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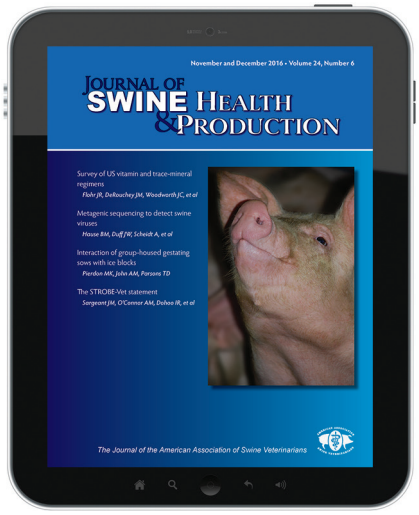

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About the cover…

In a Missouri swine facility

Photo courtesy of Tina Smith

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Errata

In the article on page 29 of the January/February issue of the *Journal of Swine Health and Production* (Scherba et al), the citation was incorrectly reported as "*J Swine Health Prod*. 2016;24(1):21-28." The correct citation is "*J Swine Health Prod*. 2016;24(1):29-35."

In the article on page 198 of the July/August issue of the *Journal of Swine Health and Production* (Greiner), the citation was incorrectly reported as "*J Swine Health Prod*. 2015;24(4):198-204." The correct citation is "*J Swine Health Prod*. 2016;24(4):198-204."

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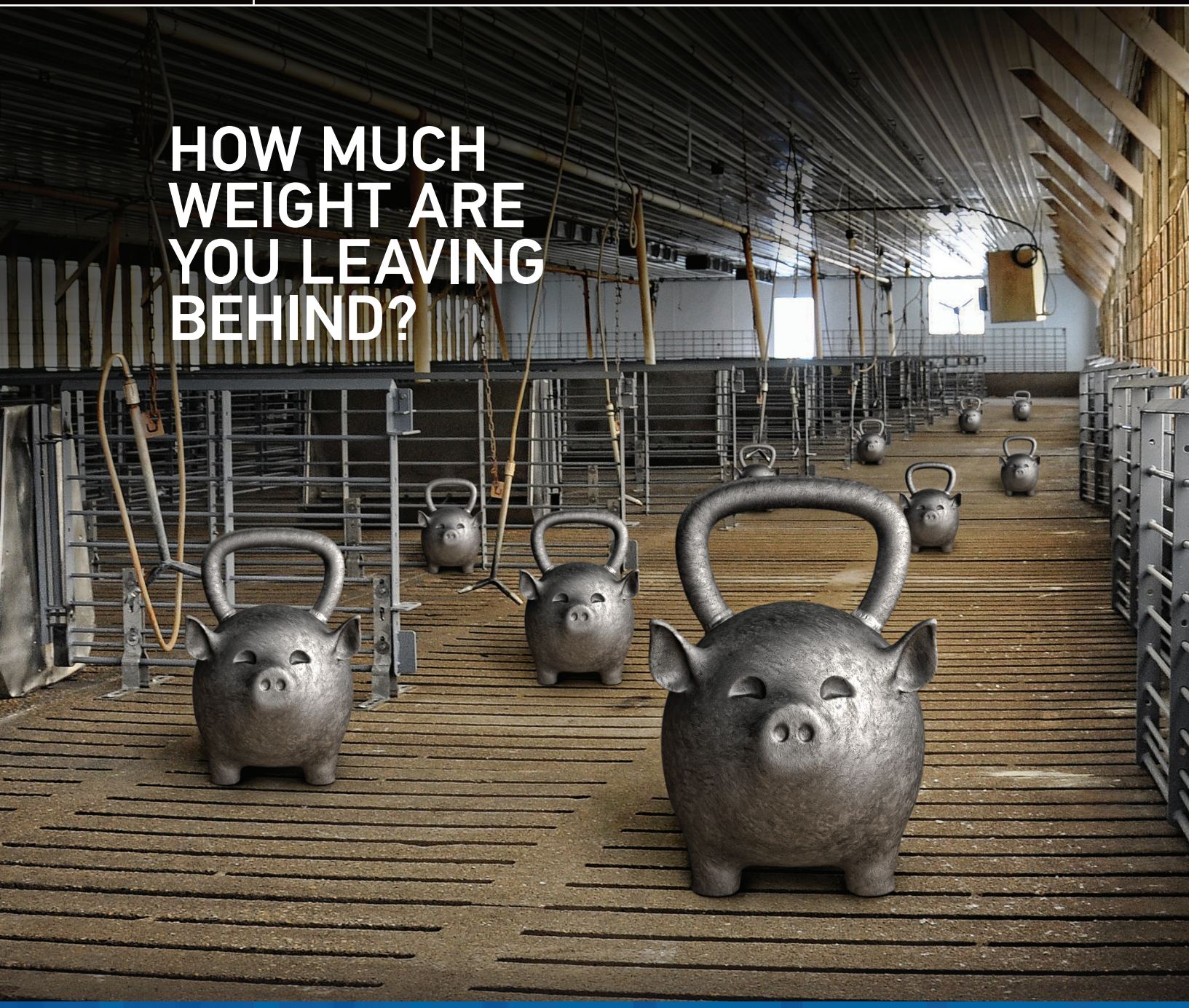

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*PRDC stands for Porcine Respiratory Disease Complex.

Issues management: "Small but mighty!"

During the American Association of Swine Veterinarians (AASV) Strategic Planning Session in 2014, Dr Michelle Sprague led a very thoughtful review of the AASV mission statement. At the time, our industry was experiencing another painful summer of porcine epidemic diarrhea virus (PEDV). The way forward was not clear. Roles and responsibilities for dealing with an emerging disease had not been defined. Our AASV staff had taken on an important leadership role in our industry's response to this devastating disease. Because all of the regular work of managing our association still needed to be done, it was clear that this level of response was not going to be sustainable. A rethink of our mission statement was very timely. The result of that exercise was a broader scope of advocacy that added industry and public-health issues to the traditional veterinary issues. The AASV sets out policy statements that help to guide our members. The AASV also plays an important role in influencing broader industry policy through advocacy.

Issues management starts with early identification of issues before they reach a crisis level. This early identification requires continuous scanning at a global level. William Gibson, the American-Canadian science -fiction writer, perhaps best known for coining terms like "cyberspace," was quoted as saying that "The future is already here — it's just not very evenly distributed."[1] For anyone that spends time scanning for potential issues, this statement will ring true. Animal welfare issues, for example, are well advanced in nations with food security and developed economies, while this issue barely hits the radar screen in the poorest nations. Gathering intelligence about these issues in other regions can provide insight about how an issue might unfold in North America. Unfortunately, the process of scanning can be somewhat tedious and often about as exciting as watching paint dry. Every so often there are clear signals that an issue is heating up.

"Issues management starts with early identification of issues before they reach a crisis level."

The AASV has developed a level of respect and trust over the years despite being a relatively small organization. I have always thought of AASV as being "small but mighty." Able to leap tall buildings in a single bound? Faster than a speeding locomotive? Unfortunately, no. Having said that, I sometimes secretly wonder when AASV staff or colleagues slip out to make a phone call if they might be changing into a uniform with a bright red "S." Because our resources are limited, we need to be able to prioritize the issues that we will tackle. Will the issue affect the entire pork supply chain or one small sector? Will the issue affect our association's reputation or our ability to create veterinary policy? What is the probability that an issue will gain momentum? Is the issue being "championed" by another organization that already has some influence?

If our goal is to influence, then it is important to identify the key players that are involved in any particular issue. This list includes those that act by influencing and those that are influenced to act. Because many players can be involved in any one issue, the process of issues management becomes less predictable than normal project management. It is important that plans and timelines remain flexible. Awareness, information, and understanding of an issue are important first steps in paving the way to action. Without action, however, all of this increased understanding may only result in a better informed rant about how someone else needs to address the problem. Issues management is alive and well at AASV. Thanks to Dr Sprague's leadership, we have a mission statement that is more clear about the AASV's role in advocacy and issues management. Our AASV staff work tirelessly at gathering and analyzing information, as well as sharing our positions with other players. Our committee chairs and volunteers provide insight by getting down into the weeds on many developing issues. Our members are woven into the fabric of the entire industry and are in an excellent position to inform our supply-chain partners at a grass-roots level. We truly are small but mighty!

References

1. Wikiquote. William Gibson. Available at https://en.wikiquote.org/wiki/William_Gibson. Accessed 24 August 2016.

George Charbonneau, DVM
AASV President

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Special Topic: STROBE-Vet

I would like to draw your attention to a special topic that is published in this issue of the *Journal of Swine Health and Production* (JSHAP). The special topic article presents a newly developed STROBE-Vet statement. As described in the article, "STROBE" is an acronym that stands for "**St**rengthening the **R**eporting of **OB**servational studies in **E**pidemiology" and hence represents a guideline document for reporting on observational research. The STROBE statement has existed for some time now for research related to human medicine, but it has also been modified to suit other areas of research. The STROBE-Vet recommendations presented here represent the hard work of many co-authors. They have worked through the STROBE recommendations to reach a consensus on each STROBE item in order to present a STROBE document specific to veterinary medicine. The authors also describe, very nicely, how consensus was reached for each of the items discussed and (or) how modification recommendations were agreed upon. Hence, this consensus document has been put forward to help strengthen the reporting of observational trials in **veterinary** epidemiology, and I would like to thank the authors for the dedication and hard work that they committed to this initiative. I am very pleased to say that, in order to encourage the broad dissemination and sharing of this statement, JSHAP is one of five journals that are simultaneously publishing this article. This statement can also be found in the *Journal of Veterinary Internal Medicine*, *Journal of Food Protection*, *Preventive Veterinary Medicine,* and *Zoonosis and Public Health*. This is not the first time JSHAP has published a document of this type. Previously, JSHAP (along with other journals), has published the REFLECT statetment.[1] REFLECT stands for **R**eporting **G**uidelines for **R**andomized **C**ontrolled **T**rials, and the authors of this article modified the statement to address issues for livestock trials.

"...this consensus document has been put forward to help strengthen the reporting of observational trials in veterinary epidemiology..."

How does such an article impact swine practice today? Well, it may not have an immediate applied action that a practitioner can take to the barn today. But it does positively impact veterinary practice significantly. Practitioners, as well as all of those involved in conducting veterinary research in general, can refer to both the STROBE-Vet and REFLECT statements when designing trials, interpreting results, and presenting or interpreting important implications. This all has a direct impact on how a practitioner can or would make any on-farm recommendations based on such research.

There is also a supporting document, the Explanation and Elaboration document.[2,3] Due to the length of the Explanation and Elaboration document, JSHAP will not be publishing this sister article. However, it is available, and I encourage all of you who conduct research, interpret research results, and (or) apply such results on-farm to read the sister article as well.

I will leave you to enjoy this issue of JSHAP. Happy reading.

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1. O'Connor AM, Sargeant JM, Gardner IA, et al. The REFLECT statement: Methods and processes of creating reporting guidelines for randomized controlled trials for livestock and food safety. *J Swine Health Prod*. 2010;18(1):18–26.

2. O'Connor AM, Sargeant JM, Dohoo IR, et al. Explanation and Elaboration Document for the STROBE-Vet statement: Strengthening the Reporting of Observational Studies in Epidemiology – Veterinary extension. *J Vet Intern Med*. In press.

3. O'Connor AM, Sargeant JM, Dohoo IR, et al. Explanation and Elaboration Document for the STROBE-Vet statement: Strengthening the Reporting of Observational Studies in Epidemiology – Veterinary extension. *Zoonosis Public Health*. In press.

Terri O'Sullivan, DVM, PhD
Executive Editor

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Swine: Enroflox 100 is indicated for the treatment and control of swine respiratory disease (SRD) associated with *Actinobacillus pleuropneumoniae, Pasteurella multocida, Haemophilus parasuis* and *Streptococcus suis*.

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Swine: Animals intended for human consumption must not be slaughtered within 5 days of receiving a single-injection dose.

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Quinolone-class drugs should be used with caution in animals with known or suspected Central Nervous System (CNS) disorders. In such animals, quinolones have, in rare instances, been associated with CNS stimulation which may lead to convulsive seizures. Quinolone-class drugs have been shown to produce erosions of cartilage of weight-bearing joints and other signs of arthropathy in immature animals of various species. See Animal Safety section for additional information.

ADVERSE REACTIONS: No adverse reactions were observed during clinical trials.

ANIMAL SAFETY:

In cattle safety studies, clinical signs of depression, incoordination and muscle fasciculation were observed in calves when doses of 15 or 25 mg/kg were administered for 10 to 15 days. Clinical signs of depression, inappetance and incoordination were observed when a dose of 50 mg/kg was administered for 3 days. An injection site study conducted in feeder calves demonstrated that the formulation may induce a transient reaction in the subcutaneous tissue and underlying muscle. In swine safety studies, incidental lameness of short duration was observed in all groups, including the saline-treated controls. Musculoskeletal stiffness was observed following the 15 and 25 mg/kg treatments with clinical signs appearing during the second week of treatment. Clinical signs of lameness improved after treatment ceased and most animals were clinically normal at necropsy. An injection site study conducted in pigs demonstrated that the formulation may induce a transient reaction in the subcutaneous tissue.

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I01 March 2015

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Why I do what I do

I did not intend to be a swine veterinarian. I planned to be a general mixed-animal practicing veterinarian. When I got to Canistota, South Dakota, the practice didn't have a swine-focused guy. I received a call from one farm that had severe coccidiosis and 106 aluminum farrowing crates all in the same room. Many attempts had already been made at getting rid of the coccidiosis. I was blessed in that the farm owners were ready to try anything to cure the disease. We bought a steam cleaner and some leather chaps for the crew. Within two rounds around the farrowing room, coccidiosis was gone. Then they called their swine-producing friends who started calling me. They, in turn, called their friends. Pretty soon I had no time for any other kind of vet call. I am sure glad that happened.

Now I "do what I do" mainly because of the non-financial rewards of practicing swine veterinary medicine. The personal client relationships invigorate me. Sioux Nation Ag Center is an awesome place to work. The team there *rocks*. I really have enjoyed watching this company evolve. We have some really good pig people. Also, the pigs themselves and the veterinary medical tasks needed by them are fascinating. Folks say health is king in swine production. I see that often. As I watch production and welfare practices continue to improve rapidly, I am totally blessed to be working in our industry. "Precision ag" in the swine-production farm is a term I saw Dennis DiPietre use recently. This concept is so true.

I can't even fathom the thought of retirement, even though I am about in my "5th or 6th parity." I may be just out of my prime. I figured that part out when I tried to jump up onto the second level of a transport trailer during a recent audit and hit the thing and fell right on my butt. I used to be able to jump that high easily. I would like to get to parity 9 but know I must continue to excel in practice. These parity zeros and parity ones coming up are REALLY good now. We hired two recently (Dr Jon Ertl and Dr Luke Baldwin).

"As I watch production and welfare practices continue to improve rapidly, I am totally blessed to be working in our industry."

The swine producers over the years have been so good to work with. Some are now my best friends. My Hutterite producers are really no different than my non-Hutterite folks. I enjoy the God-centered culture and family-centered lifestyle they embrace. I hope I get to continue to work with all of our producers well into my 9th parity.

Learning, along with all you folks, continues to lead me in a professionally rewarding life. Thanks to so many, many of you.

Monte Fuhrman, DVM
Sioux Nation Ag Center

Original Research

Peer reviewed

A survey of current feeding regimens for vitamins and trace minerals in the US swine industry

Josh R. Flohr, PhD; Joel M. DeRouchey, PhD; Jason C. Woodworth, PhD; Mike D. Tokach, PhD; Robert D. Goodband, PhD; Steve S. Dritz, DVM, PhD

Summary

Objective: To describe added vitamin and trace-mineral concentrations used in the US swine industry for breeding and growing pigs.

