it had visited was infected with PRRS virus, the probability that the truck had more animals in that shipment than Min_{*anik*} (minimum number of animals required on a truck to have enough infectious animals to contaminate the truck), and the probability that the travel time was more than 2 hours.

Data description

Data used in this study were obtained from the literature^{4,24} and from a pilot pig trace-

ability study carried out in four Canadian regions and described elsewhere.¹⁸ As the Bayesian approach is useful in combining information from several sources, and since most of the data used in the study are based on published literature or experts’ judgment, we considered these data as prior information for the model.

For this study, we assumed that a truck was free of PRRS virus when it was used for the first time on Day 1. In assessment of the perpetuation of risk on Day 2 and subsequent days, we did not consider any new sources of infection for that truck, such that all farms visited by the truck after the first day were assumed to be clean. On the basis of the experts’ judgment, we assumed the farm-level prevalence (F prev) of PRRS virus to be 50%. One co-author (DH, professor of swine health management) and an external

Table 1: List of nodes and parameters, process models, prior distributions, and observed data with source and references used to estimate the probability that a truck will be contaminated with porcine reproductive and respiratory syndrome virus (PRRSV) at the end of a working day

Nodes and parameters	Notation	Definition	Process model and equation	Data/priors	Reference
Truck use	Tr use	Probability that the truck is used between two, three, or four, or more farms in a single day	NA	Two = 0.49 Three = 0.19 ≥ Four = 0.32	Pilot Pig Traceability Data ¹⁸
Farm positives	F Pos 2	No. of farms infected with PRRSV of the two farms visited by the truck	Binomial	NA	Assumption of 50% farm level prevalence (F Prev) of PRRSV
	F Pos 3	No. of farms infected with PRRSV of the three farms visited by the truck	Binomial	NA	
	F Pos 4	No. of farms infected with PRRSV of the four farms visited by the truck	Binomial	NA	
Farm infection	F inf 2 /3 /4	Probability that at least one of the farms was infected when the truck was used by two, three, or four farms	$1-(1-F \text{ prev})^{\wedge}F \text{ Pos}$	NA	
	Comb prob	Probability that at least one farm the truck visited was infected, when the number of farms it visited was unknown	$F \text{ inf } 2*0.49 + F \text{ inf } 3*.19 + F \text{ inf } 4*.32$	NA	
Animal level prevalence	A prev _k	Prevalence of PRRSV in the batch of animals shipped	NA	Fixed: 0.8	Experts' judgment
Shedding animals	Shed ani _k	Probability of shedding animals in a batch of animals shipped	NA	Fixed: 0.2, 0.5, 0.8	For farrowing, nursery and finishing farms, based on experts' judgment
Shedding prevalence	Shed prev _k	Probability of infectious and shedding animals in a batch of animals shipped	$A \text{ prev} * \text{Shed ani}$	NA	NA
No. of shedding animals	Nani _k	No. of infectious and shedding animals on a truck to characterize it as contaminated	NA	Fixed = 2	Dee et al study ⁴
Minimum no. of animals	Min _{anik}	Minimum no. of animals required on a truck to have at least two infectious and shedding animals in a batch of animals shipped (based on shedding prevalence)	Hypergeometric $N \text{ ani fa} \sim \text{dhyper} (\text{Min ani fa}, m \text{ fa}, N \text{ fa}, 1)$	NA	NA
	N _{ani1k}	No. of infectious and shedding animals on a truck when the no. of animals on the truck is equal to Min _{ani}	Hypergeometric $N \text{ ani nu} \sim \text{dhyper} (\text{Min ani nu}, m \text{ nu}, N \text{ nu}, 1)$	NA	NA
	N _{ani1 stepk}	Probability that a truck with Min _{ani} has at least two infectious and shedding animals	$N \text{ ani fi} \sim \text{dhyper} (\text{Min ani fi}, m \text{ fi}, N \text{ fi}, 1)$	NA	NA
Shipment size	Ship _{sizek}	The distribution of shipment size for shipments from the three production types	Triangular (†)	For farrowing farms (min, max): 10,350; nursery farms: 12,700, finishing farms: 6300	Pilot Pig Traceability Data ¹⁸
Min shipment size	Min _{shipFa/Nu/Fi}	Probability that the truck has more animals than Min _{ani} if it was coming from a farrowing/nursery/finishing farm	$\text{Step} (\text{Ship}_{\text{sizek}} - \text{Min}_{\text{anik}}) * N_{\text{ani1 stepk}}$	NA	NA
Travel time	Travel time	Distribution of travel time for trucks, obtained by assuming a triangular distribution for travel time with min and max values of 0.5 and 6, respectively	Triangular (‡)	Mini = 0.5 Max = 6	Experts' judgment
Travel	Travel	Probability that travel time was more than 2 hours in order to qualify the truck as infective	$\text{Step} (\text{travel time} - 2)$	NA	NA
Infective dose	Inf dose	Probability that the truck has an infective dose of virus: depends on shipment size and travel time	$\text{Travel} * \text{min}_{\text{ship}}$	NA	NA

Table 1: Continued

Nodes and parameters	Notation	Definition	Process model and equation	Data/priors	Reference
Truck infection	Tr inf	Probability that the truck is contaminated at the end of the day's work	$Tr\ use * F\ inf * Inf\ dose$	NA	NA
Truck wash efficacy	W efficacy	Probability that washing clears the virus from the truck	Binomial (N W prot, W efficacy)	N prot \S = 0 N w \P = 20 Wd efficacy ~ beta (0.5,0.5) $\S\S$	For values, Dee et al ^{4,24}
Truck wash and disinfection efficacy	Wd efficacy	Probability that washing and disinfection clears the virus from the truck	Binomial (N wd, Wd efficacy)	N prot \S = 6 N wd \ddagger = 10 Wd efficacy ~ beta (0.5,0.5) $\S\S$	
Truck wash, disinfection, and dry efficacy	Wdd efficacy	Probability that washing, disinfection, and drying clears the virus from the truck	Binomial (N wdd, Wd efficacy)	N prot \S = 10 N wdd \ddagger = 10 Wdd efficacy ~ beta (0.5,0.5) $\S\S$	
Truck infection after wdd	Tr inf wdd	Probability that the truck is still contaminated after washing, washing, and disinfection and washing, and disinfection and drying	$Tr\ inf * W\ efficacy$	NA	NA

† For shipment size a triangular distribution was simulated using two uniform distributions [Uniform (min/2, max/2) + Uniform (min/2, max/2)] in OpenBUGS with minimum and maximum as 5th and 95th percentiles of shipment size.

‡ For travel time, a triangular distribution was simulated using two uniform distributions [Uniform (min/2, max/2) + Uniform (min/2, max/2)].

§ N prot = No. of clean trucks after wash, wash and disinfection, or wash, disinfection, and dry.

¶ N w = Total no. of trucks washed.

‡‡ N wd = Total no. of trucks washed and disinfected.

‡‡ N wdd = Total no. of trucks washed, disinfected, and dried.

§§ Jeffreys priors.

NA = not applicable.

expert (Dr Zvonimir Poljak, an associate professor of veterinary epidemiology with a research focus on swine diseases), who have extensive expertise in swine production and management across Canada, provided input to estimate some of the parameter values. Using the farm-level prevalence of the virus, we estimated the number of farms that might be infected with PRRS virus (of the farms visited by the truck on any day), as well as the probability that at least one of the visited farms was infected with PRRS virus. A detailed description of the estimation procedure for the values and parameters of each node is provided in the supplementary material.

Models

Two sets of models were evaluated to estimate the likelihood that the trucks shared between farms for the shipment of pigs were contaminated with PRRS virus. First, a baseline model was simulated that did not involve any cleaning or disinfection protocol being applied to the truck, which resulted in an estimation of the “baseline” probability that the truck would be contaminated at the

end of Day 1. The baseline model was then extended to incorporate decay of the virus over time under two different seasonal settings: warmer months (assuming an ambient temperature of approximately 22°C) and colder months (which assumed an ambient temperature of approximately 4°C or less) to assess the probability that the truck would remain contaminated on subsequent days under these conditions.

Evaluation of cleaning and disinfection protocols

The baseline model was extended to include three cleaning and disinfection protocols that have been assessed previously in terms of their effectiveness in eliminating the PRRS virus from contaminated trucks. Data from Dee et al studies^{4,24} (summarised in Table 1) were used for each of the three cleaning protocols to assess their effectiveness in reducing the probability that a truck used for shipments of pigs would remain contaminated with PRRS virus. Since these data are from a small number of replication experiments, non-informative Jeffreys priors were used.

As these priors depend upon the process model³³ for these nodes, beta (0.5, 0.5) was used in order to avoid a large influence of these data on the posterior estimates.

Scenarios

A total of 21 scenarios were constructed and analysed (Table 2). A subset of 12 of those scenarios did not include any cleaning or disinfection control measures, while the other nine scenarios evaluated the efficacy of each of the three cleaning and disinfection protocols. For scenarios without cleaning and disinfection protocols, the risks for trucks used by two, three, and four or more farms were evaluated, and the combined risk for a “random” truck, for which the number of farms previously visited on that day was unknown, was estimated. In addition, the production type of the initially infected farm visited by the truck was included in these scenarios. Similarly, for scenarios with cleaning and disinfection protocols, the probability that a random truck would still remain contaminated after visiting any of the three production farm types, and would

have been cleaned by one of the three cleaning protocols, was estimated.

Stochastic model

To quantify the probability that a truck used by a number of farms on a given day would be contaminated with PRRS virus at the end of the day, a stochastic model was developed (code attached in supplementary material) in OpenBUGS 3.2.2.³⁴ A total of 150,000 iterations, with a burn-in period of 30,000, were obtained after initializing the model with three chains. The convergence, diagnostic analyses, and summary of all posterior distributions were computed in R using the CODA package.³⁵ The convergence of the Markov Chain Monte Carlo (MCMC) model was assessed both visually, using the history and autocorrelation plots, and formally, using the Brooks-Gelman-Rubin diagnostic,³⁶ which provided an estimate of the shrinkage or scale reduction factor for each of the nodes and scenarios. The distribution of the scale reduction factors (median

and 97.5% upper bounds) was plotted to visually assess convergence. Once the model converged, the effective sample size was estimated by running the model for a sufficient number of iterations such that the MCMC error became less than 5% of the posterior standard deviation for monitored nodes. The median and 95% credible interval (CrI) are reported, along with the mean and standard deviations for the scenarios described above, and for each stochastic node.

Sensitivity analysis

A sensitivity analysis was performed for one scenario (fi), where the truck was used by an unknown number of farms and carried finishing pigs, without the application of any cleaning and disinfection measures. The aim was to evaluate and identify possible scenarios that could lead to a significant decrease or increase in the final probability. The percentage change in the mean probability of contamination was compared to the original scenario. These changes were

assessed using farm-level prevalence (F prev) values for PRRS of 10%, 30%, and 70%; animal-level prevalence (A prev) values of 10%, 30%, 50%, and 100%; and animal-shedding prevalence (Shed ani) of 10%, 30%, 50%, and 90%. The sensitivity of the model was also evaluated by changing the minimum number of infectious animals required to contaminate a truck (N ani) from two to four and eight.

Results

The median probabilities (and 95th percentile of the distribution) of a truck remaining contaminated with PRRS virus at the end of Day 1 for scenarios with and without the application of various cleaning and disinfection measures are presented in Figure 2. The median and 95% CrI, along with mean and standard deviation for all the parameters used in the model and for all the scenarios, are summarised in the supplementary material, Table S1. The median probability that a truck would be contaminated with PRRS

Table 2: Scenarios created to evaluate the probability that a truck will be contaminated with porcine reproductive and respiratory syndrome virus at the end of a working day

Name of scenario	Truck used by farms	Truck washed, disinfected, dried	Truck used by
2 fa	2	No	Farrowing
2 nu			Nursery
2 fi			Finishing
3 fa	3		Farrowing
3 nu			Nursery
3 fi			Finishing
4 fa	4		Farrowing
4 nu			Nursery
4 fi			Finishing
fa	Combined		Farrowing
nu			Nursery
fi			Finishing
fa w		Wash only	Farrowing
nu w			Nursery
fi w			Finishing
fa wd		Wash, disinfect	Farrowing
nu wd			Nursery
fi wd			Finishing
fa wdd		Wash, disinfect, dry	Farrowing
nu wdd			Nursery
fi wdd			Finishing

W = truck washed; wd = truck washed and disinfected; wdd = truck washed, disinfected, and dried; fa = truck used by farrowing farms; nu = truck used by nursery farms; and fi = truck used by finishing farms.

virus at the end of Day 1, when it was used by three farms or more, was 1 irrespective of the production type of the farm that used that truck. However, the median probability for trucks used by only two farms was 0. In the case of a “random” truck (ie, one for which the number of times it had been used for transportation during the first day was not specified), the median probability was 0.529 when the source of infection was a finishing farm. The median probability of a truck remaining contaminated did not differ much for truck use across the three different production types for these scenarios.

When decay of the virus over time was incorporated in the model, the outputs suggested that the median probability that a truck would still remain contaminated after 15 or 30 hours of use during warmer months, from a contamination acquired on Day 1 and without visiting any other infectious farms on subsequent days, was not much different from the probability on Day 1 (Table 3). The median probability decreased by 0.049 and 0.051 (approximately 10%) in the 15 hours of truck use subsequent to Day 1, when the truck had been used by either a nursery or a finishing farm, respectively, and by 0.063 (12.5%) when it had been used by a farrowing farm, compared to Day 1. For the next 30 hours after Day 1, the median probability of contamination decreased by 0.218 for nursery farms and by 0.211 for finishing farms, compared to Day 1. Similarly, median probability for truck contamination after 30 hours of truck use reduced to 0 when the source of infection was a farrowing farm. For colder months, the virus can remain viable for approximately 112 hours,³⁷ so once contaminated on Day 1, the trucks were expected to remain contaminated for approximately 5 additional days.

With respect to the three cleaning protocols evaluated in this study, washing alone reduced the median probability of a truck remaining contaminated by 0.011 (for example, the probability for *fi* = 0.525 decreased to 0.514 with washing), while washing with disinfection decreased the median probability by 0.346 (approximately 66%). However, washing and disinfection followed by overnight drying had by far the highest impact, lowering the median probability of contamination by more than 99%, to approximately 0.002, irrespective of the production type for which the truck had been used (Table S2 of supplementary material). The distributions of probabilities associated with a truck remaining contaminated after the application of each of the three cleaning and disinfection protocols, for the scenario involving finishing farms, are presented in

Figure 2: Median probabilities (with 95th percentiles, p95) for contamination of trucks with porcine reproductive and respiratory syndrome virus (PRRS virus) at the end of Day 1, for several scenarios, depending on the number of times the trucks were shared (three, four, or more) and the production type of the PRRS-virus-infected farm, (left) without cleaning and disinfection of trucks and (right) with application of one of the three cleaning protocols evaluated in the study. Only representative scenarios are presented (supplementary material is available [Table S1] for median probabilities for other scenarios). *Fi* = finishing farm; *w* = washing; *wd* = washing and disinfecting; *wdd* = washing, disinfecting, and drying.