Materials and methods: A convenience sample survey of nutritionists from 18 US swine production systems representing approximately 2.3 million sows or 40% of the US sow herd was conducted to characterize added vitamin and trace-mineral concentrations in swine diets. Data were compiled by dietary phases to determine descriptive statistics. Nutrients evaluated were vitamins A, D, E, and K; biotin; choline; folic acid; niacin; pantothenic acid; pyridoxine; riboflavin; thiamin; vitamin B12; betaine; vitamin C; carnitine; copper; iodine; iron; manganese; selenium; zinc; cobalt; and chromium. Questions about supplementation of vitamin D from a cross-linked vitamin AD3 beadlet, potential use of natural (d-alpha-tocopherol) vitamin E as a source of vitamin E, and the use of chelated trace minerals were included.

Results: Results indicated variation, but most vitamins and trace minerals were included at concentrations above the total dietary requirement estimates reported by the National Research Council (2012). Chelated sources for partial or complete supplementation of copper, manganese, or zinc ranged from none to 46% and none to 77% for chelated selenium across diet type. The chelated sources were more prevalent in breeding-herd and nursery-pig diets.

Implications: Adding a margin of safety for vitamin and trace-mineral supplementation appears to be standard practice in US swine diets. This survey provides a baseline for supplementation rates of the vitamins and trace minerals used in the US swine industry.

Keywords: swine, trace minerals, vitamins, swine industry, survey

Received: February 19, 2016
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Resumen - Un estudio sobre los regímenes actuales de alimentación de vitaminas y microminerales en la industria porcina de los EUA

Objetivo: Describir las concentraciones adicionadas de microminerales y vitaminas utilizadas en la industria porcina de EUA para cría y cerdos en crecimiento.

Materiales y métodos: Se realizó un estudio de conveniencia de diferentes nutriólogos de 18 sistemas de producción porcina de EUA representando aproximadamente 2.3 millones de hembras o 40% del hato de hembras de EUA para caracterizar las concentraciones adicionadas de microminerales y vitaminas en las dietas porcinas. Se recopilaron los datos por fases dietéticas para determinar la estadística descriptiva. Los nutrientes evaluados fueron las vitaminas A, D, E, and K; biotina; colina; ácido fólico; niacina; ácido pantoténico; piridoxina; riboflavina; tiamina; vitamina B12; betaína; vitamina C; carnitina; cobre; yodo; hierro; manganeso; selenio; zinc; cobalto; y cromo. Se incluyeron preguntas sobre suplemento de vitamina D de una perla de vitamina AD3 de cadena cruzada, uso potencial de vitamina E natural (d-alpha-tocoferol) como fuente de vitamina E, y el uso de microminerales quelatados.

Resultados: Los resultados indicaron variación, pero la mayoría de las vitaminas y microminerales se incluyeron en concentraciones por encima de los estimados de requerimientos dietéticos totales reportados por el Consejo de Investigación Nacional (NRC, por sus siglas en inglés; 2012). En los diferentes tipos de dieta, las fuentes quelatadas para suplemento completo o parcial de cobre, manganeso, o zinc variaron de nada a 46%, y de nada a 77% en el selenio quelatado. Las fuentes quelatadas fueron más prevalentes en las dietas de hatos de cría y en lechones de destete.

Implicaciones: La adición de un margen de seguridad para la suplementación de microminerales y vitaminas parece ser una práctica estándar en las dietas porcinas de EUA. Este estudio provee un punto de partida para los índices de suplementación de vitaminas y microminerales utilizados en la industria porcina de EUA.

Résumé - Sondage sur les régimes actuels d'alimentation en vitamines et minéraux essentiels dans l'industrie porcine américaine

Objectif: Décrire les concentrations de vitamines et minéraux essentiels utilisées dans l'industrie porcine américaine chez les porcs reproducteurs et les porcs en croissance.

Matériels et méthodes: Un sondage parmi un échantillonnage de convenance de nutritionnistes provenant de 18 systèmes de production porcine américains et représentant environ

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

Flohr JR, DeRouchey JM, Woodworth JC, et al. A survey of current feeding regimens for vitamins and trace minerals in the US swine industry. *J Swine Health Prod.* 2016;24(6):290–303.

2,3 million de truies ou 40% des troupeaux de truies a été mené afin de caractériser les concentrations de vitamines et de minéraux essentiels ajoutées dans les diètes porcines. Les données ont été compilées par phases d'alimention afin de déterminer des statistiques descriptives. Les nutriments évalués étaient les vitamines A, D, E, et K; la biotine; la choline; l'acide folique; la niacine; l'acide pantothénique; la pyridoxine; la riboflavine; la thiamine; la vitamine B12; la bétaïne; la vitamine C; la carnitine; le cuivre; l'iodine; le fer; le manganèse; le sélénium; le zinc; le cobalt; et le chrome. Des questions sur la supplémentation en vitamine D à partir d'une granule contenant une combinaison en vitamines AD3, l'utilisation potentielle de vitamine E naturelle (d-alpha-tocophérol) comme source de vitamine E, et l'utilisation de minéraux essentiels chélatés étaient incluses.

Résultats: Les résultats indiquaient des variations mais la plupart des vitamines et des minéraux essentiels étaient inclus à des concentrations supérieures aux exigences alimentaires totales estimées rapportées par le Conseil National de la Recherche (2012). Les sources chélatées pour une supplémentation complète ou partielle en cuivre, manganèse, ou zinc variaient de 0% à 46% et de 0% à 77% pour le sélénium chélaté parmi les types de diète. Les sources chélatées étaient plus fréquentes dans l'alimentation des troupeaux reproducteurs et des porcelets en pouponnière.

Implications: L'ajout d'une marge de sécurité pour la supplémentation en vitamines et minéraux essentiels semble être une pratique standard dans les diètes porcines américaines. Ce sondage fourni des valeurs de base pour les taux de supplémentation pour les vitamines et les minéraux essentiels utilisés dans l'industrie porcine américaine.

The proper vitamin and trace-mineral supplementation required to optimize performance, but also minimize unnecessary cost, is an area of limited knowledge for production nutritionists. Most commercial diets are formulated well above NRC (2012)[1] requirement estimates at a margin of safety needed to account for potential ingredient concentration variation and bioavailability, fluctuations in daily feed intake, or degradation of vitamins resulting from unfavorable storage conditions. Another factor influencing the added margin of safety is the added cost of a specific vitamin or trace mineral. A notable survey conducted by Coelho and Cousins[2] examined vitamin supplementation rates from 23 swine entities. From the survey, researchers found that all entities supplied vitamins at concentrations higher than NRC (1998)[3] recommendations. Also, entities in the highest quartile supplied vitamins at rates of two to 10 times that of the lowest quartile. The Coelho and Cousins[2] survey showed that a wide range of supplementation rates were used across commercial systems. Ultimately, since that survey was reported, two NRC publications have been distributed, illustrating the long lapse in time since a survey was conducted to examine industry vitamin supplementation rates. To our knowledge, there has never been a survey of the supplementation rates of trace minerals used in commercial diet formulation. Mahan et al[4] discussed the potential need to express trace-mineral pig requirements on a digestible basis, which would help account for the impact that exogenous enzymes and mineral sources may have on the requirement for the nutrient. Because of the increased usage of phytase and other enzymes, along with the increased availability of chelated trace-mineral sources, there is interest in characterizing trace-mineral usage in the swine industry. With this information, future research examining various vitamin and trace-mineral concentrations for commercially raised pigs could be conducted. Potential for future research, based on findings of the survey, will help determine vitamin and trace-mineral requirements needed to optimize performance and maximize economic return.

Materials and methods

The procedures for this survey were approved by the Kansas State University Committee for Research Involving Human Subjects. The survey information was gathered in an electronic spreadsheet (Excel 2013; Microsoft, Redmond, Washington). The subjects of the survey were swine producers within the United States. A convenience sampling of nutritionists for the swine producers were contacted via e-mail or telephone from the beginning of March to the end of August of 2014 and were asked if they were willing to participate. Of the 22 nutritionists initially contacted, 18 agreed to be involved with the survey. Those willing to participate were provided the survey spreadsheet, or a telephone interview was conducted to collect their information.

The goal of the survey was to identify industry concentrations of added vitamins and trace minerals in complete diets for different phases of production. The phases of production were nursery (weaning to 23 kg), finishing (23 kg to market), gilt development (pre-breeding), and breeding-herd diet formulations. Producers provided approximate weight breaks for feeding phases within each stage of production, along with the premix specifications, inclusion rates, and inclusion rates of any other added vitamin, vitamin-like nutrients, and trace minerals. Specifications were surveyed only for commercial production systems, not for nucleus or multiplier herds.

Results were compiled and pooled to determine descriptive statistics for the supplementation rates. The descriptive statistics used included average, weighted average (determined by the total number of sows), median, minimum, maximum, 25th percentile (lowest quartile), and 75th percentile (highest quartile). Sow inventories were obtained from the *Successful Farming* 2013 Pork Powerhouse list,[5] and producers who were not on the top 25 producers list were asked to provide a current sow inventory. All values were determined using functions in the spreadsheet and included average, standard deviation (STDEV.S), median, minimum (MIN), maximum (MAX), and 25th and 75th percentiles (QUARTILE.EXC). Weighted averages were calculated using the spreadsheet sumproduct function in which producer supplementation rate was multiplied by the size of the producer (sow herd size), then divided by the total number of sows for all participating producers. In addition, the average supplementation rate was calculated as a ratio to the suggested requirement as provided by the NRC.[1] It should be noted that the NRC reports total dietary requirements, while the values we surveyed were those of supplementation rates in vitamin and trace-mineral premixes.

Feeding phases and approximate dietary weight breaks varied from producer to producer; however, results are reported in broad weight ranges that were relatively consistent among all participating producers. Feeding phases were divided into three stages of production, including nursery, finishing, and breeding herd. The nursery diets consisted of phase 1 (weaning to 7 kg), phase 2 (7 to 11 kg), and phase 3 (11 to 23 kg); finishing diets consisted of early-finishing (23 to 55 kg), mid-finishing (55 to 100 kg), late-finishing (100 kg to market), and late-finishing with ractopamine HCl (100 kg to market); and breeding herd diets consisted of gilt development (20 kg to breeding), gestation, lactation, and boar.

Within each dietary phase, the vitamins, vitamin-like substances, and trace minerals of interest were vitamins A, D, E, and K (menadione); betaine; biotin; choline; folic acid; niacin; riboflavin; thiamin; pantothenic acid; pyridoxine; vitamin B12; vitamin C (ascorbic acid); carnitine; copper; iodine; iron; manganese; selenium; zinc; cobalt; and chromium. Participants were also asked to provide the specified source of the nutrient used within each dietary phase in order to distinguish potential differences in the use of vitamin-trace-mineral sources.

Results

In total, 18 US swine production systems participated in the survey, totaling approximately 2,268,900 sows. The systems included the greater Midwest and Southeast regions of the United States. Using the December 2013 US Department of Agriculture sow inventory estimate of 5,760,000 (Quarterly Hogs and Pigs Report, 2013),[6] this survey sampled information from approximately 40% of the US sow herd.

Nursery

Phase 1 (weaning to 7 kg) nursery diet supplementation rates (Table 1) were provided by 13 producers, which represented approximately 19.4% of the US sow inventory. The average

Table 1: Added vitamin and trace-mineral concentrations in phase 1 nursery diets (weaning to 7 kg)*

	N†	Weighted average‡	Average	Ratio to NRC§	Standard deviation	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	13	11,033	10,600	4.8	832.0	8800	9900	9900	11,002	14,630
D (IU/kg)	13	2222	2554	11.6	2303	1542	1705	1995	2200	10,175
E (IU/kg)	13	86.0	73.9	4.6	27.7	44.0	59.6	66.0	77.0	150.0
K (mg/kg)	13	3.7	4.0	7.7	0.53	3.1	3.5	4.0	4.4	4.4
Other vitamins										
Biotin (mg/kg)	11	0.44	0.33	4.2	0.90	0.15	0.22	0.26	0.33	1.06
Choline (mg/kg)	6	202.4	245.5	0.4	167.0	129.8	129.8	166.8	385.0	550.0
Folic acid (mg/kg)	11	1.6	1.6	5.5	4.8	0.77	0.99	1.5	1.7	3.6
Niacin (mg/kg)	13	45.8	49.1	1.6	11.4	36.1	43.6	45.3	52.4	82.5
Pantothenic acid (mg/kg)	13	32.1	30.1	2.5	3.6	25.3	27.5	29.7	33.0	37.6
Riboflavin (mg/kg)	13	9.5	9.0	2.3	1.0	7.7	8.1	8.8	9.9	11.0
Thiamin (mg/kg)	5	2.9	2.9	1.9	0.42	2.2	2.4	3.1	3.3	3.3
Vitamin B6 (mg/kg)	11	4.0	3.7	0.5	0.97	2.2	3.1	4.0	4.4	5.5
Vitamin B12 (μg/kg)	13	41.1	38.9	2.0	0.24	33.0	33.4	38.5	44.0	45.1
Trace minerals										
Copper (mg/kg)	13	157.3	111.4	18.6	96.9	11.2	15.8	157.7	194.0	248.5
Iodine (mg/kg)	13	0.62	0.52	3.7	0.21	0.30	0.34	0.50	0.68	1.0
Iron (mg/kg)	13	104.6	103.5	1.0	15.9	89.8	91.3	99.8	109.9	150
Manganese (mg/kg)	13	38.2	36.6	9.1	7.7	26.5	30.0	34.9	39.8	55.0
Selenium (mg/kg)	13	0.30	0.30	1.0	0.004	0.29	0.30	0.30	0.30	0.30
Zinc (mg/kg)	13	3173	3032	30.3	599.5	1906	2804	2931	3475	4002
Conditionally essential nutrients										
Betaine (mg/kg)	1	960.0	960.0	NA	ND	960.0	ND	960.0	ND	960.0
Carnitine (mg/kg)	1	50.0	50.0	NA	ND	50.0	ND	50.0	ND	50.0
Chromium (mg/kg)	5	0.20	0.20	NA	0.00	0.20	0.20	0.20	0.20	0.20
Vitamin C (mg/kg)	1	250.0	250.0	NA	ND	250.0	ND	250.0	ND	250.0

* Thirteen producers' nutritionists provided information for phase 1 nursery diets, totaling approximately 1,115,400 sows (19.4% of the US sow herd). All reported values are on a complete-feed basis.
† N indicates the number of producers adding concentrations of a nutrient.
‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products, they were divided by the total number of sows for all participating producers.
§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]
NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.
ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

fat-soluble vitamin supplementation rate was 4.6 to 11.6 times that of their NRC[1] requirement estimates. Vitamin D was supplemented at 11.6 times that of the NRC[1] requirement estimate, and a high amount of variation (SD, 2303 IU per kg) occurred in vitamin D supplementation across producers. Other vitamins were supplemented from 0.4 to 5.5 times their NRC[1] requirement estimates. Pyridoxine and choline were supplemented below their requirement estimate, presumably because other ingredients in the diet provide adequate concentrations of these nutrients. One producer supplied betaine as a methyl donor rather than choline, and one producer added vitamin C to the weaning-to-7-kg diet. Trace minerals were supplemented from 1.0 to 30.3 times their requirement estimate. Iron and selenium were supplemented at their requirement estimate, and copper and zinc were supplemented well above their requirement estimate, at 18.6 and 30.3 times, respectively. Carnitine was supplemented by one producer, and five producers supplemented chromium to the weaned pigs during this phase.

Phase 2 (7 to 11 kg) nursery diet supplementation rates (Table 2) were provided by 17 participants, representing 39.0% of the US sow herd. Fat-soluble vitamins were supplemented at rates ranging from 4.0 to 8.1 times their NRC[1] requirement estimates. Other vitamins were supplemented at rates from 0.4 to 7.1 times their respective NRC[1] requirement estimates. Similar to phase 1

Table 2: Added vitamin and trace-mineral concentrations in Phase 2 nursery diets (7 to 11 kg)*

	N†	Weighted average‡	Average	Ratio to NRC§	Standard deviation	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	17	12,129	10,274	4.7	3373	2996	9900	9900	11,002	19,415
D (IU/kg)	17	1912	1773	8.1	527.8	706.2	1487	1760	2160	2849
E (IU/kg)	17	71.3	63.4	4.0	25.1	26.4	44.0	60.1	77.0	125.0
K (mg/kg)	17	4.8	4.0	7.8	1.5	1.2	3.1	4.0	4.4	8.4
Other vitamins										
Biotin (mg/kg)	11	0.37	0.35	7.1	0.22	0.15	0.22	0.29	0.33	0.99
Choline (mg/kg)	4	224.4	209.0	0.4	97.0	129.8	129.8	187.0	308.0	330.0
Folic acid (mg/kg)	11	1.8	1.8	5.9	0.90	0.88	1.1	1.5	2.2	3.5
Niacin (mg/kg)	17	51.3	47.7	1.6	15.2	25.1	41.1	45.1	50.8	82.5
Pantothenic acid (mg/kg)	17	35.6	29.7	3.0	8.6	10.6	26.4	29.3	33.0	54.8
Riboflavin (mg/kg)	17	9.7	8.6	2.5	2	3.3	7.7	8.4	9.9	13.6
Thiamin (mg/kg)	5	2.9	2.9	2.9	0.42	2.2	2.4	3.1	3.3	3.3
Vitamin B6 (mg/kg)	9	4.0	4.0	0.6	0.81	3.1	3.3	4.0	4.6	5.5
Vitamin B12 (μg/kg)	17	46.0	38.5	2.2	11.9	16.5	33.0	38.5	44.0	73.7
Trace minerals										
Copper (mg/kg)	17	169.1	118.2	19.7	96.0	11.2	15.0	156.5	195.1	248.5
Iodine (mg/kg)	17	0.62	0.54	3.9	0.21	0.30	0.34	0.55	0.70	1.0
Iron (mg/kg)	17	118.0	106.4	1.1	29.0	61.1	89.8	99.8	110.1	166.7
Manganese (mg/kg)	17	33.5	35.0	8.8	7.8	24.2	29.1	33.1	39.5	55.0
Selenium (mg/kg)	17	0.29	0.29	1.0	0.02	0.22	0.30	0.30	0.30	0.30
Zinc (mg/kg)	17	2,340	2,081	20.8	751.4	75.0	1,908	2,050	2,527	3,294
Conditionally essential nutrients										
Betaine (mg/kg)	1	960.0	960.0	NA	ND	960.0	ND	960.0	ND	960.0
Chromium (mg/kg)	5	0.23	0.21	NA	0.03	0.20	0.20	0.20	0.24	0.27

* Seventeen producers' nutritionists provided information for phase 2 nursery diets, totaling approximately 2,243,900 sows (39.0% of the US sow herd). All reported values are on a complete-feed basis.
† N indicates the number of producers adding concentrations of a nutrient.
‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.
§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]
NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.
ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

diets, added choline and pyridoxine were supplemented below NRC[1] requirement estimates, presumably because other ingredients provide these nutrients. Trace minerals were supplemented at rates of 1.0 (selenium) to 9.1 times their NRC[1] requirement estimates, except for zinc (20.8) and copper (19.7), which are likely supplemented at high concentrations for growth promotion purposes. One producer supplemented betaine rather than choline as a methyl donor, and five producers supplemented chromium in phase 2 nursery diets.

Phase 3 (11 to 23 kg) nursery diet supplementation rates (Table 3) were provided by all 18 producers who participated in the survey. Fat-soluble vitamins were supplemented at 4.3 to 7.7 times their respective NRC[1] requirement estimates. Other vitamins were supplemented at 1.2 to 6.3 times their respective NRC[1] requirement estimates. No producers who participated in the survey supplemented choline in phase 3 nursery diets. Trace minerals were supplemented at rates of 1.0 to 9.8 times their NRC[1] requirement estimates, except for copper, which was supplemented at a rate of 31.6 times the pig's requirement estimate, probably due to its growth-promotion influences. One producer supplemented cobalt in phase 3 nursery diets.

Finishing

The early-finishing diet (23 to 55 kg) supplementation rates (Table 4) were provided by all 18 survey participants. Fat-soluble vitamins were supplemented at 2.5 to 6.7 times their respective NRC[1] requirement estimates.Other vitamins were supplemented from 0.9 to 2.2 times their respective NRC[1]

Table 3: Added vitamin and trace-mineral concentrations in Phase 3 nursery diets (11 to 23 kg)*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	18	10,954	8868	5.1	3676	3630	5940	9434	11,000	18,698
D (IU/kg)	18	1760	1537	7.7	552.2	825.0	979.0	1478	1984	2748
E (IU/kg)	18	51.5	46.9	4.3	20.5	16.5	36.3	43.8	50.2	100.1
K (mg/kg)	18	4.4	3.5	7.1	1.6	1.3	2.4	4.0	4.4	8.1
Other vitamins										
Biotin (mg/kg)	7	0.26	0.26	5.2	0.07	0.13	0.22	0.26	0.33	0.33
Folic acid (mg/kg)	6	1.9	1.9	0.0	1.1	0.99	0.99	1.4	3.1	3.5
Niacin (mg/kg)	18	46.2	41.6	6.3	17.6	16.5	26.4	39.2	50.4	82.5
Pantothenic acid (mg/kg)	18	32.1	25.7	1.4	9.7	10.8	19.4	25.1	30.6	52.8
Riboflavin (mg/kg)	18	8.6	7.5	2.9	2.4	3.3	5.5	8.1	9.0	13.2
Thiamin (mg/kg)	2	3.1	3.1	2.5	0.16	3.1	ND	3.1	ND	3.3
Vitamin B6 (mg/kg)	5	4.2	3.5	3.2	1.9	0.88	1.8	4.0	5.3	5.5
Vitamin B12 (μg/kg)	18	42.2	33.2	1.2	13.6	16.5	22.9	30.8	39.8	71.3
Trace minerals										
Copper (mg/kg)	18	159.5	158.0	31.6	81.3	11.2	99.5	158.4	200.6	326.5
Iodine (mg/kg)	18	0.55	0.49	3.5	0.25	0.22	0.30	0.36	0.67	1.0
Iron (mg/kg)	18	111.9	104.0	1.0	31.3	60.9	76.7	102.5	122.9	166.7
Manganese (mg/kg)	18	28.0	29.3	9.8	10.9	9.0	24.7	29.8	33.2	55.0
Selenium (mg/kg)	16	0.28	0.29	1.1	0.08	0.14	0.30	0.30	0.30	0.30
Zinc (mg/kg)	18	672.6	401	5.0	959.4	65.8	104.4	120.3	145.8	3030
Conditionally essential nutrients										
Chromium (mg/kg)	2	0.26	0.20	NA	0.09	0.13	ND	0.20	ND	0.27
Cobalt (mg/kg)	1	0.39	0.39	NA	ND	0.39	ND	0.39	ND	0.39

* Eighteen producers' nutritionists provided information for phase 3 nursery diets, totaling approximately 2,268,900 sows (39.4% of the US sow herd). All reported values are on a complete-feed basis.

† N indicates the number of producers adding concentrations of a nutrient.

‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.

§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]

NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.

ND = not done; SD is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

Table 4: Added vitamin and trace-mineral concentrations in early-finishing diets (23 to 55 kg)*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	18	5859	5643	4.3	1057	3630	5104	5533	6600	7480
D (IU/kg)	18	984.9	998.8	6.7	166.5	800.8	825.0	990.0	1102	1320
E (IU/kg)	18	25.1	27.1	2.5	7.7	16.1	20.5	26.4	33.2	39.8
K (mg/kg)	18	2.4	2.4	4.7	0.57	1.3	2.0	2.4	2.9	3.3
Other vitamins										
Biotin (mg/kg)	2	0.07	0.07	1.2	ND	0.07	ND	0.07	ND	0.07
Niacin (mg/kg)	18	24.9	27.5	0.9	6.9	16.5	24.0	26.4	29.7	49.5
Pantothenic acid (mg/kg)	18	17.4	16.9	2.1	2.9	10.8	14.7	16.5	18.9	22.4
Riboflavin (mg/kg)	18	4.8	4.8	2.0	1.3	3.3	4.0	4.8	5.7	8.8
Vitamin B12 (μg/kg)	18	22.9	22.0	2.2	3.1	15.8	19.8	22.4	23.8	26.4
Trace minerals										
Copper (mg/kg)	18	80.8	112.3	28.1	81.3	4.6	66.9	135.7	156.7	242.1
Iodine (mg/kg)	18	0.42	0.42	3.0	0.25	0.22	0.30	0.30	0.45	1.0
Iron (mg/kg)	18	79.8	86.9	1.4	31.3	39.5	70.9	86.0	109.9	123.8
Manganese (mg/kg)	18	21.5	25.2	12.6	10.9	6.6	15.0	29.3	33.0	40.0
Selenium (mg/kg)	18	0.27	0.28	1.4	0.08	0.14	0.27	0.30	0.30	0.30
Zinc (mg/kg)	18	86.0	98.8	1.6	959.4	30.4	78.7	110.0	120.7	150.0
Conditionally essential nutrients										
Cobalt (mg/kg)	1	0.39	0.39	NA	ND	0.39	ND	0.39	ND	0.39

* Eighteen producers' nutritionists provided information for early-finishing diets, totaling approximately 2,268,900 sows (39.4% of the US sow herd). All reported values are on a complete-feed basis.
† N indicates the number of producers adding concentrations of a nutrient.
‡ Weighted averages were calculated using the sumproduct function of Excel (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.
§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]
NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.
ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

requirement estimates. On average, niacin was supplemented below the estimated requirement. Biotin was supplemented in early finishing diets by two producers. Trace minerals were supplemented at rates of 28.1 times copper, 3.0 times iron, 1.4 times iodine, 12.6 times manganese, 1.4 times selenium, and 1.6 times zinc requirement estimates. One producer supplemented cobalt at 0.39 mg per kg.

Mid-finishing (55 to 100 kg) supplementation rates (Table 5) were reported by all 18 producers participating in the survey. Fat-soluble vitamins were supplemented at rates of 2.1 to 5.7 times their respective NRC[1] requirement estimates. Other vitamins were supplemented from 0.8 to 3.8 times their respective NRC[1] requirement estimates. Similar to the previous phase, average niacin supplementation was below the current NRC[1] suggested requirement. Two producers provided added biotin in their mid-finishing diets. Trace minerals were supplemented at rates of 1.6 to 2.7 times the requirement estimate for iodine, iron, selenium, and zinc. Average supplementation rates of copper and manganese were 27.4 and 10.7 times their requirement estimates, respectively.

Late-finishing (100 kg to market) vitamin and trace-mineral supplementation rates (Table 6) were provided by all 18 producers who participated in the survey. Fat-soluble vitamins were supplemented at rates of 3.2 times vitamin A, 5.0 times vitamin D, 1.8 times vitamin E, and 3.6 times vitamin K requirement estimates. Other vitamins were supplemented at rates from 0.7 to 3.3 times their NRC[1] requirement estimates. Niacin, on average, was supplemented at rates below the current NRC[1] requirement. Two producers supplemented biotin in late finishing diets. Trace minerals were supplemented at rates of 1.5 to 2.4 times the requirement estimate for iodine, iron, selenium, and zinc. Average supplementation rates of copper and manganese were 22.0 and 9.3 times their requirement estimates, respectively. One producer only provided added zinc for trace minerals in late-finishing diets.

Supplementation rates of vitamins and trace minerals in late-finishing diets with

ractopamine HCl (Table 7) were reported by seven of the 18 producers. Fat-soluble vitamin supplementation rates were 3.4 times vitamin A, 5.2 times vitamin D, 1.9 times vitamin E, and 3.9 times vitamin K requirement estimates. Other vitamins were supplemented at rates from 0.7 to 3.4 times their NRC[1] requirement estimates. Niacin, on average, was supplemented at rates below the current NRC[1] requirement estimate. Trace minerals were supplemented at rates 1.4 to 2.3 times the requirement estimate for iodine, iron, selenium, and zinc, respectively. Average supplementation rates of copper and manganese were 17.1 and 9.0 times their requirement estimates, respectively. Overall, producers who responded with information on both late-finishing and late finishing diets with ractopamine HCl supplemented 10% more vitamins, 8.5% more trace minerals (copper, iodine, iron, manganese, selenium), and 33% more zinc in those diets that also contained ractopamine HCl.

Breeding-herd diets

Gilt-development diets were provided by 17 producers. When evaluating the gilt developer diets, compared to the suggested growing pig requirements, the average supplementation rates of fat-soluble vitamins were 3.3 times the vitamin A, 4.9 times vitamin D, 2.6 times vitamin E, and 3.0 times vitamin K requirement estimates (Table 8). Compared to gestation requirement estimates, average supplementation rates were 1.1 times vitamin A, 0.9 times vitamin D, 0.6 times vitamin E, and 3.0 times vitamin K requirements. Other vitamins were supplemented at average rates of 2.5 times biotin, 0.8 times choline, 2.5 times folic acid, 0.6 times niacin, 1.4 times pantothenic acid, 1.5 times pyridoxine, 1.3 times riboflavin, 1.0 times thiamin, and 1.5 times vitamin B12 requirement estimates for growing pigs. When evaluating the gilt-developer diets, compared to the suggested gestation requirement estimates, other vitamins were supplemented at an average of 0.6 times biotin, 0.2 times choline, 0.6 times folic acid, 1.8 times niacin, 0.9 times pantothenic acid, 1.5 times pyridoxine, 0.9 times riboflavin, 1.0 times thiamin, and 1.0 times vitamin B12 requirements. One producer supplemented vitamin C at 250 mg per kg. Trace

Table 5: Added vitamin and trace-mineral concentrations in mid-finishing diets (55 to 100 kg)*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	18	5192	4842	3.7	955.2	3520	3852	5280	5603	6162
D (IU/kg)	18	874.9	859.1	5.7	150.7	550.0	790.7	880.0	990.0	1057
E (IU/kg)	18	22.2	23.3	2.1	7.9	16.1	17.4	19.8	27.7	39.8
K (mg/kg)	18	2.2	2.0	4.0	0.46	1.3	1.7	2.2	2.2	2.9
Other vitamins										
Biotin (mg/kg)	2	0.07	0.07	1.1	ND	0.07	ND	0.07	ND	0.07
Niacin (mg/kg)	18	22.0	23.5	0.8	5.1	16.5	20.7	22.0	26.4	34.5
Pantothenic acid (mg/kg)	18	15.4	14.5	2.1	2.4	10.8	12.1	14.5	16.9	17.8
Riboflavin (mg/kg)	18	4.2	4.2	2.1	1.4	2.6	3.3	4.2	4.8	8.8
Vitamin B12 (μg/kg)	18	20.2	18.9	3.8	3.1	13.2	15.8	19.6	22.0	24.2
Trace minerals										
Copper (mg/kg)	18	66.6	82.3	27.4	65.0	3.9	10.1	109.1	146.5	161.7
Iodine (mg/kg)	18	0.39	0.37	2.7	0.25	0.16	0.20	0.30	0.39	1.0
Iron (mg/kg)	18	73.7	75.0	1.9	22.5	32.9	61.5	73.3	88.5	123.8
Manganese (mg/kg)	18	19.4	21.4	10.7	10.5	6.4	15.0	22.0	24.5	40.0
Selenium (mg/kg)	18	0.26	0.24	1.6	0.04	0.11	0.20	0.24	0.30	0.30
Zinc (mg/kg)	18	77.8	84.8	1.7	32.3	30.4	61.5	89.1	100.0	131.2
Conditionally essential nutrients										
Cobalt (mg/kg)	1	0.31	0.31	NA	ND	0.31	ND	0.31	ND	0.31

* Eighteen producers' nutritionists provided information for mid-finishing diets, totaling approximately 2,268,900 sows (39.4% of the US sow herd). All reported values are on a complete-feed basis.