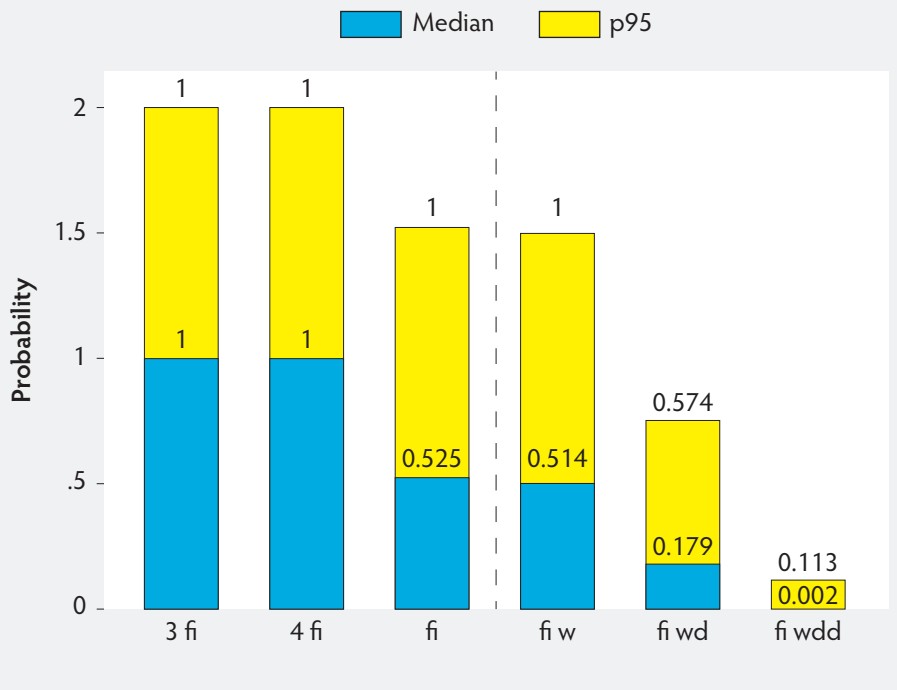


Figure 3. Similar distributions for scenarios without cleaning and disinfection protocols could not be obtained due to the parametrizing of nodes used in those scenarios with step function, which did not allow for the propagation of uncertainty across these nodes or for the scenarios evaluated. However, we would expect those scenarios to have similar distributions to that of the “*fi w*” scenario.

Finally, outputs from the sensitivity analyses suggested that the highest percentage changes (100% decrease for each scenario evaluated) were observed for large decreases in farm-level or animal-level prevalence of PRRS virus and for a large decrease in the probability of shedding animals in the shipment (when either one of these was decreased to 10%). However, only a small increase or decrease in the median probabilities was observed for a smaller increase or decrease in each of the parameters evaluated (farm-level prevalence, animal-level prevalence, and the probability of shedding animals in any particular shipment (Figure 4 and supplementary material, Table S2.) Similarly, large increases

(2× and 4×) in the minimum number of infectious animals (N_{ani}) required to contaminate the truck with PRRS virus resulted in only a small decrease (approximately 10% and 40%, respectively) in the median probability of contamination.

The MCMC error was less than 5% of the posterior standard deviation for all of the reported scenarios and nodes, which suggested that the model had been run for a sufficient number of iterations, and 40,000 iterations with a burn-in period of 10,000 for each chain was sufficient to allow the models to converge with a sufficient sample size for posterior inference. The scale-reduction factor was less than 1.05 for all nodes and scenarios evaluated, indicating that the model converged. The shrinkage plots, showing the evolution of the scale reduction factor with an increase in the number of iterations, also suggest that the MCMC models converged after approximately an initial 4000 iterations, following the burn-in period of 10,000 iterations, for most nodes.

Table 3: Probability that a truck will remain contaminated with porcine reproductive and respiratory syndrome virus in subsequent time periods during warmer months

Nodes-scenarios	Mean probability on Day 1	Mean probability for next 15 hours after Day 1	% decrease in mean probability from Day 1	Mean probability for next 30 hours after Day 1	% decrease in mean probability from Day 1
fa	0.508	0.445	12.40	0.000	100
nu	0.517	0.468	9.48	0.299	42.17
fi	0.525	0.474	9.71	0.314	40.19

Fa = truck used by farrowing farms; nu = truck used by nursery farms; and fi = truck used by finishing farms.

Discussion

This analysis evaluated the risk for contamination with PRRS virus of trucks involved in the transportation of pigs. To do so, a baseline model was first developed to assess the likelihood that trucks used for shipment of pigs will become contaminated with PRRS virus and remain so at the end of Day 1. The model was extended to explore a number of possible scenarios, including variations in the number of times a truck was used in a day, the farm- and animal-level prevalence of PRRS virus, the size of the shipment on a truck, the probability of shedding animals in the shipment, and the period of travel involved. The model was extended to quantify the probability that the truck would remain contaminated on subsequent days once it became contaminated, without visiting any other infected farms, by including decay of the virus over time in the model. We also attempted to evaluate the efficacy of commonly-used cleaning and disinfection protocols in eliminating this virus from contaminated trucks.

On the basis of this model, the estimated probability of a truck being contaminated at the end of a day increased substantially with an increase in the number of visits the truck made on a given day. However, there were no major differences in the probabilities for scenarios when the truck was used by farrowing, nursery, or finishing farms. The two parameters that were different in the model among the three production types were shedding percentage and shipment size. The sensitivity analysis suggested that the model was less influenced by changes in shedding percentage, unless it was a very large change, and that above a certain threshold for this parameter, the model behaved similarly. This explains why very limited differences in risk were observed among the three production types.

While separate shipment size distributions were specified for the three production types, in most cases the shipment size was very large, typically large enough to have the minimum number of animals required to characterize the trucks as being contaminated. Thus, this parameter also had little impact in terms of overall differential risk among the three production types.

The model suggested that the virus would be eliminated from only a very small proportion of trucks by simply washing the vehicle, while washing followed by disinfection should clean the virus from just over half of the trucks. Washing and disinfection, followed by overnight drying, had the highest impact, resulting in the removal of PRRS virus from a large majority of contaminated trucks. One possible explanation for the high efficacy of this protocol may be as follows. Washing alone can reduce the amount of debris and organic matter but cannot eliminate the virus, while washing followed by disinfection can be useful when the surfaces are free of organic matter. However, the addition of drying can eliminate the virus from contaminated surfaces by eliminating the residual virus that persists after washing and disinfection has occurred.³⁸ Findings from our study are in slight contrast with those observed in the experimental studies.^{5,24} In the experimental study, washing had no effect at all, and washing and disinfection were effective in approximately a quarter of replications, while washing, disinfection, and drying resulted in the elimination of the virus in all replications. The differences observed in the current study were likely due to the introduction of uncertainty and stochasticity into the model.

Finally, the model suggested that, during warmer months, a slight decrease may occur in the probability that the trucks will be contaminated on the following day, as some trucks may become decontaminated the following day simply due to viral decay. How-

ever, most trucks that are contaminated on Day 1 will remain contaminated for at least 30 hours. Again, this finding was associated with shipment size, as most of the trucks, due to large shipment sizes, qualified to have infectious and shedding animals sufficient to maintain the contamination for the next few days. In colder months, when the virus can survive much longer,³⁷ a truck will tend to remain contaminated for approximately 5 days once contaminated. Cleaning and disinfection of trucks to eliminate PRRS virus is crucial during winter months,^{22,39} when the virus exhibits increased survival. However, our study suggests that cleaning and disinfection should not be ignored during the warmer months, as the likelihood that trucks will remain contaminated for a number of days following shipment from an infected farm is substantial.

In the present study, the viral load on trucks could not be quantified because data on the amount of PRRS virus that is typically shed were not available. Instead, trucks were classified in terms of whether they were likely to have sufficient viral load to be able to transmit the infection, on the basis of work by Dee et al,⁴ using shipment size as a proxy for viral load. Shipment size was linked to PRRS viral load on the trucks in terms of a dose-response relationship, which further affected the time that the truck would likely remain infected with the virus. Even with decay of the virus over time, trucks that carry larger shipments from infected farms can remain contaminated for several subsequent days and have sufficient viral loads to infect susceptible animals.

The sensitivity analysis attempted to identify the most influential parameters on the probability of truck contamination, particularly parameters whose values had been estimated on the basis of the experts' input. However, the outputs suggested that small incremental changes in the farm-level prevalence of

Figure 3: Distribution of posterior probabilities for the contamination of trucks with porcine reproductive and respiratory syndrome virus after application of one of the three different cleaning and disinfection protocols (w = washing; wd = washing and disinfection; and wdd = washing, disinfection, and drying), for a truck that was used by an infected finishing (fi) farm. Boxes represent inter quartile range of the distribution.

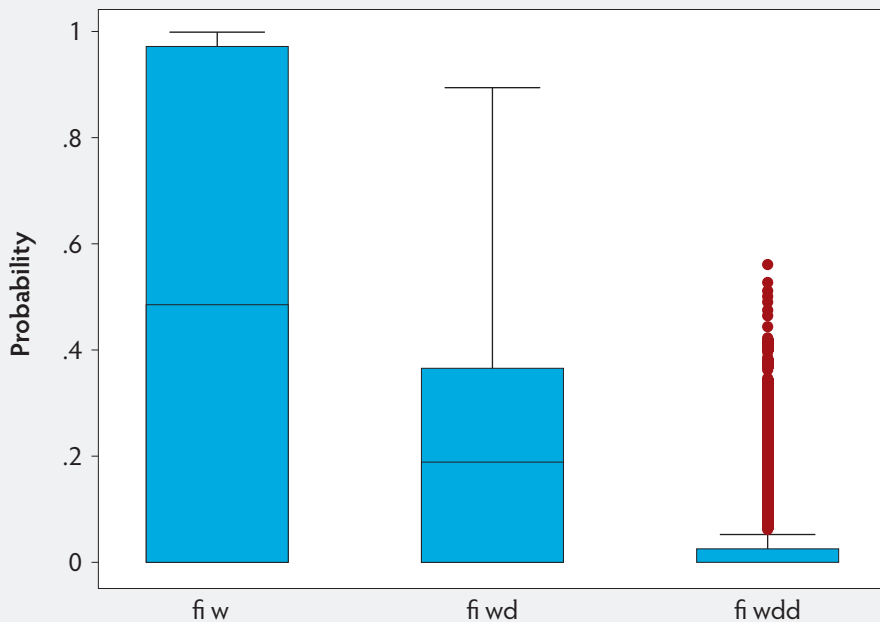
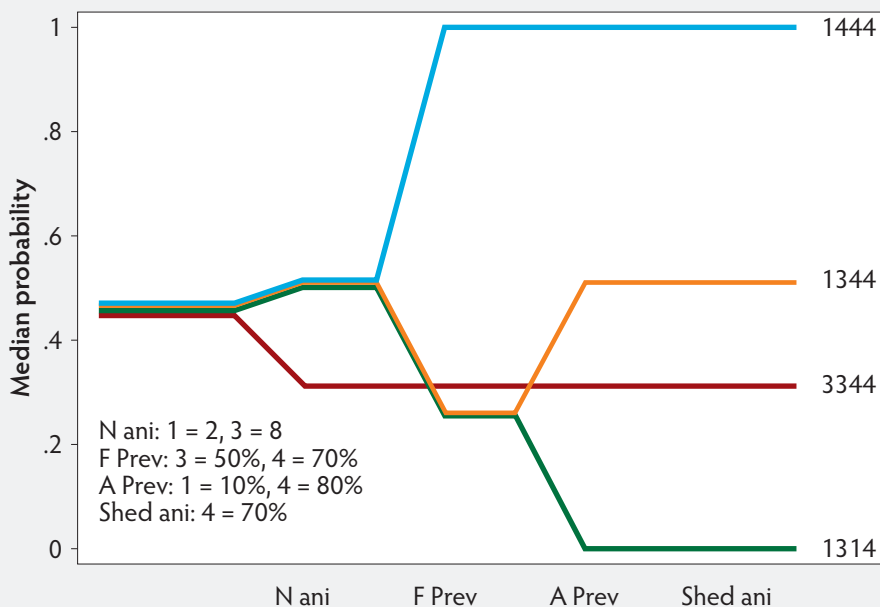


Figure 4: Risk plot showing sensitivity of the median probability that a truck will be infected with porcine reproductive and respiratory syndrome virus to changes in key model parameter values from those of the baseline model (1344): N ani (minimum number of infectious animals required to contaminate the truck), farm-level prevalence (F prev), animal-level prevalence (A prev) of the virus, and the probability of shedding animals (Shed ani) on the truck, respectively. Only representative sensitivity analysis scenarios are presented (supplementary material is available [Table S2] for median probabilities for other scenarios).



PRRS virus, in the animal-level prevalence of the virus, and in the percentage of shedding animals in the shipment, did not greatly affect the model outcome (median probability of truck contamination). The sensitivity analysis indicated that either decreasing the farm-level prevalence of the virus to 10% (from 50%) by participating in area regional control programs, or decreasing the animal-level prevalence of the virus to a similar level by adopting a number of PRRS elimination programs such as herd closure, all in-all out animal flow, and avoiding direct or indirect contacts between subpopulations within a farm, could decrease the probability for truck contamination by more than half. These two findings may have practical significance in controlling the spread of PRRS virus via shared transport.