† N indicates the number of producers adding concentrations of a nutrient.

‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.

§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]

NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.

ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

Table 6: Added vitamin and trace-mineral concentrations in late-finishing diets (100 kg to market)*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	18	4616	4187	3.2	999.2	2904	3520	3942	4840	6160
D (IU/kg)	18	781.7	745.8	5.0	209.0	412.5	550.0	756.4	897.6	1078
E (IU/kg)	18	19.6	20.0	1.8	6.6	8.1	16.5	17.6	24.0	33.4
K (mg/kg)	18	1.9	1.8	3.6	0.53	1.0	1.3	1.8	2.2	2.9
Other vitamins										
Biotin (mg/kg)	2	0.04	0.04	1.0	ND	0.04	ND	0.04	ND	0.07
Niacin (mg/kg)	18	19.4	20.2	0.7	4.8	15.0	16.7	18.3	22.4	33.0
Pantothenic acid (mg/kg)	18	13.6	12.5	1.8	3.1	6.8	11.0	12.3	14.5	18.5
Riboflavin (mg/kg)	18	3.7	3.5	1.8	0.95	2.0	3.1	3.3	4.2	5.5
Vitamin B12 (μg/kg)	18	18.0	16.5	3.3	3.5	7.9	15.2	16.5	18.5	22.2
Trace minerals¶										
Copper (mg/kg)	17	56.3	65.9	22.0	71.0	3.1	8.1	10.0	147.2	160.8
Iodine (mg/k)	17	0.37	0.34	2.4	0.24	0.15	0.18	0.24	0.42	1.0
Iron (mg/k)	17	69.3	66.5	1.7	25.2	30.9	54.1	62.9	80.3	103.1
Manganese (mg/kg)	17	17.7	18.6	9.3	9.8	3.3	14.7	19.4	23.0	40.0
Selenium (mg/kg)	17	0.24	0.22	1.5	0.08	0.12	0.17	0.20	0.30	0.30
Zinc (mg/kg)	18	71.7	73.8	1.5	26.8	30.4	55.0	74.9	90.1	131.2
Conditionally essential nutrients										
Cobalt (mg/kg)	1	0.31	0.31	NA	ND	0.31	ND	0.31	ND	0.31

* Eighteen producers' nutritionists provided information for late-finishing diets, totaling approximately 2,268,900 sows (39.4% of the US sow herd). All reported values are on a complete-feed basis.
† N indicates the number of producers adding concentrations of a nutrient.
‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size), and after summing those products they were divided by the total number of sows for all participating producers.
§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]
¶ One producer provided added zinc supplement only for trace minerals in the late-finishing diets.
NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.
ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

minerals were supplemented at average rates of 5.7 times copper, 3.7 times iodine, 1.6 times iron, 18.6 times manganese, 1.4 times selenium, and 2.0 times zinc growing pig requirement estimates. Compared to gestation requirement estimates, developing gilts were supplemented 2.3 times copper, 3.7 times iodine, 1.2 times iron, 1.5 times manganese, 1.9 times selenium, and 1.2 times zinc requirements. Five producers supplemented chromium at 0.20 mg per kg, and one producer supplemented cobalt at 0.39 mg per kg. Two producers supplemented carnitine at a rate of 50 mg per kg of diet.

Gestation diet information (Table 9) was provided by 17 of the producers. Fat-soluble vitamins were supplemented at rates of 2.6 times vitamin A, 2.2 times vitamin D, 1.6 times vitamin E, and 7.3 times vitamin K requirement estimates. Other vitamins were supplemented at rates of 1.4 times biotin, 1.3 times folic acid, 4.6 times niacin, 2.3 times pantothenic acid, 3.4 times pyridoxine, 2.2 times riboflavin, 2.2 times thiamin, and 2.4 times vitamin B12 requirement estimates. Choline was supplemented at 0.5 times its requirement estimate due to partial reliance on choline from other ingredients to meet the animal's requirement. One producer supplemented vitamin C in gestation diets at a rate of 250 mg per kg. Trace-mineral supplementation rates were 1.6 times copper, 3.8 times iodine, 1.3 times iron, 1.5 times manganese, 1.9 times selenium, and 1.2 times zinc requirement estimates. Nine producers supplemented chromium, and one producer supplemented cobalt at 0.39 mg per kg. Two producers supplemented carnitine at a rate of 50 mg per kg.

Lactation diet information (Table 10) was provided by 17 of the producers. Fat-soluble vitamins were supplemented at rates of 5.2 times vitamin A, 2.2 times vitamin D, 1.6 times vitamin E, and 7.3 times vitamin K requirement estimates. Other vitamins were supplemented at rates of 1.4 times biotin, 0.5 times choline, 1.3 times folic acid, 4.6 times niacin, 2.3 times pantothenic acid,

Table 7: Added vitamin and trace-mineral concentrations in late-finishing diets with ractopamine (100 kg to market)*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	7	5247	4473	3.4	1099	3520	3630	3960	5500	6160
D (IU/kg)	7	911.0	774.0	5.2	284.9	440.0	550.0	770.0	1008.3	1078.0
E (IU/kg)	7	25.5	21.1	1.9	7.5	10.1	17.6	20.9	27.5	30.8
K (mg/kg)	7	2.2	2.0	3.9	0.48	1.3	1.7	2.0	2.4	2.9
Other vitamins										
Niacin (mg/kg)	7	20.2	20.5	0.7	2.9	16.5	18.7	20.7	22.0	24.6
Pantothenic acid (mg/kg)	7	15.6	13.6	1.9	3.7	8.6	11.0	13.0	16.5	18.5
Riboflavin (mg/kg)	7	4.4	3.7	1.9	1.2	2.4	3.1	4.0	4.8	5.5
Vitamin B12 (μg/kg)	7	18.5	16.9	3.4	4.4	9.9	13.2	17.6	19.8	22.0
Trace minerals										
Copper (mg/kg)	7	66.2	51.4	17.1	76.6	3.9	8.9	11.5	154.7	159.7
Iodine (mg/kg)	7	0.37	0.29	2.1	0.13	0.20	0.20	0.20	0.37	0.50
Iron (mg/kg)	7	67.1	71.6	1.8	19.6	38.6	64.9	66.5	88.7	99.1
Manganese (mg/kg)	7	19.8	18.0	9.0	10.2	4.1	4.5	20.9	24.9	27.4
Selenium (mg/kg)	7	0.18	0.21	1.4	0.06	0.12	0.15	0.19	0.27	0.28
Zinc (mg/kg)	7	113.9	112.5	2.3	29.6	74.8	99.1	105.2	131.2	160.2
Conditionally essential nutrients										
Cobalt (mg/kg)	1	0.35	0.35	NA	ND	0.35	ND	0.35	ND	0.35

* Seven producers' nutritionists provided information for late-finishing diets with ractopamine, totaling approximately 556,000 sows (9.7% of the US sow herd). All reported values are on a complete-feed basis.
† N indicates the number of producers adding concentrations of a nutrient.
‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.
§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]
NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.
ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

3.4 times pyridoxine, 2.2 times riboflavin, 2.2 times thiamin, and 2.4 times vitamin B12 requirement estimates. One producer supplemented vitamin C in lactation diets at a rate of 250 mg per kg of diet. Trace-mineral supplementation rates were 0.8 times copper, 3.8 times iodine, 1.3 times iron, 1.5 times manganese, 1.9 times selenium, and 1.2 times zinc requirement estimates. Nine producers supplemented chromium at a rate of 0.20 mg per kg, and one producer supplemented cobalt at a rate of 0.39 mg per kg. Two producers supplemented carnitine at a rate of 50 mg per kg of diet.

Boar diet information (Table 11) was provided by 13 of the producers. Fat-soluble vitamins were supplemented at rates of 2.8 times vitamin A, 9.3 times vitamin D, 1.8 times vitamin E, and 7.0 times vitamin K requirement estimates. Other vitamins were supplemented at rates of 1.6 times biotin, 0.6 times choline, 1.4 times folic acid, 4.5 times niacin, 2.3 times pantothenic acid, 3.2 times pyridoxine, 2.2 times riboflavin, 2.0 times thiamin, and 3.1 times vitamin B12 requirement estimates. One producer supplemented vitamin C in boar diets at a rate of 250 mg per kg of diet. Trace-mineral supplementation rates were 4.0 times copper, 4.4 times iodine, 1.4 times iron, 2.3 times manganese, 1.0 times selenium, and 2.8 times zinc requirement estimates. One producer supplemented selenium at a concentration (0.42 mg per kg) above the maximum concentration of 0.30 mg per kg, which was due to an increased inclusion rate of a premix that was also used in other diets. Seven producers supplemented chromium at a rate of 0.21 mg per kg, and one producer supplemented cobalt at a rate of 0.39 mg per kg. One producer supplemented carnitine at a rate of 60 mg per kg of diet.

Nutrient sources

Along with reporting their supplementation rates of vitamins and trace minerals, participants were also asked about the sources of specific nutrients (Table 12) used within the diets. The most distinguishable differences among sources within this survey were associated with supplementation of vitamin D from a cross-linked vitamin AD_3 beadlet, potential use of natural (d-alpha-tocopherol) vitamin E as a source of vitamin E, and the use of chelated trace minerals (copper, manganese, selenium, and zinc). For

Table 8: Added vitamin and trace-mineral concentrations in gilt-development diet (20 kg to breeding)*

	N†	Weighted average‡	Average	Ratio to NRC (grower)§	Ratio to NRC (gestation)§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins											
A (IU/kg)	17	8452	9405	3.3	1.1	2444	4400	9900	9979	11,000	11,986
D (IU/kg)	17	1339	1621	4.9	0.9	497.2	687.5	1320	1760	1996	2218
E (IU/kg)	17	52.1	62.5	2.6	0.6	29.7	16.5	48.4	60.1	66.0	150.0
K (mg/kg)	17	3.1	3.3	3.0	3.0	1.1	1.3	2.4	3.1	4.4	4.8
Other vitamins											
Biotin (mg/kg)	16	0.24	0.29	2.5	0.6	0.09	0.07	0.22	0.26	0.33	0.44
Choline (mg/kg)	13	572.0	541.2	0.8	0.2	132.0	259.6	519.2	519.2	611.6	818.4
Folic acid (mg/kg)	15	1.7	1.7	2.5	0.6	0.73	1.1	1.3	1.5	1.8	3.5
Niacin (mg/kg)	17	34.3	40.3	0.6	1.8	10.8	20.9	38.5	44.0	45.3	55.0
Pantothenic acid (mg/kg)	17	23.5	25.1	1.4	0.9	5.9	15.4	22.0	25.3	28.6	35.0
Riboflavin (mg/kg)	17	6.6	7.5	1.3	0.9	2.0	4.0	5.5	7.7	8.8	9.9
Thiamin (mg/kg)	5	2.0	2.2	1.0	1.0	0.77	1.1	1.7	2.2	2.8	3.3
Vitamin B6 (mg/kg)	12	3.5	3.3	1.5	1.5	1.1	0.88	2.8	3.3	4.0	5.1
Vitamin B12 (μg/kg)	17	30.1	32.1	1.5	1.0	7.7	19.4	27.5	33.0	37.2	44.0
Trace minerals											
Copper (mg/kg)	17	25.1	22.9	5.7	2.3	30.0	8.8	12.2	15.0	16.5	136.8
Iodine (mg/kg)	17	0.50	0.51	3.7	3.7	0.30	0.22	0.33	0.38	0.66	1.3
Iron (mg/kg)	17	88.7	97.8	1.6	1.2	23.1	61.1	89.8	99.8	110.0	149.5
Manganese (mg/kg)	17	30.7	37.2	18.6	1.5	14.4	14.2	26.5	33.1	50.0	70.0
Selenium (mg/kg)	17	0.29	0.29	1.4	1.9	0.03	0.20	0.30	0.30	0.30	0.30
Zinc (mg/kg)	17	105.3	121.5	2.0	1.2	26.8	60.8	110.1	123.8	130.0	173.6
Conditionally essential nutrients											
Carnitine (mg/kg)	2	50.0	50.0	NA	NA	0.00	50.0	ND	50.0	ND	50.0
Chromium (mg/kg)	5	0.20	0.20	NA	NA	0.00	0.20	0.20	0.20	0.20	0.20
Cobalt (mg/kg)	1	0.39	0.39	NA	NA	ND	0.39	ND	0.39	ND	0.39
Vitamin C (mg/kg)	1	250.0	250.0	NA	NA	ND	250.0	ND	250.0	ND	250.0

* Seventeen producers' nutritionists provided information for gilt-development diets, totaling approximately 2,223,600 sows (38.6% of the US sow herd). All reported values are on a complete-feed basis.

† N indicates the number of producers adding concentrations of a nutrient.

‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.

§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1] Since the NRC does not list specific gilt-development requirements, the supplementation rates were compared to the NRC requirements of growing pigs from 25 to 50 kg, as well as to gestation requirements, because most strategies for feeding the developing gilt were related to one of these two diet types.

NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.

ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

Table 9: Added vitamin and trace-mineral concentrations in gestation diets*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	17	9819	10,362	2.6	1026	7698	9900	11,000	11,002	11,986
D (IU/kg)	17	1531	1783	2.2	360.4	1097	1562	1762	2141	2218
E (IU/kg)	17	66.0	70.0	1.6	25.1	44.0	59.0	66.0	73.9	150.0
K (mg/kg)	17	3.5	3.7	7.3	0.99	1.7	2.8	4.0	4.4	4.8
Other vitamins										
Biotin (mg/kg)	17	0.26	0.29	1.4	0.07	0.22	0.22	0.24	0.33	0.44
Choline (mg/kg)	17	645.3	610.7	0.5	114.4	389.8	519.6	571.8	713.0	788.7
Folic acid (mg/kg)	17	1.7	1.7	1.3	0.59	1.1	1.3	1.7	1.7	3.5
Niacin (mg/kg)	17	40.5	45.5	4.6	11.7	24.2	41.1	44.0	49.1	82.5
Pantothenic acid (mg/kg)	17	26.8	27.3	2.3	4.0	22.0	24.4	27.5	29.5	35.0
Riboflavin (mg/kg)	17	7.5	8.1	2.2	1.4	5.5	7.3	8.4	9.5	9.9
Thiamin (mg/kg)	5	2.1	2.2	2.2	0.77	1.1	1.7	2.2	2.8	3.3
Vitamin B6 (mg/kg)	13	4.0	3.5	3.4	1.1	0.88	3.0	3.3	4.4	5.1
Vitamin B12 (μg/kg)	17	34.1	35.2	2.4	4.8	27.3	33.0	33.9	38.5	44.0
Trace minerals										
Copper (mg/kg)	17	15.0	16.1	1.6	6.0	6.8	13.2	15.0	16.5	35.0
Iodine (mg/kg)	17	0.56	0.53	3.8	0.30	0.16	0.31	0.50	0.68	1.3
Iron (mg/kg)	17	101.8	102.2	1.3	28.8	45.4	89.9	100.0	115.1	165.0
Manganese (mg/kg)	17	32.5	37.6	1.5	13.2	21.2	25.7	38.5	50.0	70.0
Selenium (mg/kg)	17	0.29	0.29	1.9	0.04	0.14	0.30	0.30	0.30	0.30
Zinc (mg/kg)	17	112.9	123.0	1.2	28.3	56.7	108.0	125.0	147.2	165.0
Conditionally essential nutrients										
Carnitine (mg/kg)	2	50.0	50.0	NA	0.0	50.0	ND	50.0	ND	50.0
Chromium (mg/kg)	9	0.20	0.20	NA	0.0	0.20	0.20	0.20	0.20	0.20
Cobalt (mg/kg)	1	0.39	0.39	NA	ND	0.39	ND	0.39	ND	0.39
Vitamin C (mg/kg)	1	250.0	250.0	NA	ND	250.0	ND	250.0	ND	250.0

* Seventeen producers' nutritionists provided information for gestation diets, totaling approximately 2,223,600 sows (38.6% of the US sow herd). All reported values are on a complete-feed basis.
† N indicates the number of producers adding concentrations of a nutrient.
‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.
§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]
NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.
ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

vitamin D_3, more than 50% of participants supplemented at least 25% of vitamin D from a vitamin AD_3 cross-linked beadlet, across all surveyed diet types. The use of natural (d-alpha-tocopherol) vitamin E as a potential source of vitamin E ranged from 29% to 62% across all surveyed diet types. It is important to note that this question addresses only producers that specifically note natural vitamin E as a possible source when ordering premix from premix blenders. It does not distinguish whether natural vitamin E was used within their premixes or complete diets. Use of chelated sources for partial or complete supplementation of copper, manganese, or zinc ranged from 0% to 46% across surveyed diet types. Chelated selenium for partial or total selenium supplementation ranged from 0% to 77% of respondents across the different diets. Most chelated trace-mineral supplementation occurred in breeding-herd and early-nursery diets.

Discussion

Presumably, the high inclusion rates for copper and zinc reported for some producers were used for growth promotion, as discussed previously by Reese and Hill.[7] This led to a large variation in copper and zinc supplementation rates in the nursery phases. In the finishing phase, in general the only vitamin or trace mineral supplemented below the requirement was niacin. It is speculated this may be due to the increase (10 to 30 mg per kg) in niacin requirement from the 1998[3] to the 2012 NRC[1] publication, while the other requirements were unchanged. Again in the finishing phase, similar to the nursery, there was a high ratio relative to the NRC suggestions and a wide variability in copper supplementation rates. Again, we speculate this is due to the use by some producers of high levels for growth promotion versus others that only included concentrations to meet the nutritional requirement. Also, in general, manganese supplementation concentrations were high relative to NRC suggestions in the finishing phases, and we do not have a good explanation for this discrepancy.

Large differences in weight categories were associated with gilt-development diets across

Table 10: Added vitamin and trace-mineral concentrations in lactation diets*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	17	9997	10,404	5.2	918.5	8415	9900	11,000	11,002	11,986
D (IU/kg)	17	1557	1789	2.2	348.7	1100	1562	1762	2141	2218
E (IU/kg)	17	67.1	70.2	1.6	24.9	44.0	59.0	66.0	73.9	150.0
K (mg/kg)	17	3.5	3.7	7.3	0.99	1.7	2.8	4.0	4.4	4.8
Other vitamins										
Biotin (mg/kg)	17	0.29	0.29	1.4	0.07	0.22	0.22	0.24	0.33	0.44
Choline (mg/kg)	17	478.5	533.9	0.5	108.5	259.8	519.6	519.6	609.6	675.6
Folic acid (mg/kg)	17	1.7	1.7	1.3	0.59	1.1	1.3	1.7	1.8	3.5
Niacin (mg/kg)	17	41.4	45.8	4.6	11.7	24.2	41.1	44.0	49.1	82.5
Pantothenic acid (mg/kg)	17	27.3	27.5	2.3	3.7	22.0	24.6	27.5	29.5	35.0
Riboflavin (mg/kg)	17	7.7	8.1	2.2	1.4	5.5	7.3	8.4	9.5	9.9
Thiamin (mg/kg)	5	2.1	2.2	2.2	0.77	1.1	1.7	2.2	2.8	3.3
Vitamin B6 (mg/kg)	13	4.0	3.5	3.4	1.1	0.88	3.0	3.3	4.4	5.1
Vitamin B12 (μg/kg)	17	34.8	35.4	2.4	4.6	27.5	33.0	33.9	38.5	44.0
Trace minerals										
Copper (mg/kg)	17	15.0	16.1	0.8	6.0	6.8	13.2	15.0	16.5	35.0
Iodine (mg/kg)	17	0.56	0.53	3.8	0.30	0.16	0.31	0.50	0.68	1.3
Iron (mg/kg)	17	101.8	102.2	1.3	28.8	45.4	89.9	100.0	115.1	165.0
Manganese (mg/kg)	17	32.5	37.6	1.5	13.2	21.2	25.7	38.5	50.0	70.0
Selenium (mg/kg)	17	0.29	0.29	1.9	0.04	0.14	0.30	0.30	0.30	0.30
Zinc (mg/kg)	17	112.9	123.0	1.2	28.3	56.7	108.0	125.0	147.2	165.0
Conditionally essential nutrients										
Carnitine (mg/kg)	2	50.0	50.0	NA	0.0	50.0	ND	50.0	ND	50.0
Chromium (mg/kg)	9	0.21	0.20	NA	0.0	0.20	0.20	0.20	0.20	0.22
Cobalt (mg/kg)	1	0.39	0.39	NA	ND	0.39	ND	0.39	ND	0.39
Vitamin C (mg/kg)	1	250.0	250.0	NA	ND	250.0	ND	250.0	ND	250.0

* Seventeen producers' nutritionists provided information for lactation diets, totaling approximately 2,223,600 sows (38.6% of the US sow herd). All reported values are on a complete-feed basis.

† N indicates the number of producers adding concentrations of a nutrient.

‡ Weighted averages were calculated using the sumproduct function of Excel 2013 (Microsoft) in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.

§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]

NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.

ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

Table 11: Added vitamin and trace-mineral concentrations in boar diets*

	N†	Weighted average‡	Average	Ratio to NRC§	SD	Low	25%	Median	75%	High
Fat-soluble vitamins										
A (IU/kg)	13	10,549	11,249	2.8	1898	7698	9957	11,000	12,558	15,400
D (IU/kg)	13	1608	847	9.3	442.9	1097	1541	1760	2141	2614
E (IU/kg)	13	72.2	77.4	1.8	31.0	44.0	59.0	66.0	99.0	150.0
K (mg/kg)	13	3.5	3.5	7.0	1.0	1.8	2.6	3.7	4.4	4.8
Other vitamins										
Biotin (mg/kg)	13	0.31	0.33	1.6	0.15	0.22	0.22	0.29	0.40	0.64
Choline (mg/kg)	10	637.6	715.7	0.6	507.8	259.8	480.7	584.1	786.1	2079
Folic acid (mg/kg)	13	1.8	1.8	1.4	0.70	1.1	1.3	1.7	2.3	3.5
Niacin (mg/kg)	13	41.4	44.9	4.5	6.6	33.0	41.4	45.1	49.5	55.0
Pantothenic acid (mg/kg)	13	27.7	27.7	2.3	4.2	22.0	25.3	27.5	28.8	37.0
Riboflavin (mg/kg)	13	7.7	8.1	2.2	1.5	5.5	7.5	8.4	9.5	9.9
Thiamin (mg/kg)	5	2.1	2.0	2.0	1.2	0.09	1.1	2.2	2.8	3.3
Vitamin B6 (mg/kg)	10	3.7	3.3	3.2	1.6	0.13	2.2	3.3	4.6	5.1
Vitamin B12 (μg/kg)	13	39.2	46.4	3.1	34.8	27.3	33.0	37.2	44.0	160.8
Trace minerals										
Copper (mg/kg)	13	16.6	19.8	4.0	10.6	11.2	13.7	15.1	23.9	46.5
Iodine (mg/kg)	13	0.62	0.61	4.4	0.31	0.22	0.36	0.52	0.71	1.3
Iron (mg/kg)	13	109.6	109.0	1.4	26.9	61.1	90.1	105.8	122.5	165.0
Manganese (mg/kg)	13	35.3	45.1	2.3	22.9	21.2	28.1	38.5	64.9	96.8
Selenium (mg/kg)	13	0.31	0.31	1.0	0.03	0.30	0.30	0.30	0.30	0.42
Zinc (mg/kg)	13	122.3	142.5	2.8	50.5	83.8	112.8	129.8	170.0	279.3
Conditionally essential nutrients										
Carnitine (mg/kg)	1	60.0	60.0	NA	ND	60.0	ND	60.0	ND	60.0
Chromium (mg/kg)	7	0.21	0.21	NA	0.08	0.20	0.20	0.20	0.20	0.24
Cobalt (mg/kg)	1	0.39	0.39	NA	ND	0.39	ND	0.39	ND	0.39
Vitamin C (mg/kg)	1	250.0	250.0	NA	ND	250.0	ND	250.0	ND	250.0

* Thirteen producers' nutritionists provided information for boar diets, totaling approximately 1,921,100 sows (33.4% of the US sow herd). All reported values are on a complete-feed basis.
† N indicates the number of producers adding concentrations of a nutrient.
‡ Weighted averages were calculated using the sumproduct function of Excel in which the producer supplementation rate was multiplied by the size of the producer (sow herd size). After summing those products they were divided by the total number of sows for all participating producers.
§ Values represent average supplementation rates as a proportion to total dietary vitamin and trace-mineral requirements from the NRC 2012.[1]
NA = not applicable; NRC[1] does not list a requirement for conditionally essential nutrients.
ND = not done; standard deviation (SD) is not meaningful for N of 1, or for the 25th and 75th percentiles for N = 1 or N = 2.

the participating production systems. Thus, to standardize the information, the last diet fed before gilts entered the breeding herd was used. Since the NRC does not provide specific requirements for gilt development, the gilt-development diets were compared to NRC[1] growing-pig (25 to 50 kg) and gestation requirements. We used these two categories because most recommended vitamin and trace-mineral feeding strategies for developing gilts are similar to those for feeding growing pigs in the early-finisher or gestation diet supplementation rates.

In conclusion, adding a margin of safety for vitamin and trace-mineral supplementation rates over those requirement estimates of NRC[1] appear to be standard practice in many US swine diet formulations. However, the degree or range of supplementation varies considerably. We believe this wide variation represents differing opinions on vitamin and trace-mineral requirements and highlights the need for research to examine vitamin and trace-mineral requirements of today's modern genotypes.

Table 12: Percentage of participating producers using alternative vitamin and trace-mineral sources*

	Nursery phase†			Finishing‡				Breeding herd			
	1	2	3	Early	Mid	Late	Ract	Gilt dev	Gestation	Lactation	Boar
Participating producers (n)	**13**	**17**	**18**	**18**	**18**	**18**	**7**	**17**	**17**	**17**	**13**
Vitamins											
AD (%)§	92	76	67	67	67	67	86	65	65	65	54
E (%)¶	38	62	56	56	33	33	29	41	41	41	38
Trace minerals**											
Copper (%)	15	18	6	0	0	0	0	29	29	29	46
Manganese (%)	15	18	6	0	0	0	0	29	29	29	46
Selenium (%)	69	47	33	6	6	6	0	76	76	76	77
Zinc (%)	15	18	6	0	0	0	0	29	29	29	46

* A total of 18 swine producers' nutritionists representing approximately 2,268,900 sows (39.4% of the US sow herd) were surveyed on their supplementation rates of vitamins and trace minerals.
† Nursery diets consisting of phase 1 (weaning to 7 kg), phase 2 (7 to 11 kg), and phase 3 (11 to 23 kg).
‡ Finishing diets consisting of early-finishing (23 to 55 kg), mid-finishing (55 to 100 kg), late-finishing (100 kg to market), and late-finishing with ractopamine HCl (Ract;100 kg to market). Ractopamine is fed in late-finishing diets at a rate of 5 to 10 g/tonne for improved feed efficiency and gain.
§ Values represent the percentage of producers supplying at least 25% of vitamin D from a vitamin AD3 cross-linked beadlet.
¶ Values represent the percentage of producers that specify natural (d-alpha-tocopherol) vitamin E as a potential source of vitamin E.
** Values represent the percentage of producers that supplement partial or complete trace-mineral concentrations from chelated sources.
Gilt dev = gilt development.

Implications

- There is variation in vitamin and trace-mineral supplementation rates across the population of respondents within this survey.
- Although supplementation rates are variable, on the basis of this survey, inclusion of margins of safety for vitamin and trace-mineral supplementation rates appears to be standard practice in US swine diets.
- This survey provides a baseline for characterization of standard practice for trace-mineral supplementation rates.
- The variation in vitamin and trace-mineral supplementation observed in this survey will be useful in identifying research needed to determine vitamin and trace-requirements for various phases of production.

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Conflict of interest

None reported

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Peer reviewed

Virus detection using metagenomic sequencing of swine nasal and rectal swabs

Ben M. Hause, MS, PhD; Joshua W. Duff, DVM; Alan Scheidt, DVM; Gary Anderson, DVM, PhD

Summary

Advances in DNA sequencing have increased our ability to generate large amounts of sequence data at lower costs. These developments have enabled microbial detection and characterization directly from clinical specimens, known as metagenomic sequencing. Viral metagenomic sequencing was performed on five nasal- and five fecal-swab pools collected from each of two primary and two secondary market slaughterhouses and a cull-swine buying station in the southeastern United States. Sequences were assembled de novo and analyzed by BLASTN to identify viruses present in the samples. Twenty seven different viruses were identified. Reads similar to a diverse family of single-stranded circular DNA viruses were identified in nearly every sample (47 of 50). Other viruses identified at all five sampling sites and in over half of the samples were bocavirus, torovirus, posavirus, torque teno virus, IAS virus, picobirnavirus, and teschovirus. Viruses identified in multiple sites in greater than 20% of the samples included enterovirus, parvovirus, influenza A virus, sapelovirus, and Senecavirus A. Other significant swine viruses detected less frequently include porcine circovirus type 2, porcine epidemic diarrhea virus, and porcine deltacoronavirus. Together, these results suggest that metagenomic sequencing is a powerful tool for virus detection and characterization.

Keywords: swine, DNA sequencing, virus, Senecavirus A, virome

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Resumen - Detección de virus utilizando secuenciación metagenómica de hisopos nasales y rectales porcinos

Los avances en la secuenciación de DNA han incrementado nuestra habilidad para generar grandes cantidades de información de secuencias a costos más bajos. Estos desarrollos han permitido la caracterización y la detección microbiana directamente de especímenes clínicos, conocida como secuenciación metagenómica. Se realizó la secuenciación metagenómica viral en cinco grupos de cinco muestras nasales y fecales recolectadas de dos mataderos primarios y dos secundarios y de una estación de compra de animales de desecho en el sureste de los Estados Unidos. Las secuencias se montaron de novo y se analizaron por medio de BLASTN para identificar los virus presentes en las muestras. Se identificaron veintisiete virus diferentes. Se identificaron lecturas semejantes a una familia diversa de virus de DNA circular de cadena simple casi en cada muestra (47 de 50). Otros virus identificados en los cinco sitios de muestreo y en más de la mitad de las muestras fueron bocavirus, torovirus, posavirus, virus torque teno, virus IAS, picobirnavirus, y teschovirus. Los virus identificados en sitios múltiples en más del 20% de las muestras incluyeron enterovirus, parvovirus, virus de la influenza A, sapelovirus, y Senecavirus A. Otros virus porcinos significativos detectados con menor frecuencia incluyeron circovirus porcino tipo 2, virus de la diarrea epidémica porcina, y el deltacoronavirus porcino. Conjuntamente, estos resultados sugieren que la secuenciación metagenómica es una herramienta poderosa para la caracterización y detección de virus.