Despite several simplifying assumptions, we believe the model has captured the underlying pathways leading to the contamination with PRRS virus of trucks used in the transportation of pigs on Canadian farms, from which infection can be transmitted to susceptible pigs. However, for some scenarios, only point estimates are presented for the probability of truck contamination, as the model could not produce uncertainties around these estimates due to the use of a step function in the model, which is a limitation of the model. Due to the lack of available data, the current model did not include pathways leading to eventual transfer of infection from such trucks to susceptible pigs or naive farms. However, the model could be further extended to elucidate such probabilities, as well as to estimate the indirect-contact transmission probability of spreading the PRRS virus via the sharing of trucks. A similar approach could be utilized in understanding the risk of truck sharing on the spread of other swine diseases where transportation has been implicated as a medium for viral spread, as appears to be the case for porcine epidemic diarrhea.²¹

Findings from this study have value to the Canadian swine industry in helping producers make informed decisions regarding the sharing of trucks among farms and guiding their selection of cleaning protocols for trucks. Given the current truck-sharing patterns among Canadian swine farms, where, for more than half of the shipments on any given day, the same truck has been used on more than one farm,¹⁸ together with current biosecurity practices for truck cleaning in Canada, where only approximately one third of the trucks used for the shipment of pigs are cleaned after every shipment,⁴⁰ the current model suggests that there is a sub-

stantial risk for spread of PRRS virus through contaminated trucks. This risk could be largely eliminated either by properly washing, disinfecting, and drying trucks between shipments, by substantially decreasing the farm- or animal-level prevalence of the PRRS virus, or by using designated trucks for each farm in an attempt to minimize sharing among farms. Planning shipments so that farms of similar PRRS status are visited in sequence (on the assumption that the PRRS virus status of each farm is known), or using dirty trucks for the transportation of market pigs and clean trucks for shipping gilts and young pigs to farms, may be strategies that minimize the transmission of PRRS virus via shared transportation. Cost is a major determinant for regular cleaning and disinfection of shipment trucks, so future studies to evaluate the cost and benefit of proper cleaning and disinfection of trucks should aid swine producers and transporters in making informed decisions.

Implications

- Findings from this study suggest that under current biosecurity practices, a substantial risk exists for the spread of PRRS virus due to truck sharing.
- Properly washing, disinfecting, and drying trucks between shipments could largely eliminate this risk.
- This model could also be utilized in understanding the risk of truck sharing on the spread of other swine diseases, such as porcine epidemic diarrhea.

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Conflict of interest

None reported.

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* Non-refereed reference.



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

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

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

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
	198	90
Finisher	220	100
	231	105
	242	110
	253	115
	300	135
Sow	661	300
	794	360
Boar	800	363

1 tonne = 1000 kg

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

1 ppm = 1 mg/L

In vitro fertility of cryopreserved spermatozoa from boars fed diets supplemented with selenium

Mark J. Estienne, PhD; Brian D. Whitaker, PhD

Summary

In vitro fertilization rates were determined for cryopreserved spermatozoa from control boars and boars supplemented with selenium from organic or inorganic sources. Percentages of embryos cleaved and becoming blastocysts were greatest ($P < .01$) for boars fed 0.3 ppm organic selenium. Dietary selenium may improve fertility of cryopreserved boar spermatozoa.

Keywords: swine, spermatozoa, cryopreservation, selenium

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Resumen - Fertilidad in vitro de espermatozoos criopreservados de machos alimentados con una dieta suplementada con selenio

Se determinaron los índices de fertilización in vitro del espermatozoos criopreservados de machos control y machos suplementados con selenio de fuentes inorgánicas y orgánicas. Los porcentajes de embriones divididos y que se convirtieron en blastocitos fue mayor ($P < .01$) en los machos alimentados con 0.3 ppm de selenio orgánico. El selenio dietético puede mejorar la fertilidad del espermatozoos de macho criopreservado.

Résumé - Fertilité in vitro de spermatozoïdes cryopréservés provenant de verrats nourris avec une diète supplémentée avec du sélénium

Les taux de fertilisation in vitro ont été déterminés pour des spermatozoïdes cryopréservés provenant de verrats témoins et de verrats nourris avec un supplément de sélénium de sources organiques et inorganiques. Les pourcentages d'embryons clivés et devenant des blastocystes étaient plus élevés ($P < 0,01$) pour les verrats nourris avec 0,3 ppm de sélénium organique. Le sélénium dans la diète pourrait améliorer la fertilité des spermatozoïdes cryopréservés de verrats.

Beneficial effects of supplemental selenium on reproductive characteristics in boars are well-documented.¹⁻⁵ For example, improvements in sperm production and morphology and fertility were reported for boars fed diets supplemented with inorganic selenium in the form of sodium selenite at a concentration of 0.5 ppm.¹⁻³ Mahan and Kim⁶ suggested that selenite may not be as biologically effective as the selenium indigenous to grains, which is incorporated in an organic form (selenomethionine). This concept is supported by work in which boars fed an organic source of selenium containing 63% selenomethionine (Sel-Plex; Alltech, Inc, Nicholasville, Kentucky) tended to have greater in vitro fertilization (IVF) rates than did boars fed 0.3 ppm selenium from sodium selenite or unsupplemented control boars.⁷ Moreover, enhanced IVF rates displayed by selenomethionine-fed boars were maintained

during storage at 18°C for 8 days.⁷ The objective of this experiment was to extend these findings by determining the effect of dietary supplementation with 0.3 ppm selenium from an organic source on IVF rates for cryopreserved boar spermatozoa.

Materials and methods

The protocol was reviewed and approved by the Virginia Tech-Institutional Animal Care and Use Committee.

Animals and housing

At weaning, crossbred boars were each randomly assigned, using a random number table, to one of three dietary treatments fed during a six-phase feeding program, ie, Nursery 1, 2, and 3; Grower 1 and 2; and Finisher. The dietary treatments were basal corn and soybean meal-based diets that met the nutrient recommendations for growing

boars⁸ with the exception of selenium; basal diets supplemented with 0.3 ppm selenium from an organic source (selenomethionine); and basal diets supplemented with 0.3 ppm selenium from sodium selenite (Premium Selenium 270; North American Nutrition Co, Inc, Lewisburg, Ohio). The US Food and Drug Administration (FDA) allows a maximum of 0.3 ppm supplemental selenium in swine diets.⁹ Boars had ad libitum access to feed and water.

Following completion of the finisher phase, boars were individually penned and were trained to mount an artificial sow to allow semen collection. During the training period and throughout the remainder of the study, boars received approximately 2.73 kg of a basal, breeder-boar diet⁸ or the basal diet supplemented with 0.3 ppm selenium from either selenomethionine or sodium selenite. Selenium concentrations in the basal diets, determined at the Virginia-Maryland College of Veterinary Medicine Toxicology Laboratory in Blacksburg using previously reported procedures,⁷ were 0.03 ppm.

Semen collection and processing

Boars were maintained on a once weekly semen collection frequency, and the experiment reported here was conducted when animals were approximately 1.5 years of age.

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Estienne MJ, Whitaker BD. In vitro fertility of cryopreserved spermatozoa from boars fed diets supplemented with selenium. *J Swine Health Prod.* 2017;25(4):194–197.

Semen was collected using the gloved-hand technique from boars receiving the control diet ($n = 4$), the diet supplemented with 0.3 ppm selenomethionine ($n = 5$), or the diet supplemented with 0.3 ppm sodium selenite ($n = 7$). The sperm-rich fraction of semen was filtered (US BAG; Minitube of America, Inc, Verona, Wisconsin) during collection to remove gel. Sperm motility in collected semen was determined as previously described.¹⁰

Freezing of boar semen

Modena Extender (Swine Genetics International, Cambridge, Iowa) was added to collected semen at an amount 1.5 times the volume of the semen. The extended semen was poured into a Nalgene bottle (Fisher Scientific; Pittsburgh, Pennsylvania), placed in a Styrofoam box with gel packs to maintain a temperature of 18°C, and shipped overnight to Swine Genetics International. The day after collection, semen was frozen in 5-mL plastic macrotubules using commercial procedures (Swine Genetics International) and then stored at -196°C in liquid nitrogen until used for IVF procedures at Findlay University, Ohio. The proportion of live spermatozoa was determined prior to freezing and after thawing using 0.6% eosin red and 5.0% aniline blue dye.¹¹ At the commercial stud, semen with less than 75% live spermatozoa upon arrival is not frozen. On the basis of this criterion, one boar in the group fed selenomethionine was rejected, and data for this animal were not included in the statistical analyses.

Determination of sperm fertilizing capability

Previously described procedures^{7,12} were used. Unless otherwise stated, chemicals were purchased from Sigma-Aldrich (St Louis, Missouri). The oocyte maturation medium was medium 199 with Earle's salts (Thermo Fisher Scientific, Inc, Pittsburgh, Pennsylvania), supplemented with 5 µg per mL follicle stimulating hormone (FSH), 1 µg per mL insulin, 50 ng per mL gentamicin sulfate, 10 ng per mL epidermal growth factor, and 10% (volume by volume) porcine follicular fluid. The IVF medium used was a modified Tris-buffered medium (mTBM),¹³ and the in vitro culture (IVC) medium employed was North Carolina State University (NCSU) 23 medium containing 0.4% (weight by volume) bovine serum albumin.¹⁴

Porcine oocytes (Applied Reproductive Technologies; Madison, Wisconsin) surrounded by a compact cumulus cell mass and uniform ooplasm were washed three times in a 50-mm × 9-mm Falcon polystyrene dish (Thermo Fisher Scientific) using the oocyte maturation medium, and 60 oocytes were placed into each well of a Nunclon four-well multidish (Thermo Fisher Scientific) containing 500 µL of oocyte maturation medium overlaid with mineral oil. The oocytes were incubated at 39°C in an atmosphere of 5% carbon dioxide for 20 to 24 hours. Oocytes were then matured in oocyte maturation medium without FSH, insulin, or porcine follicular fluid for an additional 20 to 24 hours in the manner described.

After incubation, cumulus cells were removed from the oocytes by repeat pipetting with 0.1% hyaluronidase in NCSU 23 solution for 15 to 30 seconds. Oocytes were then washed three times in a Falcon polystyrene dish in 100-µL drops of mTBM and stored in 50 µL drops of mTBM under mineral oil. Semen samples were each thawed in a 15-mL polypropylene conical tube containing 10 mL of mTBM at 37°C, and centrifuged at 36g for 5 minutes. The supernatant was poured into a new tube and mTBM was added to bring the volume to 10 mL. Viable sperm cells were collected after centrifugation at 553g for 5 minutes. The supernatant was discarded and the pellet washed once more as described. Following the wash, the supernatant was discarded and 10 mL of mTBM was added to the pellet. Spermatozoa were counted using a Bright-Line hemacytometer (Thermo Fisher Scientific) and were then diluted with mTBM such that the final concentration was 1×10^6 cells per mL. Then, 50 µL of spermatozoa in mTBM was added to each well, mixed by gentle repeat pipetting, and the oocytes and spermatozoa were co-incubated for 6 to 8 hours at 39°C in an atmosphere of 5% carbon dioxide. For each boar, spermatozoa were added to each of three wells (triplicates), thus 180 oocytes per boar were used and a total of 2700 oocytes were employed for the study (720 total oocytes each for the control and selenomethionine-fed groups and 1260 total oocytes for the sodium selenite group). The IVF and embryo characteristics for each individual boar were determined by averaging the values for the three wells.

After 12 hours from the end of IVF, a portion of the potential embryos were washed three times in 100-µL drops of IVC medium

and then placed in 10 µL of phosphate buffered saline containing 1 µg per mL bisbenzimidazole Hoechst 33342 stain. After 15 minutes of staining, the oocytes were de-stained in IVC medium for 5 minutes and examined under a fluorescent microscope (346 nm excitation wavelength; 460 nm emission wavelength). Oocytes were characterized for penetration by spermatozoa (swollen spermatozoon head), polyspermic (more than one swollen spermatozoon head) penetration, or undergoing male pronucleus (MPN) formation (visual identification of an MPN).

The remaining zygotes were washed three times in 100 µL of IVC medium, placed in 100-µL drops of IVC medium in a 100-mm × 9-mm Falcon polystyrene dish, and incubated at 39°C in an atmosphere of 5% carbon dioxide under mineral oil. After 48 hours post IVF, embryos were placed in fresh IVC medium in the manner described. Cleavage and blastocyst formation were evaluated using a stereomicroscope after 48 and 144 hours post IVF, respectively.

Statistical analyses

Data were analyzed by analysis of variance using the GLM procedure of SAS (SAS Institute Inc, Cary, North Carolina). Boar was the experimental unit for the analyses and the model included treatment as the main effect. Replicate and time were not included in the model. With three treatments, only two orthogonal comparisons were allowed, so single degree of freedom contrasts were used to compare selenium-supplemented boars (selenomethionine and sodium selenite supplementation) versus control boars, and selenomethionine boars versus sodium selenite boars. Data were checked and satisfied the assumptions of analysis of variance.

Results

Results of the investigation are shown in Table 1. There were no effects ($P > .05$) of dietary treatment on the percentage of motile spermatozoa immediately after semen collection, on the proportion of live cells post thaw, or on the percentages of oocytes penetrated, polyspermic penetration, or MPN formation, when frozen-thawed boar spermatozoa were used for IVF. There was a tendency ($P = .09$) for selenium-supplemented boars to have a greater MPN than controls. The percentage of embryos cleaved by 48 hours post IVF was affected by treatment ($P = .01$), with selenium-supplemented boars tending ($P = .07$) to have greater values than

Table 1: Effects of dietary supplementation with selenomethionine or sodium selenite sources of selenium* or no selenium supplementation on in vitro fertilization and early embryonic development after boar spermatozoa were frozen and stored at -196°C

	Selenomethionine	Sodium selenite	Control	SE	Overall	P†	
						Selenomethionine and sodium selenite versus control	Selenomethionine versus sodium selenite
No. of boars	4	7	4	NA	NA	NA	NA
Motile spermatozoa (%)‡	98.0	97.6	97.8	.7	.29	.91	.12
Live spermatozoa (%)§	43.3	42.7	41.3	2.9	.84	.56	.87
Penetrated oocytes (%)¶	90.0	84.8	89.4	3.9	.49	.67	.31
Polyspermic penetration (%)	16.3	15.2	18.7	5.4	.90	.65	.88
Male pronucleus formation (%)	81.4	78.7	66.1	6.4	.22	.09	.74
Embryonic development (%)							
Cleaved by 48 hours post IVF	32.6	23.1	22.1	2.4	.01	.07	< .01
Blastocyst by 144 hours post IVF	21.3	18.3	10.0	2.0	< .01	< .01	.27

* From weaning until approximately 1.5 years of age, boars consumed control diets (no supplementary selenium; n = 4) or diets supplemented with 0.3 ppm selenium from selenomethionine (Sel-Plex; Alltech, Inc, Nicholasville, Kentucky; n = 5) or sodium selenite (Premium Selenium 270; North American Nutrition Co, Inc, Lewisburg, Ohio; n = 7). Collected semen from one boar fed selenomethionine had less than 75% live spermatozoa and was not frozen. Data from this boar were not included in the statistical analysis.