Résumé - Détection de virus en utilisant le séquençage métagénomique d'écouvillons nasaux et rectaux

Les avancées dans le séquençage de l'ADN ont augmenté la capacité à générer de grandes quantités de données de séquences à des coûts moindres. Ces développements ont permis la détection microbienne et la caractérisation directement à partir de spécimens cliniques, connus sous l'appellation de séquençage métagénomique. Le séquençage métagénomique viral a été effectué sur cinq pools d'écouvillons nasaux et cinq pools d'écouvillons rectaux prélevés de chacun de deux abattoirs primaires et deux abattoirs secondaires, ainsi que d'une station d'achat d'animaux réformés dans le sud-est des États-Unis. Les séquences ont été assemblées de novo et analysées par BLASTN afin d'identifier les virus présents dans les échantillons. Vingt-sept virus différents ont été identifiés. Des lectures similaires à une famille variée de virus à ADN circulaire simple brin ont été identifiées dans presque tous les échantillons (47 des 50). Les autres virus identifiés dans tous les sites échantillonnés et dans plus de la moitié des échantillons étaient des bocavirus, des torovirus, des posavirus, des torque teno virus, les virus IAS, les picobirnavirus, et les teschovirus. Les virus identifiés dans des sites multiples dans plus de 20% des échantillons incluaient les enterovirus, les parvorirus, le virus de l'influenza A, les sapelovirus, et le Senecavirus A. Les autres virus porcins significatifs détectés moins fréquemment incluaient le circovirus porcin de type 2, le virus de la diarrhée épidémique porcine, et le deltacoronavirus porcin. Ces résultats suggèrent que le séquençage métagénomique est un outil puissant pour la détection et la caractérisation des virus.

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For greater than a decade, DNA sequencing has been widely used by swine veterinarians to study the epidemiology of clinically important viruses such as porcine reproductive and respiratory syndrome virus (PRRSV) and influenza A virus (IAV). Traditional DNA sequencing methodology, developed by Sanger, has the advantages of low cost, fast turnaround times, and relatively long read lengths.[1] Commonly, the gene encoding the most variable immunodominant viral protein is targeted. Polymerase chain reaction (PCR) is used to amplify the gene of interest, and the purified PCR product is subjected to Sanger sequencing using a DNA primer that binds to the PCR product. Multiple sequencing reads are utilized to achieve complete gene coverage. Prices charged by veterinary diagnostic laboratories in the United States vary, but are typically approximately $100 to $180 per sample, with results available within days. A significant disadvantage of Sanger sequencing is a requirement for a priori knowledge of an organism's presence in a sample, as well as sufficient sequence homology to enable binding of the sequencing primer.

New DNA sequencing technologies have become more commonplace in diagnostic laboratories.[2,3] Next-generation sequencing platforms generate massive amounts of sequencing information at low cost. Owing to this feature, metagenomic sequencing techniques have been developed that utilize random priming approaches to non-specifically amplify nucleic acids present in a sample.[4] While these techniques lack specificity and amplify host, environmental, and pathogen sequences, the sheer quantity of sequencing reads enables identification and characterization of pathogen nucleic acids present in relatively low concentrations. For viral metagenomic sequencing, a variety of protocols have been published to enrich the sample for viral populations.[5,6] A significant advantage of metagenomic sequencing is the lack of requirement for prior knowledge of virome composition for DNA sequencing. Universal metagenomic sequencing protocols have been published that are capable of detecting both single- and double-stranded DNA and RNA viruses.[5] Despite these advantages, next-generation sequencing remains more expensive, on a per-sample basis, than traditional methods, and requires more time. Owing to the large number of sequences generated per sample, data management is more complex, often requiring specialized software.

Large numbers of viruses are known to infect swine, and new viruses are routinely being discovered. While several publications have explored the swine virome, we have limited understanding of the clinical significance of most of these viruses.[7,8] The goal of this study was to characterize the swine virome at points of animal concentration and commingling.

Sampling protocol

Nasal and fecal swabs were collected in universal viral transport medium from five individual pigs derived from a single producer and assembled into nasal- and fecal-swab pools. Pigs from five producers were collected per site. Five sites in total were sampled in August 2015. Samples were collected by a veterinarian, and all animals were clinically healthy. Sites 1 and 2 were abattoirs that purchased top-quality hogs (primary market). Sites 3 and 4 were cull-swine abattoirs. Site 5 was a cull-swine buying station. Animals from sites 1 to 4 were greater than 20 weeks of age, while animals at Site 5 were greater than 10 weeks of age.

Metagenomic sequencing

Metagenomic sequencing was performed approximately as previously described.[5] Swabs in transport medium were vortexed, and pools of five nasal or fecal swabs were assembled (10 total pools per site). Samples were clarified by centrifugation and subsequently enriched for viral nucleic acids by treatment with a mixture of nucleases.[6] Viral nucleic acids were extracted using the MinElute Virus Spin Filter Kit (Qiagen, Valencia, California) according to the manufacturer's instructions. First-strand cDNA was synthesized from viral RNA using the Superscript III First-Strand Synthesis System (ThermoFisher Scientific, Waltham, Massachusetts) as specified by the manufacturer, with previously described random primers.[4] Second-strand synthesis was performed with Sequenase 2.0 DNA Polymerase (ThermoFisher Scientific) followed by cDNA purification using the Agencourt AMPure XP beads (Beckman Coulter, Brea, California). The double-stranded cDNA was amplified with TaKaRa DNA polymerase (Clontech Laboratories, Mountain View, California) with primers identical to those used for first-strand synthesis, but lacking the random hexamer. Size selection and purification were performed using Agentcourt AMPure XP beads, selecting for products > 300 bp. Amplicons were quantified using a Qubit fluorometer (ThermoFisher Scientific), and libraries were prepared by the standard Nextera XT Library Preparation Kit (Illumina, San Diego, California) protocol. All 50 libraries were pooled and sequenced using paired 300-bp reads on a single Miseq (Illumina) run. Sequence reads were parsed using barcodes incorporated during library preparation and imported into CLC Genomics Workbench (CLC Bio, Waltham, Massachusetts). Reads were mapped to the host genome (*Sus scrofa*), and from the unmapped reads, contigs were assembled de novo. Contigs, the consensus sequences derived from overlapping DNA sequences, were analyzed by the basic local alignment search tool nucleotides (BLASTN). Contigs with expectation (*E*) values (a measure of database hit strength) less than 10^{-10} were considered positive for virus identification. For viruses with multiple BLASTN hits to similar viral species, virus identity was assigned to a higher, more inclusive taxonomic level, typically the genus.

Results

Viruses detected in primary market swabs are shown in Figure 1. A total of 19 different viruses were detected. Contigs with significant *E* values to bocavirus, torovirus, posavirus, IAS virus, picobirnavirus, and a diverse family of circular single-stranded DNA viruses (ssDNA) were found in over half of the primary market swabs. Torque teno virus, teschovirus, and adeno-associated virus were also identified at both sites. Other viruses identified at only one of the primary swine markets include porcine circovirus type 2 (PCV2), astrovirus, enterovirus, porcine parvovirus, parecho-like virus, pasivirus, IAV, sapelovirus, calicivirus, and porcine adenovirus 5. Averages of 6.6 and 5.3 viruses were detected per swab pool from sites 1 and 2, respectively.

Twenty-four viruses were identified in swabs collected at the two secondary-market abattoirs, nine of which were in over 50% of the swabs (ssDNA, bocavirus, torovirus, posavirus, torque teno virus, IAS virus, enterovirus, sapelovirus, and Senecavirus A; Figure 2). Viruses identified at both secondary sites at lower prevalence include astrovirus, picobirnavirus, teschovirus, parvovirus, pasivirus, and IAV. Viruses identified at a single site were PCV2, parecho-like virus, hemagglutinating encephalomyelitis virus (HEV), hokovirus, porcine respiratory coronavirus,

Figure 1: Percentage of pooled swab samples collected from primary-market abattoirs positive for identified viruses. Separate nasal- and fecal-swab pools were assembled from swabs collected from five individual pigs derived from a single producer. Pigs from five producers were collected per site. Viral metagenomic sequencing was performed on the five nasal-swab and five fecal-swab pools collected at each site to identify viruses present in the pooled samples.

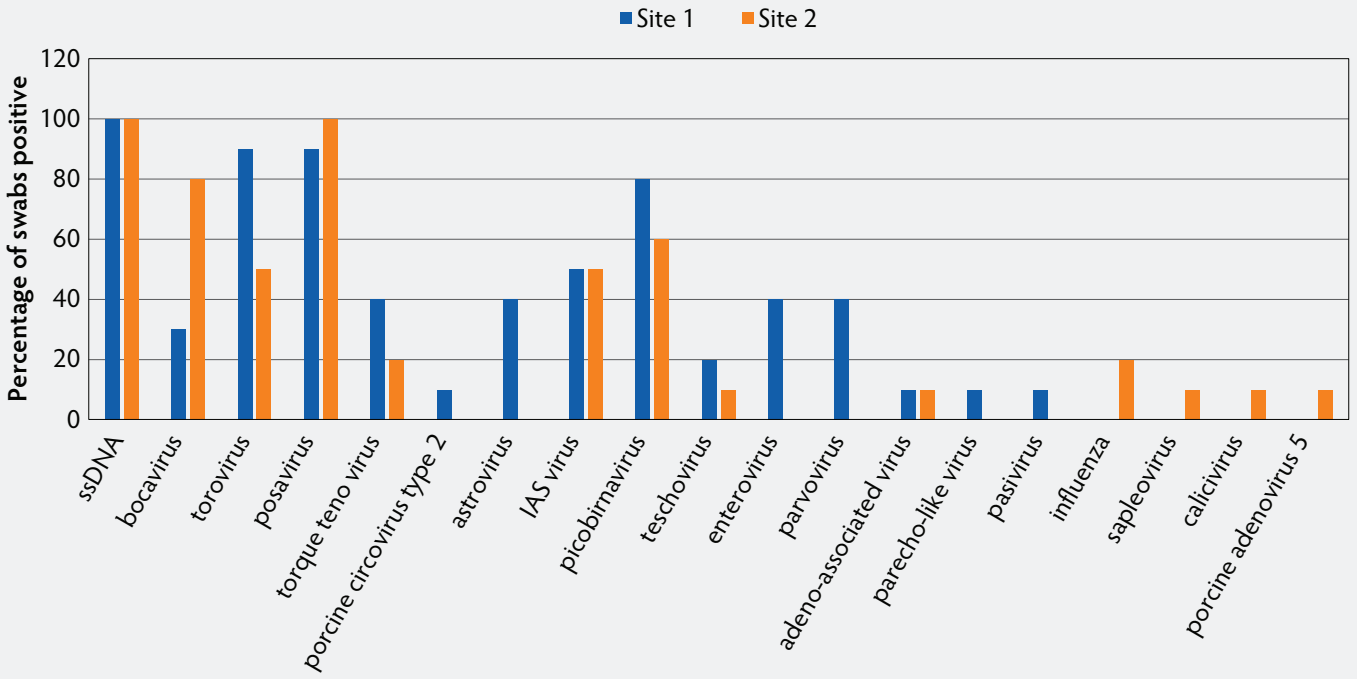
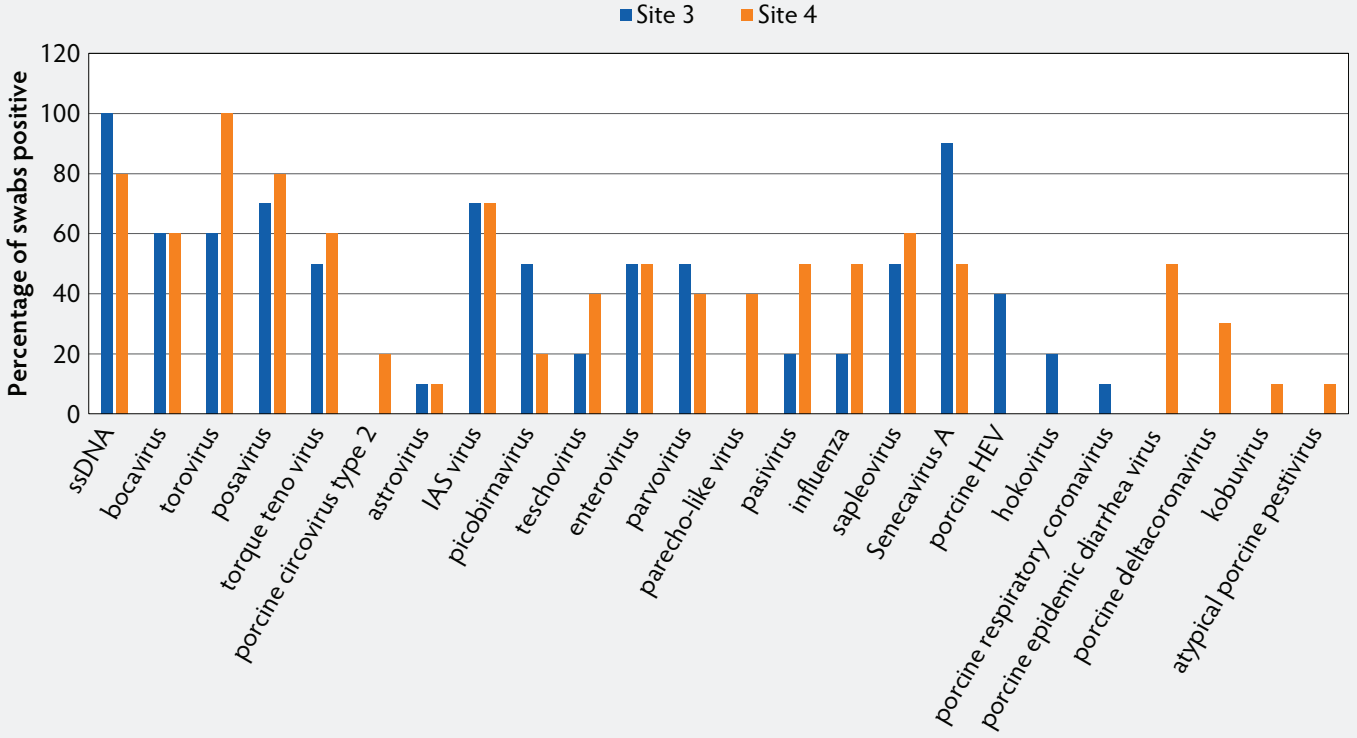


Figure 2: Percentage of pooled swab samples collected from secondary-market slaughterhouses positive for identified viruses. Study described in Figure 1. Porcine HEV = porcine hemagglutinating encephalomyelitis virus.



porcine epidemic diarrhea virus (PEDV), porcine deltacoronoavirus, kobuvirus, and atypical porcine pestivirus (APPV). Swab pools from sites 3 and 4 had the highest average number of viruses detected (8.4 and 9.8, respectively).

Analysis of swabs from Site 5 identified 14 viruses (Figure 3). The most commonly identified viruses were ssDNA, bocavirus, posavirus, IAS virus, picobirnavirus, enterovirus, and torovirus, similar to those seen at sites 1 to 4. The remaining viruses were also variably identified at sites 1 to 4. An average of 5.2 viruses were identified per swab pool.