† Data were analyzed by analysis of variance. A P value of < .05 was considered statistically significant; P < .10 was considered a trend.

‡ Determined immediately post collection as previously described.⁷

§ Live spermatozoa as determined post thawing using 0.6% eosin red and 5.0% aniline blue.

¶ Spermatozoa from each boar were added to each of three wells (triplicates), each containing 60 oocytes; values for an individual boar represent the average of the triplicate values.

IVF = in vitro fertilization; NA = not applicable.

controls, and selenomethionine-fed boars having greater ($P < .01$) values than selenite-supplemented boars. The percentage of embryos that progressed to the blastocyst stage of development by 144 hours post IVF was also affected by treatment ($P < .01$), and values for selenium-supplemented boars were greater ($P < .01$) than controls.

Discussion

The dietary requirement for selenium in breeder boars is 0.3 ppm.⁸ Thus, in the current experiment, control boars consumed a diet considered nutritionally deficient in selenium. Our results suggest that dietary supplementation of boar diets with selenium may have a beneficial effect on the ability of sperm cells to maintain fertility after the freeze-thaw process. Moreover, it appears that selenium supplied in an organic form (ie, selenomethionine), rather than an inorganic form (ie, sodium selenite) is superior for maintaining fertility in stored semen. This concept is supported by previous work.⁷ Indeed, in that study, extended semen from boars supplemented with selenomethionine at a concentration of 0.3 ppm had numerically greater, but not statistically different ($P = .11$) IVF rates than did boars

supplemented with 0.3 ppm selenium from sodium selenite or unsupplemented control boars, and the greater sperm motility and enhanced IVF rates displayed by selenomethionine-fed boars were maintained during liquid storage for 8 days at 18°C.⁷

Determining the mechanism responsible for the positive effects of dietary selenium on fertility reported herein will require further experimentation. However, oxidative stress occurs when the antioxidant capacity of the boar is exceeded by the production of physiologically harmful reactive oxygen species. Cryopreservation decreases the antioxidant capacity of boar semen and decreases sperm fertility, negative effects of which are ameliorated by exogenous supplementation of semen with antioxidants.¹⁵ Selenium is an integral component of glutathioneperoxidase (GPx), and gene expression for GPx4, the primary GPx in the mammalian testis, was upregulated in boars fed selenomethionine, compared with boars fed sodium selenite.¹⁶ Thus, enhanced in vitro fertility demonstrated in this study might be a result of increased antioxidant capacity and protection against reactive oxygen species in selenium-supplemented boars.

The vast majority of US sows are bred using artificial insemination (AI)¹⁷ with fresh, liquid semen that is stored at 16°C to 18°C for use within 5 days. Use of frozen semen in swine production has numerous theoretical advantages over use of fresh, liquid semen. For example, frozen semen can be stored indefinitely, and the genetics of outstanding sires can be available for many years after death of the boar. Although good fertility of frozen-thawed porcine semen has been reported in some research trials,^{18,19} in general, lower farrowing rates and litter sizes are obtained after insemination with frozen-thawed semen than with fresh, liquid semen.²⁰ Thus, the current use of frozen semen for AI in the US swine industry is very limited. The results of the current experiment suggest that dietary inclusion of selenium may be a practical approach for improving reproductive performance in AI breeding programs employing frozen boar semen.

Implications

- Under the conditions of this study, in vitro fertility is better in boars supplemented with selenium.

- Inclusion of selenium in the diet of boars may be an effective approach for enhancing reproductive performance on swine farms using cryopreserved semen.

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Conflict of interest

None reported.

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Microcystin toxicosis in nursery pigs

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Summary

This case report documents a clinical case of blue-green algae toxicosis, caused by microcystin toxins, in 5-week-old pigs. Mortality during the investigation was elevated by approximately 7.5% in three affected groups, with a final mortality of 11.4%, and 50% of the population demonstrating clinical signs of various degrees. Affected pigs grew slowly and had distended abdomens. Histological examination of tissue samples revealed hepatic centrilobular necrosis with chronic-active

periacinar individual hepatocyte necrosis and regeneration or centrilobular hepatocyte necrosis with hemorrhage. Additional testing of the feed revealed no toxicity concerns. Algae were present on the surface of a small area of standing water near the pond that had a waterway to the main water supply. There was a small waterway that connected the standing water to the main pond. Water sampled from that small area tested positive for microcystin. On the basis of these findings, it was determined that the toxicity was

caused by algae growth in that area. The affected area was removed to prevent further exposure, and no clinical signs have been present since the standing water area was drained. To the knowledge of the authors, this report describes the first documented case of microcystin toxicosis in nursery pigs.

Keywords: swine, algae, microcystin, nursery pig

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Resumen - Intoxicación por microcistina en lechones de destete

Este reporte documenta un caso clínico de intoxicación por algas azul verdosas, causada por las toxinas de microcistinas, en cerdos de 5 semanas de edad. Durante la investigación, la mortalidad se elevó aproximadamente un 7.5% en tres grupos afectados, con una mortalidad final de 11.4%; 50% de la población mostró signos clínicos de varios grados. Los cerdos afectados crecieron lentamente y presentaron abdomen distendido. El examen histológico de muestras de tejido reveló necrosis centrolobulillar hepática con necrosis hepática individual periacinar crónica activa y regeneración o necrosis hepatocítica centrolobulillar con hemorragia. Las pruebas adicionales del alimento no revelaron problemas importantes de intoxicación. Había algas en la superficie de un área pequeña de agua estancada cerca del estanque que tenía un canal al suministro principal de agua. Había un pequeño canal que conectaba el agua estancada con el estanque principal. La muestra del agua de esa pequeña área resultó positiva a la microcistina. En base a estos hallazgos, se determinó que la toxicidad fue

causada por el crecimiento de algas en esa área. Se eliminó el área afectada para prevenir mayor exposición, no se han presentado signos clínicos desde que se drenó el área del agua estancada. De acuerdo a lo que los autores, este reporte describe el primer caso documentado de intoxicación por microcistina en lechones de destete.

Résumé - Toxicose causée par la microcistine chez des porcelets en pouponnière

Le présent rapport documente un cas clinique de toxicose à la microcistine causé par des cyanobactéries (algues bleu-vert) chez des porcelets âgés de 5 semaines. Le taux de mortalité durant cette enquête était augmenté d'environ 7,5% dans les trois groupes affectés, avec un taux de mortalité final de 11,4%, et 50% de la population montrant des signes cliniques à différents degrés. Les porcs affectés avaient une croissance ralentie et des abdomens distendus. Un examen histologique d'échantillons de tissu a révélé une nécrose hépatique centrilobulaire avec une nécrose chronique-active des hépatocytes péri-acinaires individuels et régénération ou

nécrose des hépatocytes centrilobulaires avec hémorragie. Des tests supplémentaires effectués sur l'aliment n'ont pas révélé d'évidence de toxicité. Des algues étaient présentes à la surface d'une petite zone d'eau stagnante proche de l'étang qui avait un canal jusqu'à la source principale d'approvisionnement en eau. Il y avait un petit canal qui connectait l'eau stagnante avec l'étang principal. De l'eau prélevée de la petite zone était positive pour la présence de microcistine. À la lumière de ces résultats, il a été déterminé que la toxicité était causée par la croissance des algues dans cette zone. La zone affectée a été retirée afin de prévenir une exposition future, et aucun signe clinique ne fut détecté suite au drainage de l'eau stagnante. À la connaissance des auteurs, le présent rapport décrit pour la première fois une toxicose liée à la microcistine chez des porcelets en pouponnière.

Microcystins are toxins produced by freshwater cyanobacteria.¹ Microcystin-LR is a common microcystin. When in high concentrations (such as algae blooms), ingested microcystin toxins inhibit phosphatases 1 and 2A in the liver, causing hemorrhaging. Microcystin toxins may also be associated with gastroenteritis and renal necrosis.² Blue-green algae blooms generally occur during summer months and do not always contain deadly toxins. However, certain species of algae do bloom in the winter.^{3,4}

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The water for ponds is supplied from watersheds during rainfall and snow melt. Field tiles often drain into the watershed supplying the pond. As the water from the pond enters the animal facility, it is generally treated for bacterial and viral pathogens with products such as chlorine, chlorine dioxide, hydrogen peroxide, or ozone.^{5,6} These products are effective against bacteria and viruses and can help reduce algae growth in the water lines inside the facility; however, they are not effective against pre-formed algae toxins that may already be present in the pond water.^{7,8}

Previous studies^{1,9} have documented the impact of the toxins on liver function; however, little information is currently present describing cases of accidental ingestion in swine.^{1,9}

Case description

Herd description. This facility was under veterinary care and certified by the Pork Quality Assurance (PQA; National Pork Board). The case herd was established in 2013 as a 2500 breed-to-wean facility maintaining PIC 1050 females, with an attached on-site isolation and gilt developer. The herd was stable for *Mycoplasma hyopneumoniae*

and negative for porcine reproductive and respiratory syndrome virus, porcine epidemic diarrhea virus, porcine delta coronavirus, and transmissible gastroenteritis virus infections. Drinking water for livestock was from an adjacent pond (approximately 17,000 m²) that was naturally filled via watershed. The water was treated with hydrogen peroxide in a holding tank prior to use within the sow facility. The isolation rooms were the point of water entry into the facility. Replacement females were delivered to the facility as isolated weaned pigs at approximately 21 days of age. One hundred and thirty newly weaned gilts were delivered every 28 days. Three days prior to weaning, piglets received 1 mL of Ingelvac Circoflex (Boehringer Ingelheim, St Joseph, Missouri) and 1 mL of Enterisol Ileitis (Boehringer Ingelheim). Additional vaccinations were given to control for porcine parvovirus, *Leptospira interrogans* serovars, erysipelas, and influenza A virus. Upon selection, gilts were entered into the gestation facility of the farm for their first gestation. A local feed mill manufactured the feed for the facility, with feed formulated to meet or exceed National Research Council¹⁰ recommendations.

Clinical description. Pigs presented with clinical signs at approximately 5 weeks of age, starting mid-November 2015. It was suspected that sudden death, the initial clinical presentation, was associated with *Streptococcus suis* septicemia. Initial treatment to mitigate the potential bacterial infection did not appear successful. The attending veterinarian (DMC) observed that when injectable medications were given, the population did not respond to the therapeutics, and daily and weekly mortality numbers appeared to increase after treatment.

In the three consecutive groups of replacement females affected, the first and third groups (birth dates September 16, 2015, and November 11, 2015) prevalence of clinical signs appeared to be higher, and, in addition, in these three groups, nursery mortality was elevated above the average nursery mortality of 2.3% (Figure 1). Slow growth and distended abdomens were initially reported in both replacement groups (Figure 2). Fifty percent of the pigs were clinically affected and 50% of the mortality was listed as sudden death. No cough or respiratory distress was present and no abnormal bowel movements were noted. No pattern of illness was

Figure 1: A clinical case of blue-green algae toxicosis was caused by microcystin toxins in 5-week-old replacement gilts located in the US Midwest during the fall and winter period of 2015-2016. Animals arrived on farm approximately 21 days after their birth dates and remained on the farm during the course of the observation period in the gilt developer unit. Clinical signs noted in the isolation nursery persisted in the gilt development barn in three cohorts of replacement females. Mortality during the investigation was elevated by approximately 7.5% in the three affected groups, with 50% of the population demonstrating clinical signs of various degrees. Affected pigs grew poorly, had distended abdomens, and histologically exhibited hepatic centrilobular necrosis with chronic-active periportal individual hepatocyte necrosis and regeneration or centrilobular hepatocyte necrosis with hemorrhage. The percent of mortalities each week throughout the observation period is shown, with the dates representing the birth dates of the cohorts. The August 19th birth group is a baseline group to demonstrate average mortality immediately prior to the first group showing signs of microcystin toxicosis. Birth groups that arrived after the three clinically affected birth groups are presented in the graph to further demonstrate the impact of the toxicosis on mortality.

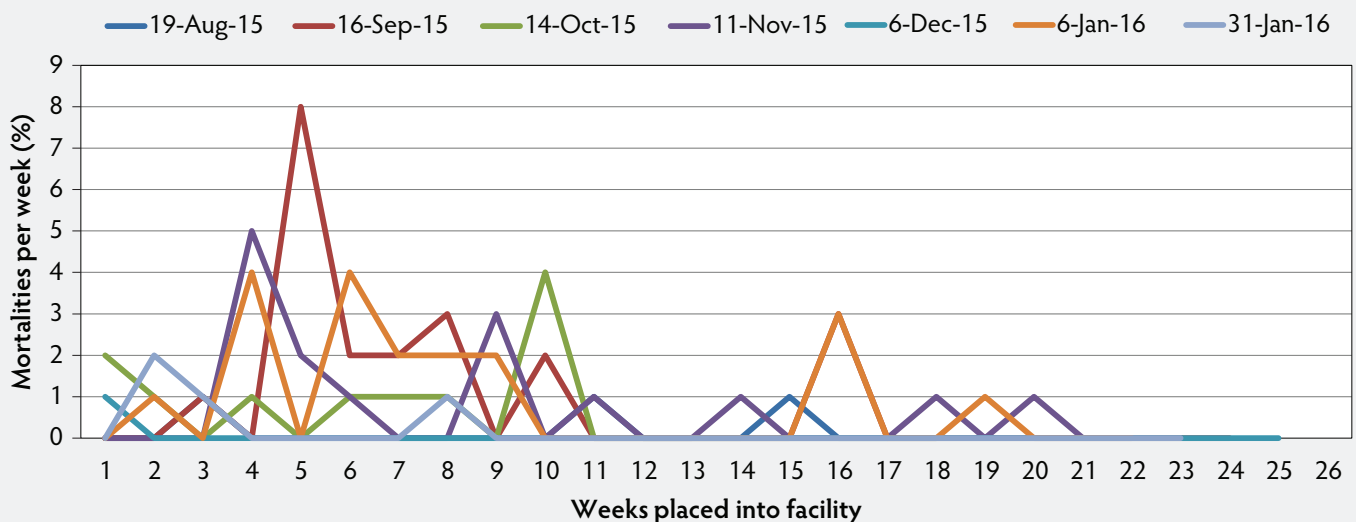


Figure 2: Clinically affected pig, as described in Figure 1, with a distended abdomen (arrow) and poor growth as the initial clinical signs of microcystin toxicosis. Paracentesis of the abdomen of euthanized pigs resulted in no fluid collected; however, necropsy of pigs that died consistently demonstrated severe ascites. Clinical signs appeared at approximately 5 weeks of age, starting mid-November 2015. As described in Figure 1, the prevalence of clinical signs in the three consecutive groups of replacement females affected appeared to be higher in the first and third groups (birth dates September 16, 2015 and November 11, 2015). In all three groups, mortality was elevated above the average nursery mortality of 2.3%.



noted by pen or by room. Paracentesis of the abdomen of euthanized pigs resulted in no fluid collected; however, necropsy of pigs that died demonstrated severe ascites consistently present. Replacement females from the same source as this sow farm did not present with similar clinical signs during the same time period; however, the source farm did have downstream reports of *S suis* meningitis and septicemia. Tissue samples (brain, colon, heart, joint swab, kidney, liver, lung, mesenteric lymph nodes, oral fluids, serum, small intestine, spinal cord, spleen, stomach contents, tonsil, and urine) were submitted to Iowa State University Veterinary Diagnostic Laboratory (ISU VDL; Ames, Iowa) and University of Minnesota Veterinary Diagnostic Laboratory (UMN VDL; St Paul, Minnesota) at various time points during the period when clinical signs were observed. Both diagnostic laboratories conducted bacteriologic and histopathologic testing, liver mineral panels, and molecular diagnostics. In addition, ISU VDL tested water samples for toxins and for nitrates and nitrites.