Discussion

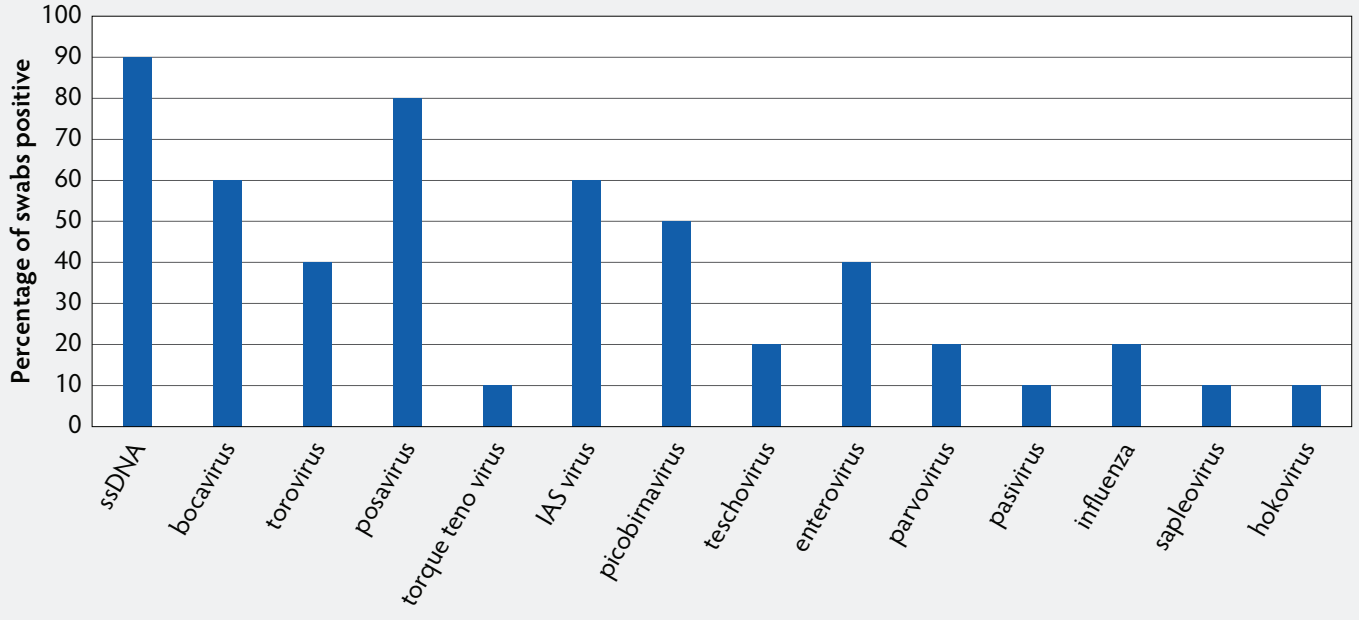
In this study, metagenomic sequencing methodology was applied to nasal and fecal swabs collected from swine commingled at slaughter and buying facilities. While the animals were suitable for slaughter, no information was available on the herd-of-origin status or health history. The objective of this study was to identify viruses circulating in swine at animal concentration points. Many of these facilities located in the southeastern United States are in close proximity to swine confinement operations and utilize common transport. Contaminated swine transport was previously implicated as one source of the rapid dissemination of PEDV throughout the United States.[9]

A minimum of 27 different viruses were identified in nasal and fecal swabs, with an overall average of 7.1 viruses per swab pool. As metagenomic sequencing often yields only partial viral genome sequences, annotation of viruses to a strain or species level can be difficult due to varying homology between different regions of the genomes. Consequently, for some viral genera with multiple species, viruses were identified only to the genus level. For example, six proposed species of porcine parvovirus are known to circulate in the United States.[10-12] While BLASTN analysis of contig sequences returned hits to numerous porcine parvovirus species, we could not confidently assign a species. Similarly, some viruses, such as small single-stranded circular DNA viruses, are extremely diverse and often poorly characterized.[13]

A significant advantage of metagenomic sequencing, compared to conventional detection technologies, is its ability to detect viruses without prerequisite sequence information. This ability uniquely positions this technology for detection of emerging viruses for which methods do not exist or are insufficient. One swab pool was positive for APPV, a highly divergent pestivirus, which was only recently identified and characterized by metagenomic sequencing of swine serum samples.[14]

As seen in this study, metagenomic sequencing often identifies viruses for which little information is known. For example, IAS virus was identified by metagenomic sequencing of stool samples from humans infected with human immunodeficiency virus (HIV) and with unexplained diarrhea.[15] To the knowledge of the authors, this is the first identification of IAS virus in pigs. Likewise, posaviruses have previously been identified in swine feces, but it is unclear if they infect pigs or are merely present in the environment.[8] A majority of the remaining viruses are known to infect pigs, with unknown clinical significance. The ability to detect environmental viruses and viruses with unclear etiological roles can complicate interpretation of clinical results, but can serve as a basis for unraveling the complex pathogeneses of disease syndromes. Metagenomic sequencing of diseased and healthy controls in a case-control format has been utilized to identify viruses associated with bovine respiratory disease, followed by quantitative PCR and statistical correlations with clinical signs.[16] Alone, metagenomic sequencing will not establish microorganism disease causation; however, it can guide further diagnostic testing to unravel disease etiology. Numerous authors have proposed revisions to Koch's postulates to establish microorganism causality with disease, taking into account advances in detection technologies.[17] Detection of a microorganism in most cases of disease, preferentially in diseased tissues, along with a lack of or

Figure 3: Percentage of pooled swab samples collected from a cull-market buying station positive for identified viruses. Study described in Figure 1.



lower numbers of microorganisms in healthy controls or unaffected tissues, have been proposed as guidelines for establishing causality of disease with microorganism detection.[17] Reduction in the number of microorganisms detected should also correspond with disease resolution.

Senecavirus A (SVA) has caused sporadic outbreaks of vesicular disease in the United States for several decades. Senecavirus A was recently identified in Brazilian pigs with vesicular disease in addition to high neonatal mortality.[18,19] Numerous outbreaks of SVA in US pigs were reported in the summer of 2015.[20] Besides vesicular disease, high neonatal mortality, resembling clinical signs reported in Brazil, were observed. Polymerase chain reaction assays for SVA performed on 2033 oral-fluid samples from routine diagnostic submissions from 25 states identified five positive cases (1%).[21] In this study, SVA was detected in 14 of 20 swab pools (70%) collected from secondary market abattoirs and not detected in primary-market abattoir samples or the buying station. Additional testing is needed to determine if cull animals are reservoirs for SVA. These results also raise the question regarding the association of SVA with animals of a lower health status.

These results demonstrate that metagenomic sequencing is a powerful tool for virus identification and characterization. More widespread use will significantly expand our knowledge of viral epidemiology and likely lead to the discovery of novel agents. Metagenomic sequencing has a number of uses, including identifying viruses in diagnostic samples where traditional diagnostics failed to identify pathogens, determining viral genome sequences directly from clinical samples, profiling viruses present in material used to inoculate other animals, and investigating the viral ecology of disease complexes.

While nasal and fecal swabs were analyzed here for simplicity of collection, choice of samples for sequencing should be based on detection of clinical signs. Metagenomic sequencing is offered as a diagnostic test at the Kansas State Veterinary Diagnostic Laboratory.

Implications

- Under the conditions of this study, viral metagenomic sequencing can identify large numbers of viruses in swine nasal and fecal swabs.
- Metagenomic sequencing can be used to characterize viruses present in clinical samples as part of diagnostic investigations.

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Conflict of interest

None reported.

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Peer reviewed

Case report

An investigation of sow interaction with ice blocks on a farm with group-housed sows fed by electronic sow feeders

Meghann K. Pierdon, VMD; Alexandra M. John; Thomas D. Parsons VMD, PhD, DACAW

Summary

More gestating sows are being housed in pens where it is challenging to implement controlled exposure to pathogens for disease control ("feedback"). Ice blocks provide a possible vehicle for feedback material in pen gestation. Ice blocks were placed once weekly for 6 consecutive weeks in a pen of approximately 130 sows to test whether sows would interact with the blocks of ice. Sows were housed in a large, dynamic pre-implantation group fed with electronic sow feeders. Each ice block was video-recorded for 1 hour. All sows that contacted it were identified. The number of sows, their duration of contact, and amount of aggression were coded from the video. Median number of sows that interacted with the ice was 94, and increasing the number of ice blocks from two to four per pen increased the median number of sows to contact the ice and the median duration of an individual sow's contact with the ice, and decreased the amount of aggression at each block. Our findings suggest ice blocks are a convenient vehicle for controlled exposure of feedback material to gestating sows housed in large pens. However, additional studies are needed to validate pathogen exposure with this method.

Keywords: swine, ice, controlled exposure, group housing, behavior

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Resumen - Una investigación sobre la interacción de hembras con bloques de hielo en una granja con hembras alojadas en grupos alimentadas con comederos electrónicos

Cada vez, se están alojando más hembras gestantes en corrales donde es difícil implementar una exposición controlada a patógenos para el control de enfermedades ("retroalimentación"). Los bloques de hielo proveen un posible vehículo para material de retroalimentación en el corral de gestación. Los bloques de hielo se colocaron una vez por semana durante 6 semanas consecutivas en un corral de aproximadamente 130 hembras para probar si las hembras interactuarían con los bloques de hielo. Las hembras se alojaron en grupos grandes, dinámicos de preimplantación alimentados con comederos electrónicos. Cada bloque de hielo fue video grabado por 1 hora. Todas las hembras que tuvieron contacto con él fueron identificadas. El número de hembras, la duración del contacto, y la cantidad de agresión fueron identificados en el video. El número mediano de hembras que interactuaron con el hielo fue de 94, y el incremento del número de bloques de hielo de dos a cuatro por corral, incrementó el número mediano de hembras que hicieron contacto con el hielo y la duración mediana del contacto de la hembra individual con el hielo, y la disminuyó la agresión hacia cada bloque. Nuestros hallazgos sugieren que los bloques de hielo son un vehículo conveniente para la exposición controlada de material de retroalimentación para las hembras gestantes alojadas en corrales grandes. Sin embargo, se necesitan estudios adicionales para validar la exposición patógena con este método.

Résumé - Étude sur l'interaction entre des truies et des blocs de glace sur une ferme avec des truies logées en groupe et nourries avec des distributeurs électroniques de nourriture

Plus de truies gestantes sont logées dans des parcs représentant ainsi un défi pour mettre en place des mesures permettant de maitriser l'exposition à des agents pathogènes pour le contrôle des maladies ("rétroaction"). Des blocs de glace fournissent un véhicule possible pour du matériel de rétroaction dans les parcs de gestation. Les blocs de glace ont été placés une fois par semaine pour 6 semaines consécutives dans un parc d'environ 130 truies pour tester si les truies interagiraient avec les blocs de glace. Les truies étaient hébergées dans un grand groupe dynamique pré-implantation et nourries avec un distributeur électronique d'aliments pour truies. Chaque bloc de glace était enregistré par vidéo pendant 1 heure. Toutes les truies qui sont entrées en contact avec le bloc étaient identifiées. Le nombre de truies, la durée du contact, et la quantité d'agressions étaient codés à partir de la vidéo. Le nombre médian de truies qui ont interagit avec la glace était de 94, et en augmentant le nombre de blocs de glace de deux à quatre par enclos on augmenta le nombre médian de truies venant en contact avec la glace et la durée médiane qu'une truie était en contact avec la glace, et on diminua le nombre d'agressions à chaque bloc. Nos trouvailles suggèrent que des blocs de glace sont un véhicule acceptable pour contrôler l'exposition à du matériel de rétroaction de truies gestantes logées dans des grands enclos. Toutefois, des études supplémentaires sont requises pour valider l'exposition à des agents pathogènes avec cette méthode.

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Pierdon MK, John AM, Parsons TD. An investigation of sow interaction with ice blocks on a farm with group-housed sows fed by electronic sow feeders. *J Swine Health Prod.* 2016;24(6):309–314.

More sows are being housed in groups, and both legislative initiatives and market forces suggest that the number of group-housed sows will only increase in the future. Producers and

veterinarians that work with loose-housed sows face different challenges from those that house sows in gestation stalls. For example, the control of some diseases is proving to be more challenging in loose-housed sows than in sows in gestation stalls. In particular, protection against endemic enteric diseases of swine is usually achieved by inducing herd immunity following uniform exposure of healthy sows to the pathogen via a controlled exposure to infected biological material. This process is commonly called "feedback" and is used routinely in the acclimatization of gilts. It increases colostral antibodies to common pathogens such as rotavirus[1] and *Clostridium perfringens*.[2] Another common use for feedback is to help develop whole-herd immunity to a newly introduced enteric pathogen such as transmissible gastroenteritis virus (TGEV).[3] These feedback programs are readily implemented in conventional gestation barns where sows are constrained by a gestation stall to a single physical location, and it is easy to ascertain if the animal has been exposed. In contrast, the ability to induce whole-herd immunity via feedback in loose-housed sows is much more challenging, as sows are free to move around and exposure is harder to achieve and confirm.

The shortcomings of feedback in loose-housed sows is even more problematic on farms that use electronic sow feeders (ESFs), as the facilities are not designed to simultaneously feed all sows in the herd. These challenges have come to the forefront in the last 2 years with the emergence of a new and more pathogenic enteric virus in the US sow herd, porcine epidemic diarrhea virus (PEDV). The acute and severe death loss associated with this disease demands a solution to enteric pathogen control in loose-housed sows. There is little that has been done investigating feedback in electronic sow-feeding facilities. A micro-doser that dispenses small amounts into each ration has been used effectively to dispense fecal material into gilt rations.[4] However, this method has its limitations, as it requires additional equipment and controlling electronics that may not be available for all systems. Ice blocks have been investigated previously as sources of environmental enrichment in pigs,[5] and motivated us to consider ice as a possible vehicle for controlled exposure in pen gestation. Other research suggests that most currently known enteric pathogens of swine can be frozen and still be viable.[6-9] Ice, therefore, could provide a convenient and effective vehicle for controlled exposure of pathogens to pen-gestating sows if sufficient numbers of sows interact with the ice blocks before they melt. This case report documents how the sows in a research herd interacted with ice blocks and supports further study of ice blocks as a means of pathogen exposure.

Case description

Routine animal care and experimental procedures were conducted under a protocol that was approved by the University of Pennsylvania IACUC.

Study farm

The farm used was the swine research and teaching facility at the University of Pennsylvania School of Veterinary Medicine. The 130 gestating sows were housed in a single large dynamic pre-implantation pen and fed by two ESFs (Compident VII; Schauer Agrotronics, Prambachkirchen, Austria), with gilts housed in a separate pen (Figure 1). The ESF stations turned on at midnight and by 4 PM the feeding cycle was completed and the feeders closed. Sows were placed in the pen 1 to 3 days post breeding and removed 1 to 7 days before farrowing. Therefore, 92% of the population in the dynamic pen remained unchanged every week when 10 sows were moved to farrowing. The result of these movements is that over the 6 weeks, of the case report, half of the sows would have been resident sows for the entire 6 weeks, and the other half of the population consisted of animals that had been introduced or were only in the pen for part of the study and then were moved to farrowing.

Ice blocks

Ice blocks were made by placing 9.5-liter plastic storage bags (Hefty; Lake Forest, Illinois) of water in a standard chest freezer. Bags were 35.6 cm wide by 39.4 cm tall and generated an ice block of a similar size. Ice-block integrity was improved by the use of non-aerated water and the addition of chopped straw to the water prior to freezing. Originally, ice blocks were made without these additions and placed in a pen that was not to be used for the actual investigation. The blocks routinely broke either before placement in the pen or shortly afterwards. In order to video record the ice block for an hour it had to stay intact, so chopped straw and non-aerated water were explored as ways to increase the strength of the blocks. With these additions, the blocks stayed whole for long enough to test them in the sow pen. Test ice blocks lasted at least 1 hour and 20 minutes. Therefore, to standardize the duration of data collection, a 1-hour interval was chosen for video recording.