Laboratory findings. Initial tissue samples submitted in November did not confirm an etiologic diagnosis, hence continued sampling and laboratory submissions occurred as differentials were identified and eliminated from consideration. Samples of feed, serum, tissues, and water were submitted at various

times during the period of November 2015 until March 2016 for toxin screening of the feed and water, as well as further pathogen screening and histopathologic and toxicosis evaluations of the tissues. A timeline for sample submission and test results is demonstrated in Figure 3.

Gross lesions. The predominant changes observed grossly in virtually all pigs were swollen livers with rounded edges and variable fibrous adhesions to the peritoneum (Figure 4). However, most livers had varying degrees of locally extensive hemorrhage and congestion, an accentuated lobular pattern, and often generalized yellowish discoloration consistent with icterus (Figure 5).

Histopathologic examination. Microscopy of livers in affected pigs presented with massive centrilobular necrosis, with chronic-active periportal individual hepatocyte necrosis and regeneration, or with severe, diffuse centrilobular hepatocyte necrosis with sinusoidal distention. Lesions appeared subacute in most examined pigs. In addition, centrilobular congestion with loss of hepatocytes and disruption of hepatic cord morphology was a common feature. Hepatocytes in periportal areas were unaffected, and periportal connective tissue, blood vessels, and bile ducts were normal in morphology. Other salient features included scattered foci

of extramedullary hematopoiesis and thickening of the liver capsule with fibrosis and fibrin accumulation in some pigs. All other submitted tissues (brain, heart, lung, spleen, spinal cord, and tonsil) were unremarkable. No myocardial lesions were present.

Bacteriologic and virologic testing

Hemophilus parasuis was present in the brain sample collected on November 10, 2015; however, no lesions were detected during histopathologic review of the brain tissue. No significant growth of bacterial pathogens was present in the additional eight sets of samples from subsequent submissions. Neither *Mycoplasma hyorhinis* nor *Hemophilus parasuis* was detected by polymerase chain reaction in any samples after November 10, 2015. Likewise, evidence for involvement of porcine circovirus type 2, porcine reproductive and respiratory syndrome virus, and influenza type A virus was consistently lacking by clinical, pathological, and microbiological assessments.

Blood chemistry. Ten blood samples (five from affected pigs and five from clinically normal cohorts) were collected and the serum was submitted December 10, 2015. In all samples, potassium, phosphorus, and alkaline phosphatase (> 130 IU per L) were elevated. Total protein concentrations were low. In three affected pigs, creatine kinase was elevated (> 2500 IU per L), and in four affected pigs, troponin concentrations were elevated (> 0.07 ng per mL). In four affected pigs, aspartate transaminase (AST) concentrations were elevated. Reference ranges provided by the testing diagnostic facility for each of these tests are as follows: potassium, 4 to 7 mEq per L; phosphorus, 4 to 9 mg per dL; alkaline phosphatase, 25 to 130 IU per L; total protein, 7 to 8.9 mg per dL; creatine kinase, 100 to 2500 IU per L; troponin, < 0.07 ng per mL; AST, 10 to 100 IU per L.

Toxin screening. Evaluation of toxic or idiosyncratic hepatic insults in November included screening for drugs, metals, mycotoxins, and organic compounds. Niacinamide and cholesterol were detected in the liver by gas chromatography-mass spectrometry (GC-MS) examination, but were not considered toxic in this case. No unusual organic compounds or concerning concentrations of trace minerals (cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, molybdenum, phosphorus, potassium, selenium, sodium, and

Figure 3: Timeline of sample submissions and findings for nursery pigs affected by microcystin toxicity in the case described in Figure 1. CK = creatine kinase; alk phos = alkaline phosphatase; GC/MS = gas chromatography-mass spectrometry.

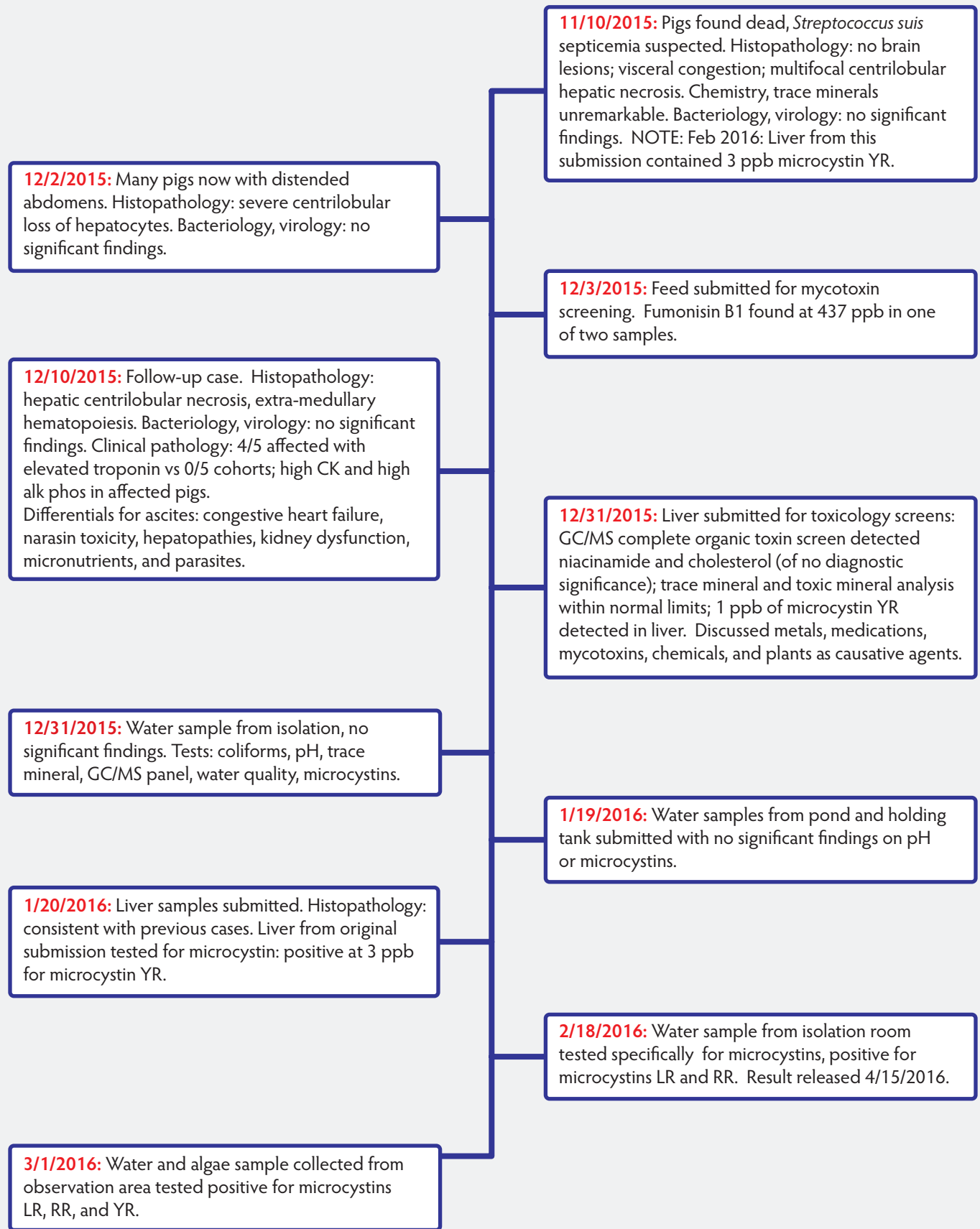


Figure 4: Initial necropsy findings of 5-week-old microcystin-affected pigs demonstrated swollen livers with rounded edges and extensive fibrous adhesions to peritoneum (case described in Figure 1).

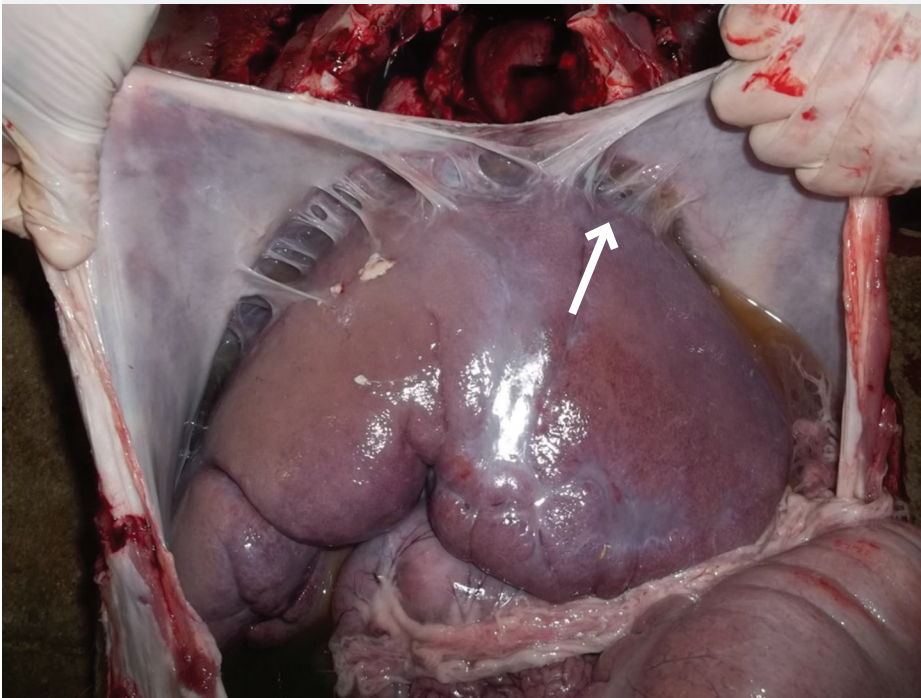
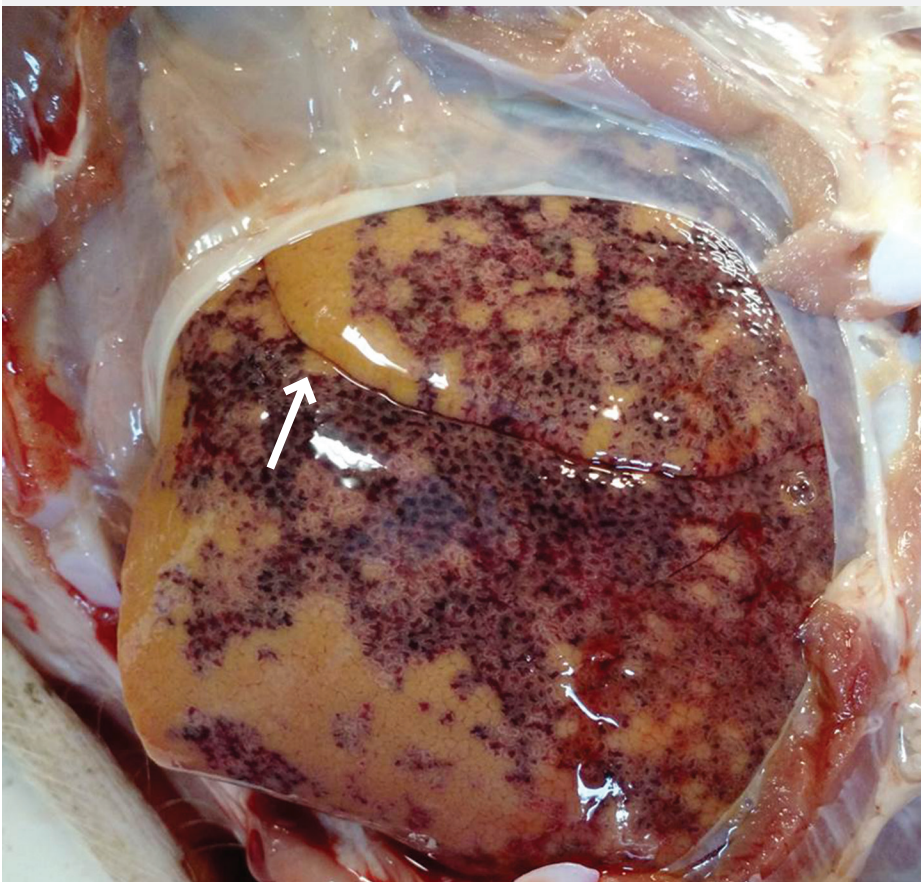


Figure 5: Additional necropsy findings from 5-week-old pigs affected by microcystins demonstrated livers with multifocal centrilobular hepatic necrosis (case described in Figure 1).



zinc) were detected in liver per the reference ranges provided by the testing diagnostic facility. Vitamin E was 3.5 ppm in liver tissue. A second liver mineral screen that included heavy metals such as arsenic, lead, and mercury was conducted on two pigs on December 31, 2015, with similar findings. Additional chemical analysis of liver toxicology screening was performed on January 20, 2016, on tissue collected from the pigs that were submitted on November 10, 2015. One set of the tissues from that date tested positive for 3 ppb of microcystin YR in the liver of an affected pig.

Additional testing. Feed samples from the isolation barn were collected on December 3, 2015, and submitted to North Dakota State University Veterinary Diagnostic Laboratory (Fargo, North Dakota). Testing for a panel of 12 mycotoxins in two feed samples resulted in one non-remarkable finding and one with 437 ppb of fumonisin B1. A single water sample, collected December 31, 2015, from the isolation room, was tested. Water samples were all collected using a clean bottle or container either by holding the container under a water nipple or directly inserting it into the water and holding the container with a clean glove. Water pH conducted by quick test in-house was 7.6. The water was then submitted to the diagnostic facility for additional testing. Tests were conducted by GC-MS for aliphatic hydrocarbons; alkyl benzenes; antioxidants; carbamates; disinfectants; drugs; heavy metals; industrial pollutants; ionophores; natural products; organochlorines; organophosphates; pesticides, plant and fungal toxins; polycyclic aromatics; and vitamins. In addition, the water was tested for coliforms, pH, trace minerals, and microcystins. The findings from that water sample were not significant in that either no chemicals were identified or that the nitrates, pH, sulfates, and total solids all tested below the recommended limits released by the diagnostic facility. Two additional water samples were collected on January 19, 2016, from the pond and the holding tank, with no clinically significant findings associated with pH or microcystins. A single water sample collected from the isolation room on February 18, 2016, held at the ISU VDL, and tested for microcystins in April of 2016, was positive for microcystin LR and RR (3.4 ppb and 2 ppb, respectively). One additional set of three water samples was collected on March 1, 2016. These samples were from an area southeast of

the main pond in which there was standing water and algae growing on the surface of the water. Upon further analysis of the area, a small waterway connected the standing water area with the main pond. The three samples collected were just water from that area, and two samples in which the algae was skimmed off the surface to be tested directly. Both of the two algae samples collected from the area tested positive for microcystins LA, LR, RR, and YR (range of 3 to 33.7 ppb LA, 4.3 to 9.9 ppb of LR, 5.4 to 14 ppb of RR, and 4.5 to 4.6 ppb of YR). The sample collected from that standing water area was positive for microcystins LR and RR (1 ppb and 1.6 ppb, respectively).

Additional investigation and outcome.

Examination of aquifer and water supply in January 2016 did not reveal algae blooms or discoloration of the main water supply. Snow cover was present during the time of the observations. Additional investigation of the water supply on February 22, 2016, led the attending veterinarian (DMC) to an area of standing water (506 m²) nearby in a wooded area next to the main water supply (Figure 6A). Algae growth was present in this area, and after further evaluation (Figure 6B), it was determined that a small waterway from this area entered the facility's pond near the point of the intake pump (Figure 6C). Due to the presence of algae during the winter season, DMC documented environmental temperatures (Figure 7) to determine if the temperatures were high enough to support algae growth in the winter. Furthermore, the standing water was removed by reshaping the ground topography to allow for rainfall to flow into the main pond instead of sitting on flat ground. Clinical signs have not returned.

During this period of investigation (November 10, 2015 through March 1, 2016), pigs with severe clinical signs were humanely euthanized. All other animals remained at the facility under observation. As of July 11, 2016, mortality was elevated in all three affected groups identified for birth weeks September 16, 2015, through November 11, 2015. Mortality rates were 15.6% for birth week September 16, 2015; 7.9% for birth week October 14, 2015; and 10.8% for birth week November 11, 2015, compared to the average mortality rate (2.3%) before and after these groups. No new groups have been affected.

Figure 6: Water supply to the facility in the case described in Figure 1, with the area of observation highlighted in white. This area was separated from the main water supply with a small connecting stream (Panel A; arrow) shown in an image captured February 22, 2016. Closer review showed areas with algae present (Panel B; arrow). The small connecting stream is shown where it entered the main water supply for the facility (Panel C; arrow).

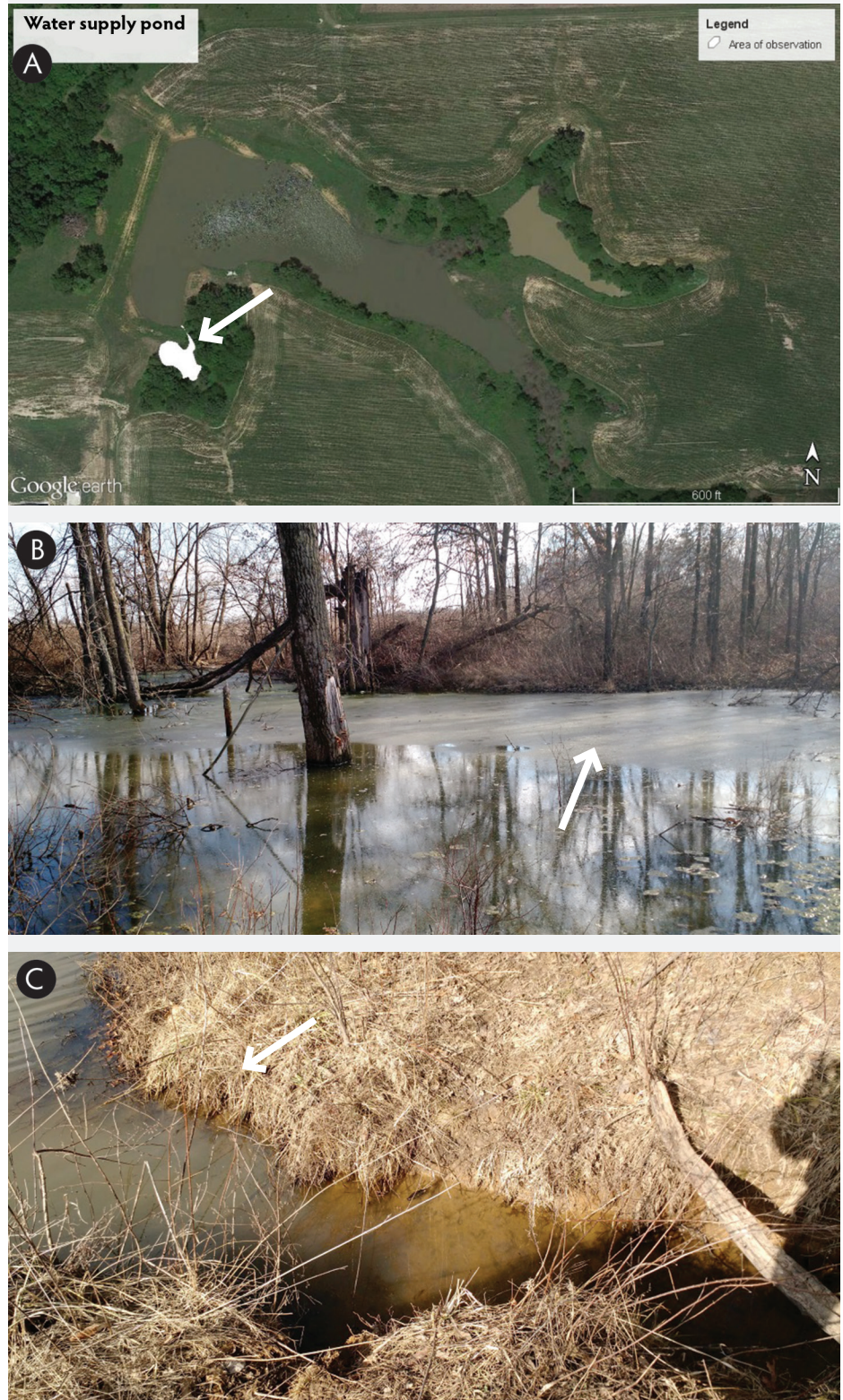
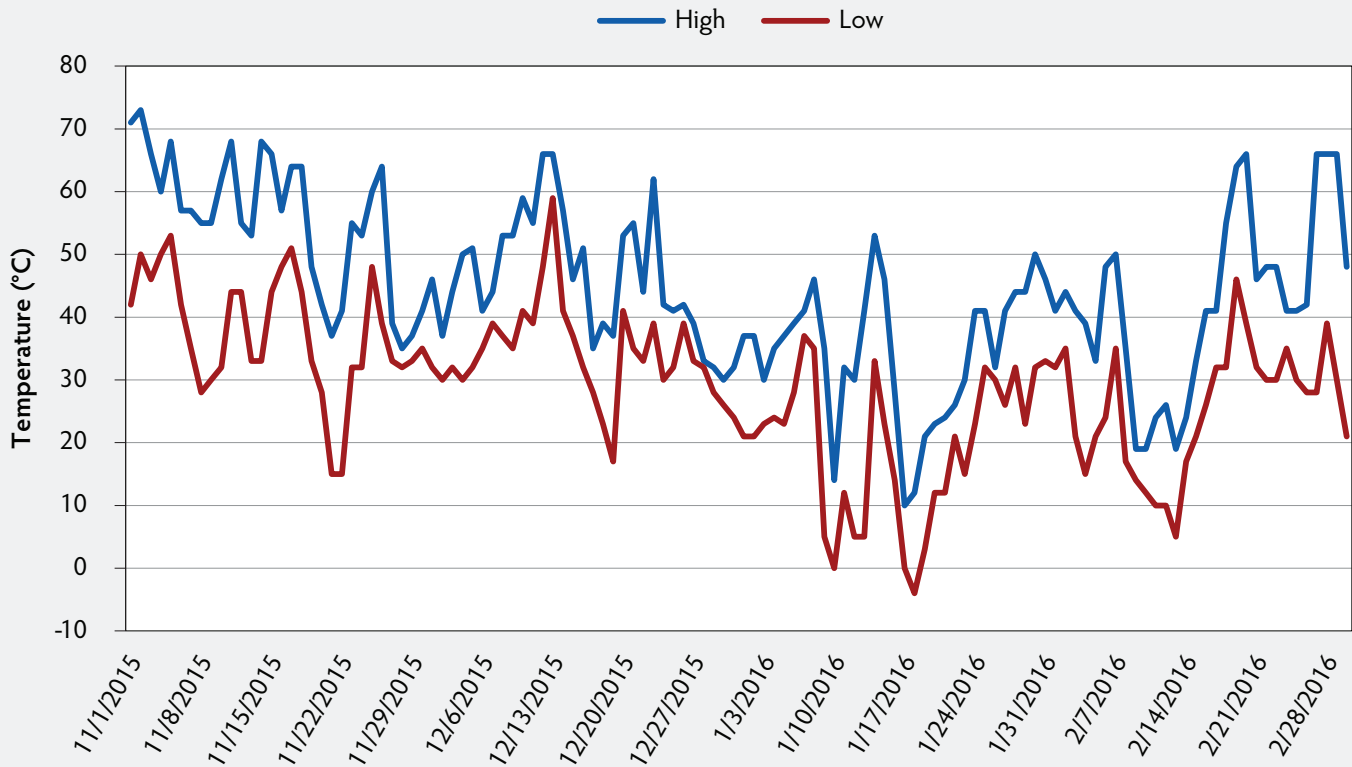


Figure 7: Ambient temperature from November 2015 until March 1, 2016, where the swine facility associated with the case described in Figure 1 was located.



Discussion

On the basis of clinical signs and absence of pathogenic bacteria or viruses, despite repeated testing, the authors sequentially investigated potential causes of liver toxicosis other than microcystins. Water was identified as a suspect for carrying a toxin; however, initial findings were unsupported for the water to contain a causative agent. Feed was also considered a source for potential toxins. Feed samples were collected and had a moderate concentration of fumonisin B1, but not at a concentration sufficient to create liver failure.¹¹

The WHO sets a microcystin LR safe allowable limit at 1.045 µg per L (1.045 ppb) for humans.¹² Mouse models demonstrate that this concentration results in no long-term consequences when provided for 28 weeks.¹³ However, animal studies demonstrate that higher concentrations than the allowable limit for long periods of time result in liver injury.¹⁴ Acute exposure has been documented and demonstrates the impact of microcystins on liver failure and mortality.¹⁹ While the duration or dosage of exposure that occurred are unknown in this case, the documentation of microcystin LR

concentrations above the human safe allowable limits indicates that liver damage would likely occur.

In this case, the attending veterinarian (DMC) observed that during periods when there were clinical signs in the herd, injectable medications did not reduce the severity of the illness, and mortality appeared to increase after treatment. Upon review of published literature from other species, it was learned that medications that create drug-induced hepatotoxicity should be avoided during periods of liver damage such as cirrhosis.¹⁵ Microcystin toxicity results in reduced hepatic perfusion and leads to hepatic failure.¹⁶ Drug metabolism is dependent upon both hepatic blood flow and liver enzyme function.¹⁷ Furthermore, a single exposure to certain microcystins, such as microcystin LR, can also cause a change in sodium transport in the kidney and result in renal damage.¹⁸ Enrofloxacin was used as part of the therapy program in this case; however, past hepatic and renal failure models have demonstrated that enrofloxacin will not cause additional hepatic impairment, but rather, renal impairment.¹⁹ Although the primary focus of the case was the liver,

because of the distention of the abdomen and coloration of the liver, blood chemistry indicated some kidney damage was present, but no direct link could be made to the use of enrofloxacin and increased mortality. However, on the basis of the literature and known effect of microcystin toxicosis, caution should be placed when selecting appropriate medications for use in animals where microcystin toxicosis is suspected, due to the nature of toxicosis associated with the hepatic and renal functions.

Although initial clinical signs presented in the fall of 2015, new groups of animals became clinically ill during the winter of 2015-2016. The water sample collected from the isolation facility in February, which tested positive for microcystin, indicates that algae growth can occur in the winter and microcystin toxicity can be an issue even during periods of snowfall.³ Upon evaluating ambient temperatures for this timeframe, it can be noted that the temperature was variable, with few days in which the temperature remained below freezing. Algae are likely to release toxins as they die off or are broken down by an animal during digestion, and so it is hypothesized that the toxins were

released when the temperatures were below freezing. However, the temperatures did not stay low long enough to kill the algae, and therefore a cycle was established in which the algae grew when temperatures were above freezing and then toxins were periodically released into the water when temperatures fell below freezing. This hypothesis is supported by the evidence of the toxins being identified in the water.⁴ Winds, snowfall, and freezing rain would all contribute to the standing water in this area, which would then be moved into the main water supply. The small waterway that connected this area to the main pond was near the water intake area. Both algae and the toxin could be moved into the main pond to the water intake area quickly, so little dilution of the toxin could occur before it was moved into the facility. Since the isolation facility was the point of entry into the barn for the water supply, these small pigs were likely to receive the highest concentration of microcystin per kg of metabolic body weight, compared to the remainder of the farm population.

Even though the liver tissue tested positive for microcystin YR in November 2015 and the isolation water tested positive for only LR and RR in February 2016, it is believed that the area of standing water was the contributing factor to this case. Algae can produce all three toxins, which was demonstrated by the March 1, 2016 collection, and therefore it is believed that the toxin presenting in the pig was in higher concentration in November than in February, when the water was collected inside the building, and also in the standing water sample on March 1, 2016.⁴

Implications

- Under the conditions of this case, fluctuating temperatures may contribute to algae dying and releasing toxins during fall and winter months.
- Surface water should be monitored for algae blooms, but any watershed into those ponds should also be evaluated.
- Use of medications that are hepatotoxic or use the renal pathway should be avoided in animals suspected of having microcystin toxicosis.

Conflict of interest

None reported

Disclaimer

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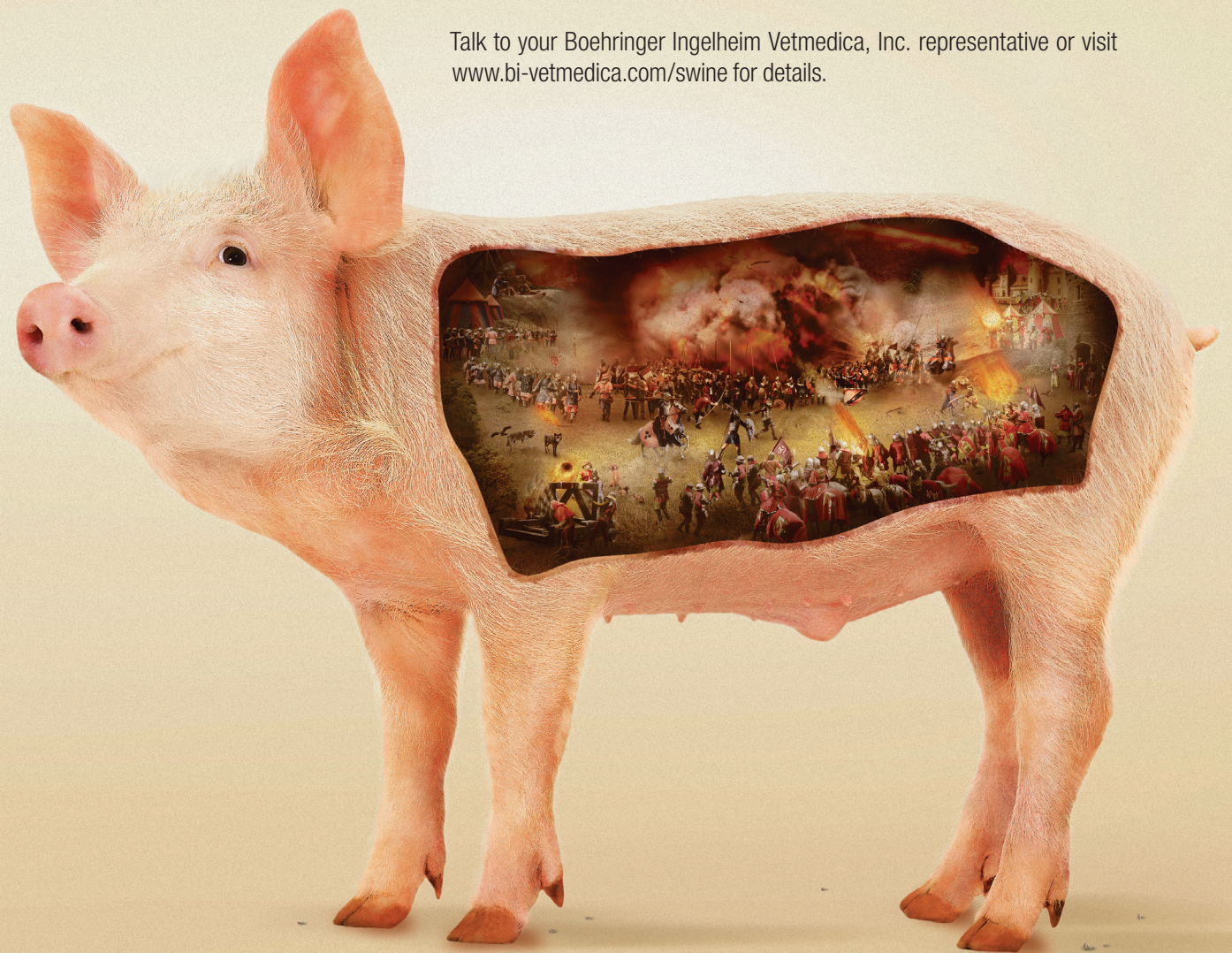


WHILE YOU'RE PREVENTING *SALMONELLA C*, *SALMONELLA T* COULD BE PLANNING ITS ATTACK.

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START HEALTHY. END STRONG.



Communications, SciTech collaborate on FAD crisis drills

Throughout the year, the National Pork Board is conducting a series of tabletop crisis preparation drills in various pig-producing states that center on the industry's response to a crisis such as the introduction of a foreign animal disease (FAD). In the first quarter of

2017, Checkoff's director of swine health and information, Dr Patrick Webb, led day-long drills in Illinois and Utah. To find out more on the content of these drills, he says producers and veterinarians can turn to the revised Transport Quality Assurance manual

to read about crisis scenarios and to use the related planning exercises.

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

Pork Checkoff awards 22 science scholarships

Each year, the National Pork Board awards scholarships to students seeking to work in the pork industry. This year, Checkoff has named 22 annual scholarship winners representing 11 colleges and universities, with scholarships totaling \$48,500. An analysis of education

and career paths from the 2010 Pork Industry Scholarship program showed that 92% of the respondents are actively employed in agriculture and 75% of this group are specifically involved in the pork industry. The 2010 class recipients have advanced degrees, including

seven with masters degrees, three with doctorates, and three with veterinary degrees.

For more information, contact Dr Chris Hostetler at CHostetler@pork.org or 515-223-2606.

OMS expands outreach to nurse practitioners

Operation Main Street (OMS) speakers are now taking the pork industry's story to yet another key influencer group – medical professionals. Earlier this year, Illinois OMS speaker Megan Schnur, DVM, with Carthage Veterinary Services, presented to members of the Society of Advanced

Practice Nursing in Springfield, Illinois. While preparing for the presentation, Megan asked the nurses what they wanted to know about pig farming. Their main interests were how antibiotics and hormones used in pig farming affect humans who eat

pork, and whether humane animal care is a priority on today's pig farms.

To learn more about OMS, go to www.pork.org or contact Ernie Barnes at EBarnes@pork.org.

Enzyme Webinar series coming in August

The Pork Checkoff's annual research Webinar series, which kicks off on August 1, will focus on "Use of Enzymes in Swine Diets." The four weekly Webinars will offer insights into how to use enzymes in swine diets to maximize nutrient uptake from fibrous feedstuffs, and will highlight related research projects. The Webinars will begin at noon (CDT) on each date.

- August 1: How dietary enzymes work – Dr Dean Boyd
- August 8: Gut physiology of pigs fed diets with carbohydrase enzymes – Dr Pedro Urriola
- August 15: Applying enzyme technology to optimize the utilization of fibrous feed ingredients – Dr Eric van Heugten

- August 22: Evaluation of the nutrient uplift provided by xylanase in finishing diets – Dr Merlin Lindemann

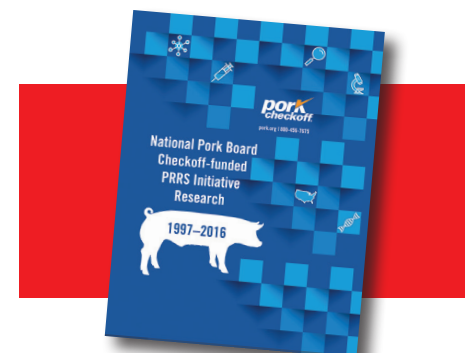
To register for these free Webinars, go to www.pork.org/animalscience. For more information, contact Dr Chris Hostetler at CHostetler@pork.org or 515-223-2606.

New PRRS Research Book available

The National Pork Board's brand new porcine reproductive and respiratory syndrome (PRRS) virus research booklet is the most comprehensive source of Checkoff-funded research ever available on the subject. This new version, updated and expanded from the 2012 edition, contains Checkoff-funded PRRS research from 1997 to 2016 that can

help producers, veterinarians, and researchers alike to learn more about how to control this costly virus. The PRRS Research Book is available online at www.pork.org/research and in limited print editions.

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



NPB news continued on page 209

Assembling All the Right Elements.

1 H																						
3 Li	4 Be																					
11 Na	12 Mg																					
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co														
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Introducing Ceva Swine.

Veterinary research. Scientific excellence. Robust development pipeline.

At Ceva Swine, these are the building blocks to solutions that improve swine health and reproduction, prevent emerging diseases and enhance grow/finish performance – and address other unmet needs in the swine industry. Founded by veterinarians, we are focused on providing the right resources and the right products. Discover the properties that make Ceva Swine an industry leader. www.ceva.us



Secure Pork Supply work moves forward

Business continuity plan

Recently, the National Pork Board (NPB) asked the Institute for Infectious Animal Diseases (IIAD) to develop a white paper on domestic pork business continuity. It would provide an estimate for the effort and cost required for designing, planning, developing, and implementing a system that allows the US swine industry to collect, store, and share data between producers and animal health regulators for purposes of business continuity. In a workshop held in

Des Moines in April, an industry group reviewed the white paper to determine if costs and timelines could be reduced if IIAD and NPB's IT department worked in tandem on the project. The collaboration is now underway.

Surveillance plan

Iowa State University's Center for Food Security and Public Health is beginning the process of developing a surveillance testing protocol (collection, testing, and reporting)

for oral fluids using spatially balanced sampling. This is a new area of research led by Dr Jeff Zimmerman. A pilot project using porcine epidemic diarrhea virus (PEDV) as the test case is set to start to show proof of concept. Following the pilot, investigators will produce a report for review by the PEDV Taskforce and the Checkoff's Swine Health Committee.

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





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AASV NEWS

Call for submissions – Industrial Partners

The American Association of Swine Veterinarians invites submissions for the Industrial Partners portion of the 49th AASV Annual Meeting, to be held March 3-6, 2018, in San Diego, California. This is an opportunity for commercial companies to make brief presentations of a technical, educational nature to members of the AASV.

As in the past, the oral sessions will consist of a series of 15-minute presentations scheduled from 1:00 to 5:00 PM on Sunday afternoon, March 4. A poster session will take place on the same day. Poster authors will be required to be stationed with their poster from 12:00 noon until 1:00 PM, and the posters will remain on display throughout the afternoon and the following day for viewing by meeting attendees.

Restricted program space necessitates a limit on the number of presentations per company.

Companies that are members of the *Journal of Swine Health and Production* Industry Support Council (listed at www.aasv.org/aasv/aasvisc.php) may submit two topics for oral presentation. All other companies may submit one topic for oral presentation. Sponsors of the AASV e-Letter may submit an additional topic for oral presentation. In addition, every company may submit one topic for poster presentation (poster topics must not duplicate oral presentations). All topics must represent information not previously presented at the AASV Annual Meeting or published in the meeting proceedings.

To participate, send 1) company name, 2) presentation title, 3) a brief description of the presentation content, and 4) contact information for the presenter (name, mailing address, telephone number, and e-mail address) to AASV by **September 29, 2017**.

Please identify whether the submission is intended for ORAL or POSTER presentation. Send submissions to aasv@aasv.org.

Presenters will be notified of their acceptance by October 13, 2017, and must submit a paper for publication in the meeting proceedings by November 15, 2017. Companies failing to submit papers in a timely manner may not be eligible for future participation in these sessions.

There is no charge for participation in the Industrial Partners sessions, but all presenters are required to register for the meeting (nonmember participants may register at the AASV regular member rate). The AASV does not provide a speaking stipend or travel reimbursement to Industrial Partners presenters.

Call for abstracts – Research Topics session

Plans are underway for the 49th annual meeting of the American Association of Swine Veterinarians (AASV), to take place March 3-6, 2018, in San Diego, California. 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.

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, 2017**. 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 paper, formatted for publication in the meeting proceedings, by November 15, 2017.

Please note: Participation in the Research Topics oral and poster session 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.

2017 AASV Foundation Golf Outing



Thursday, August 24, 2017 • 11:00 AM – 6:00 PM

It's tee time!



REGISTRATION FORM

Please complete, detach, and return this form with payment to the AASV Foundation by August 7, 2017

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)

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3. _____
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I cannot attend, but will contribute to the AASV Foundation.

My tax-deductible donation is enclosed: \$ _____

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Call for papers – AASV 2018 Student Seminar

Veterinary Student Scholarships

The American Association of Swine Veterinarians announces an opportunity for veterinary students to make a scientific presentation during the Student Seminar at the AASV Annual Meeting in San Diego, California, on Sunday, March 4, 2018. 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 (2017-2018) student member of the AASV at the time of submission, and must not have graduated from veterinary school prior to March 4, 2018. Submissions are limited to one (1) abstract per student.

Abstracts and supplementary materials must be **received** by Dr Maria Pieters (pieters@aaav.org) by **11:59 PM Central Daylight Time on Wednesday, September 20, 2017** (firm deadline). All material must be submitted electronically. Late abstracts will not be considered. Students will receive an e-mail confirming the receipt of their submission. If they do not receive this confirmation e-mail, they must contact Dr Maria Pieters (pieters@aaav.org) by Friday, September 22, 2017, with supporting

evidence that the submission was made in time; otherwise, the submission will not be considered for judging. The abstracts will be reviewed by an unbiased, professional panel consisting of private practitioners, academicians, and industry veterinarians. Fifteen abstracts will be selected for oral presentation in the Student Seminar at the AASV Annual Meeting. Students will be notified by October 13, 2017, and those selected to participate will be expected to provide the complete paper or abstract, reformatted for publication, by November 15, 2017.

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.

Each veterinary student whose paper is selected for oral presentation competes for one of several veterinary student scholarships awarded through the AASV Foundation. The oral presentations will be judged to determine the amount of the scholarship awarded. Zoetis funds the \$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 \$2500 each for 2nd through 5th place, \$1500 each for 6th through 10th place, and \$500 each for 11th through 15th place.

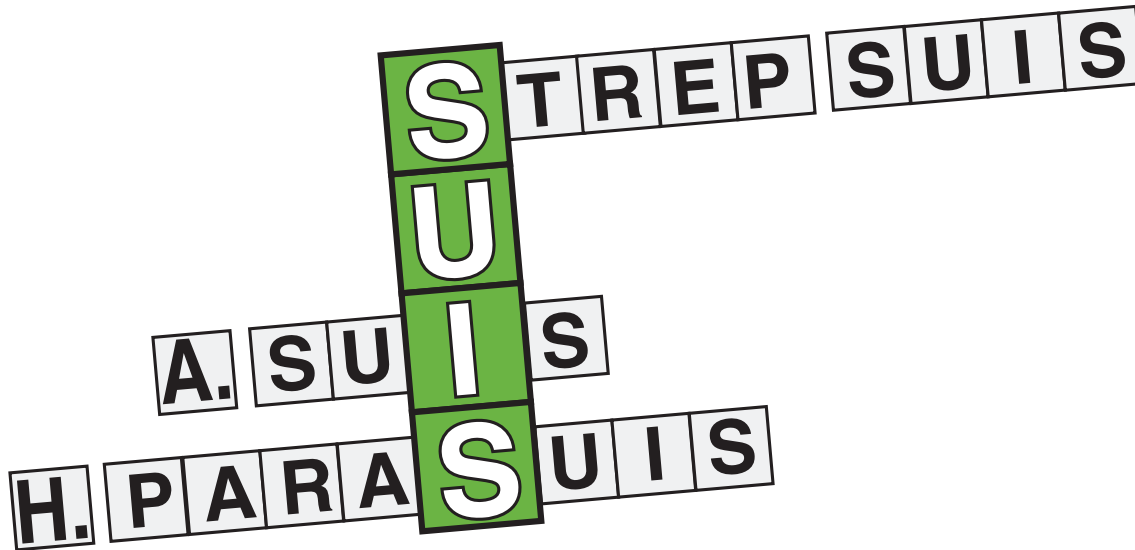
Abstracts that are not selected for oral presentation in the Student Seminar will be considered for participation in a poster session at the annual meeting. Zoetis and the AASV fund a stipend of \$250 for each student who is selected and participates in the poster presentation. In addition, the presenters of the top 15 poster abstracts compete for 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/2018/studentseminar.htm. Please note: the rules for submission should be followed carefully. For more information, contact the AASV office (Tel: 515-465-5255; Fax: 515-465-3832; E-mail: aaav@aaav.org).



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FOUNDATION NEWS

Moving to the next level

Congratulations! The AASV Foundation's endowment – the funds reserved for investment to generate a perpetual source of income for the foundation – recently surpassed \$1 million! This achievement is especially notable given that the funds were accumulated while the foundation was also awarding hundreds of thousands of dollars in scholarships, travel stipends, research grants, and funding for many other programs in support of the swine veterinary profession. Thank you to the many AASV members and industry partners whose support of the foundation made this possible!

Moving forward, the foundation is now looking towards the next level and its goal to establish a \$2 million endowment by the 2019 AASV Annual Meeting. That's an ambitious goal (some might say a big, hairy, and audacious goal), but with the current momentum, it can be achieved! The foundation offers three levels of endowed giving (Leman, Heritage, and Legacy) to enable every AASV member to participate in the effort to ensure a sustainable future for the AASV Foundation.

Are *you* ready to move to the next level?

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 make a contribution of \$1000 or more to the foundation endowment.

The Leman Fellows, recognized at <https://www.aasv.org/foundation/leman.htm>, form the backbone of the foundation, not only through financial support, but also in service to the organization. The Leman Fellows are invited to attend the foundation's annual luncheon meeting, and many have served on the foundation board and committees.

Heritage

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

To enroll in the program, the donor indicates the type and amount of the contribution when submitting the Heritage "Letter of Intent" found at <https://www.aasv.org/foundation/documents/heritageform.pdf>. Heritage Fellows receive a plaque and lapel pin when they are recognized during the foundation's annual luncheon. Since the program's inception in 2001, the roster of

Heritage Fellows has grown to 54 members, identified at <https://www.aasv.org/foundation/heritage.htm>.

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 gift of \$50,000 or more. The fund may be named after the donor or another individual or group. Additionally, the donor designates which one of three foundation mission categories the fund's proceeds will support: 1) research, 2) education, or 3) long-range issues.

To date, three Legacy Funds have been established: the Nathan L. Winkelman Legacy Fund, the K. T. Wright Legacy Fund, and the Pipestone Veterinary Services Practice Legacy Fund. Leave a legacy to the foundation by establishing a Legacy Fund. For details, see <https://www.aasv.org/foundation/legacy.php>.

For more information about the AASV endowment giving programs, or to make a contribution, see <https://www.aasv.org/foundation>, or contact the AASV Foundation: Tel: 515-465-5255, E-mail: aasv@aasv.org.

Golf for the foundation August 24 in Ames, Iowa

Registration is now open for the popular AASV Foundation Golf Outing, to be held at Veenker Memorial Golf Course on **Thursday, August 24**, in Ames, Iowa.

AASV members, clients, staff, family, and other industry stakeholders are invited to register a four-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 24th, 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 in addition to participating in individual contests along the way. Games and giveaways offered by golf-hole sponsors will add to the fun. APC is sponsoring box lunches, and beverages will also be provided on-course. 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 such as swine externship grants for veterinary students, travel stipends for students attending the AASV annual meeting, research grants, tuition grants at the Swine Medicine Education Center, and more.

To preview the golf course, visit <http://www.veenkergolf.com>. For more information about the outing, contact AASV: Tel: 515-465-5255; E-mail: aasv@aasv.org.

R-E-S-P-E-C-T

The other evening I was perusing the March 14 issue of the Virginia Law Review when I came across a study¹ examining the issue of gender in the United States Supreme Court. The study evaluated the number of times members of the court or the lawyers arguing cases interrupted justices on the basis of gender. The study examined how justices compete to have influence at oral arguments by evaluating the extent to which the justices interrupt each other. One of the interesting findings was that the female justices were interrupted at disproportionate rates by their male colleagues, as well as by male advocates. The researchers pondered the implications of this relative to the level of respect afforded to the justices. As a card-carrying member of the “good ol’ boys club” (or Fat Old Veterinarians as I have been “affectionately” referred to), the study made me wonder how our female veterinary members perceive their interactions with male colleagues in swine veterinary medicine.

I have heard female veterinarians express concerns that they don’t feel they are taken as seriously as their male counterparts (even when you remove any age bias). When performing a similar function or when included in an “advisory” or “working group” setting, their perception was that their input was not as valued as that of contemporary male colleagues – receiving a sort of dismissive “pat on the head.” So I thought I would use

this month’s column to present the topic and perhaps stimulate some thought among our members and maybe some conversation.

While some might say that perception is not reality, the fact that we have members of our profession who feel undervalued should concern us. It’s not only perception, however. There have been numerous studies showing a gender disparity across many professions. Generally these studies focus on salary disparity but, while that’s certainly an important topic, it’s not really my focus in this article. I’m more interested in the perceived intrinsic value we all bring to this profession and whether or not a disparity exists based on gender bias alone.

There have been studies indicating that women tend to exhibit less confidence and competitiveness than their male counterparts² and feel they have less influence in group settings.³ The American Veterinary Medical Association (AVMA) explored this question of the influence self-confidence might have on gender disparity in veterinary medicine as part of their 2015 AVMA Employment Survey. Survey respondents were asked to self-assess their level of confidence in performing 12 clinical skills associated with the practice of veterinary medicine. For all 12 skills assessed, female respondents rated their confidence level higher than the male respondents rated their own level of confidence. This would seem to indicate that, at least among the respondents in this survey, self-confidence was not a factor supporting the observed gender bias.

A randomized double-blind study⁴ published in 2012 in the *Proceedings of the National Academy of Sciences* explored the issue of gender bias in academic science. Science faculty from research-intensive universities rated the application materials of a student, who was randomly assigned either a male or female name, for a laboratory manager position. Faculty participants – both male and female – rated the male applicant as significantly more competent and hireable than the (identical) female applicant. Interestingly, both female and male faculty were equally likely to exhibit bias against the female student. The study

also concluded that preexisting subtle bias against women was associated with less support for the female student.

Although I have never personally managed either male or female veterinarians in a clinical capacity, from my interactions with our membership, there doesn’t appear to me to be any obvious gender-based competency variability among our members. The female swine veterinarians I have interacted with have been as confident, competent, and capable as any of their male colleagues. They fulfill every role in our profession, including research, academia, practice, government, technical service, etc. The one notable exception, however, is practice ownership. Although I have no actual figures to back this up, I feel confident in saying that there are disproportionately fewer female practice owners when compared to male cohorts. As with any discussion of gender disparity, there are likely many reasons for this other than gender bias.

“The female swine veterinarians I have interacted with have been as confident, competent, and capable as any of their male colleagues.”

As we are well aware, females have become the majority gender in the veterinary profession. At the American Association of Swine Veterinarians (AASV), we only began requesting gender information as part of the membership application-renewal process since 2012 – so not long enough to provide reliable trend information. However, I think it is evident that our membership is following this same trend. One index of the rate of female introduction into the AASV might be the gender information provided by respondents to the AASV Salary Survey. These results show a steady increase in female respondents in each survey from 2002 to 2014 (12% to 23% female respondents respectively).⁵

So, do women have a role in addressing the issue of gender bias? I’m sure they must, but I also realize that it can be a bit of a difficult position if you don’t feel supported in your job or group setting. Far be it for



me to offer advice to women, but, at the very least, women can help raise awareness of the issue when it occurs. They also need to make sure all of us are aware of their accomplishments, interests, and areas of expertise and continue to volunteer to participate and provide their opinions and expertise whenever possible.

As I was exploring this issue, I came across the Association for Women Veterinarians (AWV). The AWV, or Women's Veterinary Association as it was known then, was formed in 1947. The association's founder, Dr Mary Knight Dunlap, said she started the organization because of a sense of "duty to those who followed me...so that they don't make the same fool mistakes I did." One of the founding goals of the association was to recruit women into the veterinary profession. The association produced a bulletin that provided information on the annual meetings of the AWV, issues of interest to women veterinarians, and a means for women veterinarians to voice support for their peers. The issue of gender bias was a frequent topic of discussion in these bulletins. It's interesting that, although the percentage of women veterinarians increased from a handful in 1947 to a majority of the profession by the 2000s, the association disbanded in 2012 due to a lack of membership. Washington State University currently

houses the *Association for Women Veterinarians Bulletin* collection.

In case you're wondering, the first female veterinarian, Dr Mignon Nicholson, graduated from McKillip Veterinary College in Chicago in 1903. Many veterinary colleges in the United States actually refused to admit women until enactment of the Civil Rights Act and the Veterinary Medical Education Act in the mid-1960s finally opened the doors to female students. In the 1970s, women accounted for 16.8% of graduates from veterinary schools. This grew to 44.3 percent in the 1980s, with women in veterinary schools starting to outnumber men in the early 1990s (65.8% of US veterinary graduates in 1996, according to AVMA surveys).⁶

There are many of you out there much more qualified than I am to write this article, and hopefully I'll hear back from you. My intent was to raise awareness of an issue I've heard expressed among some of our colleagues. My hope is that this will stimulate all of us to think about how we perceive our colleagues and respect the talents and experiences each of us brings to this profession. Google defines the word respect as "a feeling of deep admiration for someone or something elicited by their abilities, qualities, or achievements." Being a member of the Fat Old

Veterinarians club, I also like the way Aretha Franklin put it, "R-E-S-P-E-C-T; Find out what it means to me..." (Ignore the fact that the lyrics to that song were actually written by a man – Otis Redding).

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Harry Snelson, DVM
Director of Communications



EXTRALABEL DRUG USE IN SWINE

When using antibiotics in an extralabel manner, always ensure the use is judicious and complies with all state and federal regulations.

Remember that the extralabel use of cephalosporins and fluoroquinolones is restricted.**

Extralabel Drug Use Algorithm*

Is there a labeled drug for food animals that:

- contains the needed ingredient,
- in the proper dosage form,
- labeled for the indication,
- and is clinically effective?

YES

You must use the labeled drug as per label directions

NO

Is there an approved food animal drug that could be used extralabel?

YES

Proceed with extralabel use of the drug approved for food animal use

NO

Is there an approved human or non-food animal drug that could be used extralabel?

YES

Can an effective withdrawal time be established?

NO

Consider compounding approved drugs -- follow FDA regulations

YES

Proceed with extralabel use with an extended withdrawal time and proper records

NO

Drug must not be used, or treated animals must not enter food supply

Cephalosporins (e.g., ceftiofur)

Extralabel use in food-producing animals is prohibited:

- for disease prevention purposes;
- at unapproved doses, frequencies, durations, or routes of administration; or
- if the drug is not approved for that species and production class.

Fluoroquinolones (e.g., Baytril®)

All extralabel use in food-producing animals is prohibited.

**Refer to FDA's AMDUCA regulations for a complete list of drugs prohibited for extralabel use in food-producing animals.



UPCOMING MEETINGS

Allen D. Leman Swine Conference

September 16-19, 2017 (Sat-Tue)
Saint Paul RiverCentre, Saint Paul, Minnesota

For program information:
Tel: 612-624-4972
E-mail: cceconf4@umn.edu
Web: <http://cceeevents.umn.edu/allen-d-leman-swine-conference>

For registration information:
Tel: 612-625-2900
E-mail: ccereg@umn.edu
Web: <http://cceeevents.umn.edu/allen-d-leman-swine-conference>

US Animal Health Association 121st Annual Meeting

October 12-18, 2017 (Thu-Wed)
Town and Country Hotel, San Diego, California

For more information:
Web: <http://www.usaha.org>

2017 ISU James D. McKean Swine Disease Conference

November 2-3, 2017 (Thu-Fri)
Ames, Iowa

Hosted by Iowa State University

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

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

Pig Welfare Symposium

November 7-9, 2017 (Tue-Thu)
Des Moines Marriott Downtown
700 Grand Avenue
Des Moines, Iowa

Hosted by the National Pork Board

For more information:
Web: <http://www.pork.org/pig-welfare-symposium/>

2017 Joint Meeting: North American PRRS Symposium and National Swine Improvement Federation

December 1-3, 2017 (Fri-Sun)
Intercontinental Chicago Magnificent Mile
505 N Michigan Avenue
Chicago, Illinois

For more information:
<http://www.vet.k-state.edu/na-prrs/index.html>

American Association of Swine Veterinarians 49th Annual Meeting

March 3-6, 2018 (Sat-Tue)
Manchester Grand Hyatt, San Diego, California

For more information:
American Association of Swine Veterinarians
830 26th Street, Perry, IA 50220-2328
Tel: 515-465-5255
E-mail: aasv@aasv.org
Web: <http://www.aasv.org/annmtg>

25th International Pig Veterinary Society Congress

June 11-14, 2018 (Mon-Thu)
Chongqing, China

For more information:
Web: <http://www.ipvs2018.net/>



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

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Photo Corner

Colorful Iowa nursery pigs

Photo courtesy of Tina Smith

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