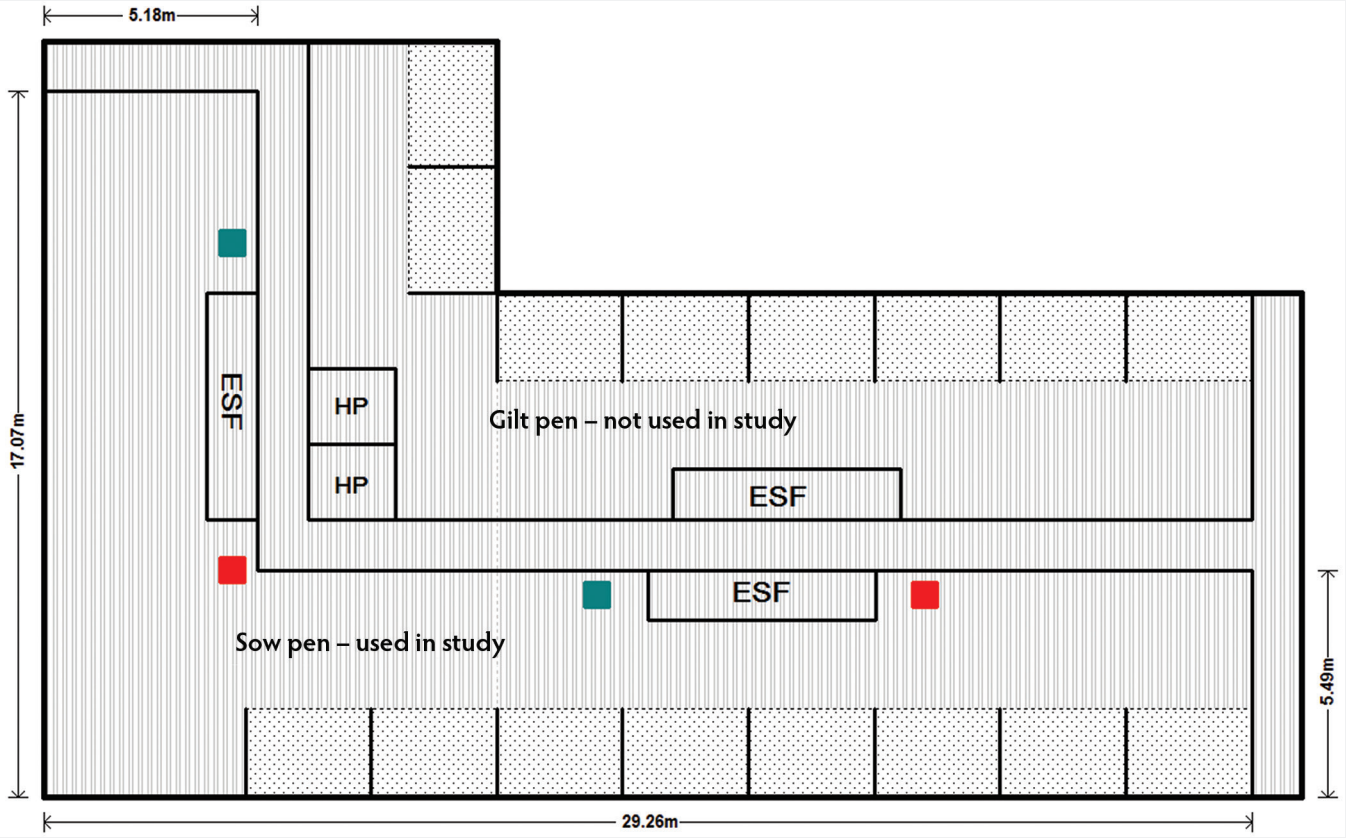
Sow interaction with the ice block

Once a week for 6 weeks at 9 AM on a weekday, either two or four ice blocks were placed in the sow pen directly on the slats. On weeks 1, 3, and 6, four ice blocks were placed in the pen, one 1 to 2 meters from the entrance of each feeder and one 1 to 2 meters from the exit of each feeder, and on weeks 2, 4, and 5, two ice blocks were introduced and placed at each of the feeder entrances at the distances described for weeks 1, 3, and 6. (Figure 1; Table 1). At 9 AM, the ESF stations were still in use and sows in the pen were active. In order to be able to identify the individual sows that interacted with the ice, and follow the ice as it was pushed around the pen, each ice block was filmed by a single observer 0.5 to 1.0 meter from the ice block with a hand-held video camera (Handycam; Sony, New York, New York). The observer stood outside the pen when possible, but entered the pen to follow the ice block or inspect sow identification tags. For 1 hour following placement of the ice in the pen, the observer filmed the ice block and verbally identified the sows as they contacted the ice by calling out their unique identification numbers. This information was then available in the audio portion of the video recording. The ice was repositioned to its starting location if it was lodged in a corner for more than 5 minutes.

Analysis

The video was analyzed using the Noldus Observer XT v 11 software (Noldus Information Technology Inc, Leesburg, Virginia), and the ethogram included both the continuous behavior of sows contacting the ice and the point behavior of aggressive events. Contact with the ice was defined as the nose or the mouth of the sow touching the ice for more than 3 seconds. Aggressive events were defined as a sow biting or head butting another sow. From the initial coding of the behavior data, additional variables were calculated. The identity of individual sows was recorded and allowed calculating, for each replicate, the total number of unique sows contacting the ice or initiating an aggressive event. Sows exhibited multiple contacts with

Figure 1: Schematic of gestation area on the study farm and placement of ice blocks. Sows were housed separately from gilts and small parity-one sows. The flooring was totally slatted except for several 2.1 × 3.1-meter sleeping areas in each pen that had raised, solid concrete bases (stippled areas). The gestation area included two 1.8 × 2.1-meter hospital pens (HPs). The behavioral observations were carried out in only the sow pen. Sows were fed via two electronic sow feeding stations (ESFs). On observation days 2, 4, and 5, an ice block was placed 1 to 2 meters from the entrance of each ESF station (red boxes) for a total of two blocks in the pen. On days 1, 3, and 6, an additional ice block was placed 1 to 2 meters from the exit of the ESF station (green boxes) for a total of four blocks in the pen. Sow behavior was recorded by a single observer 0.5 to 1.0 meter from the ice block with a hand-held video camera (Handycam; Sony, New York, New York).



the ice blocks and thus the total duration of contact with the ice was calculated as the sum of the duration of each sow's individual different contacts with the ice. Number of aggressive events per sow was the sum of individual aggressive events initiated by a given sow. Also tallied was the number of aggressive events per ice block. Since the ice was placed in the pen on consecutive weeks, and the individual sows were identified, it was possible to calculate the total number of unique sows that contacted the ice during two consecutive exposure periods (Table 1). Feed order is saved daily by the ESF computer (Topo; Schauer Agrotronics, Prambachkirchen, Austria). A feed rank was calculated for each sow using the average of her place in the eating order of the sows in the pen for the week prior to each filming session. Statistical analysis was performed with STATA v 13.1 (STATACorp LP, College Station, Texas). Pen-level data (number of sows interacting with ice block) was not normally distributed and was therefore analyzed using a Mann Whitney rank sum test. Ice-block level data (total duration of ice contact and aggressive events) were normally distributed and were analyzed with a two-way Student *t* test. Correlations were tested using point bi-serial and Spearman's correlations. A value of $P < .05$ was considered statistically significant.

Description of findings

Number of sows contacting the ice block

The median number of individual sows in the pen that contacted one of the ice blocks during an individual filming session (number of sows to contact the ice) was 94 and ranged from 76 to 106 sows or 58% to 82% of the sows in the pen (Table 1). On days with two blocks in the pen, a median number of 79 unique sows contacted one of the blocks, and on days where there were four blocks, the median number of sows was 105 (Figure 2). The number of contacts on two-block days compared to four-block days was significantly different ($P < .05$). Whether a sow contacted the ice was not correlated with her feed rank. There also was no significant effect of replicate on the number of sows to contact the ice.

To better understand how the ice blocks might be used under field conditions, the data from each 2 consecutive days of ice placement were combined and the number of unique animals that contacted the ice block was determined (Table 1). This analysis revealed

Table 1: Sow interactions with ice blocks in one pen in a loose-housing gestation facility*

Week	Pen inventory	No. of ice blocks	No. of sows contacted	2-day tally of unique sows	Weeks tallied
1	128	4	105	NA	NA
2	130	2	79	125	1, 2
3	130	4	101	116	2, 3
4	128	2	87	125	3, 4
5	132	2	76	116	4, 5
6	131	4	106	121	5, 6

* Sows were fed using electronic sow feeders. Ice blocks were placed once weekly for 6 consecutive weeks. Each ice block was video-recorded for 1 hour, and all sows that contacted it were identified. For each week, the inventory in the dynamic pen (number of sows), the number of ice blocks that were placed in the pen, the number of sows that contacted the ice, and the weekly observations combined to give a 2-day tally are shown.

NA = not applicable.

that the median number of unique animals to interact with the ice was 120 (Figure 2), or more than 90% of the pen per two consecutive weekly opportunities.

Duration of contact

The median total duration of time that individual sows contacted the ice was 93 seconds on days when there were two blocks, and 147 seconds when there were four blocks. This difference was statistically significant ($P < .001$).

Number of aggressive events

The number of sows that initiated aggressive events was not altered by the presence of two blocks (12.8 ± 1.8 sows; mean ± standard error) compared to four blocks (10.3 ± .78 sows). However, when there were only two blocks in the pen, sows were more aggressive than when there were four blocks in the pen, as the mean number of aggressive events on each block was higher when there were two blocks (68 ± 7.2) than when there were four blocks (46.2 ± 3.9) ($P < .05$). On 5 of the 6 days of observation, there was a correlation ($P < .05$) between a sow having a higher feed rank and initiating aggressive events.

Discussion

Sows that are housed in pens are still susceptible to enteric disease, and producers that use pen gestation, especially those with electronic sow feeders where all the sows do not eat at the same time, are looking for methods to administer feedback material. If ice is going to be used for pathogen control, then it is important to verify that sows will interact with the ice block in order to have the opportunity to become exposed. This case report shows that when ice was placed in the pen on two consecutive time points 1 week apart, over 90% of the sows in this large dynamic pen contacted the ice. Using four blocks instead of two blocks increased the number of sows to touch the ice, as well as increasing the duration of contact by individual sows and decreasing aggression at the ice block. Social hierarchy influenced aggression at the ice block, as animals with higher social status (animals that ate earlier during the feeding cycle)[10] were more likely to initiate aggression. However, social hierarchy did not impact contact with the ice block, as there was no correlation between feed rank and access to the block. Thus, in this dynamic pen, and given the protocol that was used here, there appeared to be enough time and material for even animals of lower social status to gain access to the ice block.

Another consideration is that a focal sampling technique was used in order to capture the individual identities of the animals contacting the ice. We cannot be sure what impact, if any, the human observer had on the number of animals to contact the ice. There is the possibility that human presence drew animals to the ice block or that human presence scared some animals away from the block. These animals had been well habituated to human presence by frequent contact with humans working in the facility, as well as being observed in the pen where they were housed. These two factors are considered the available best practices to help mitigate the presence of humans during data collection if using a camera and a remote observer is not a possibility.[11] For this study, a remote observer and unattended camera was not an option, as it would have precluded both following the ice block as it was pushed around the pen and capture of individual sow identities.

These findings suggest that the use of ice as a vehicle for pathogen exposure in loose-housed sows warrants follow-up study on a larger scale with pathogens that are of interest to producers and veterinarians. It is likely that the exact duration of contact time with the ice block required to successfully expose a sow to a pathogen will depend upon both the infectivity and concentration of the specific pathogen. In most current feedback programs, the exact concentration of pathogen in the exposure material is often poorly understood. Unlike sows in gestation stalls, loose-housed sows are at much greater risk for lateral transmission of pathogens used for controlled exposure between sows, and thus 100% exposure to the ice blocks may not be required to achieve good herd immunity. It should also be noted that the possibility for lateral transmission has the potential to confound subsequent studies designed to understand the impact of ice exposure and development of immunity in individual animals. In this case, gestating sows were housed in a large dynamic pen and fed via ESF. Several other types of pen gestation are in use, and additional studies would be required to understand how sows in other types of loose housing interact with ice blocks.

Implications

- Under conditions similar to those in this study, over 50% of loose-housed sows in a given pen may interact with an ice block over the course of an hour. More ice blocks would be expected to increase the number of sows contacting the ice and the duration of contact, and decrease the amount of aggression.
- On the basis of the outcome of this study, ice has the potential to be a convenient vehicle for exposing sows to on-farm pathogens, but further study is warranted to better understand how effective pathogen exposure will be using this method.

Conflict of interest

None reported.

Disclaimer

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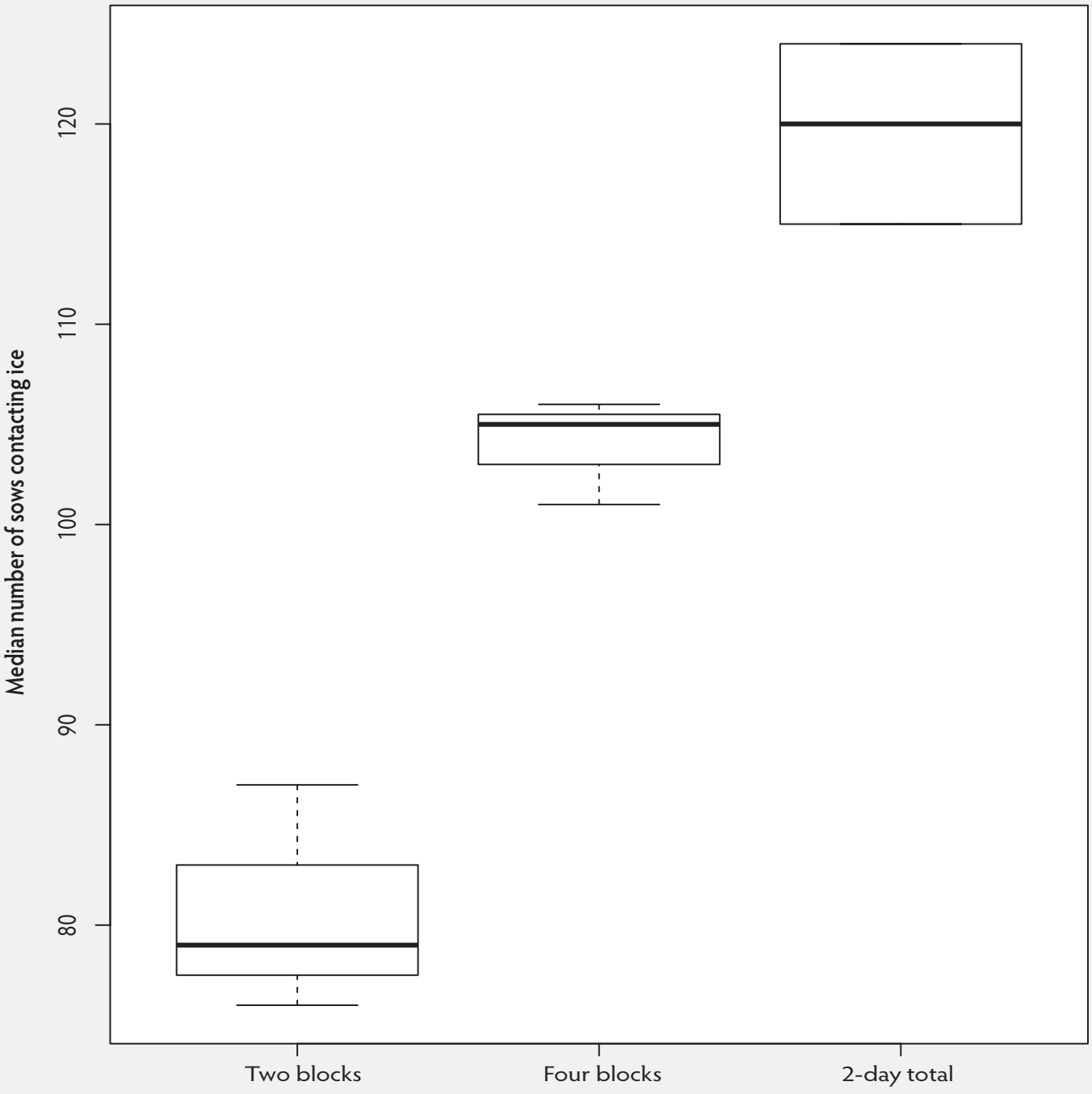
Figure 2: Boxplot of the median number of sows that contacted an ice block on days where there were two blocks (n = 3), compared to days where there were four blocks (n = 3), as well as the 2-day total of unique sows to interact with the blocks (study described in Figure 1 and Table 1).



or the practice of veterinary medicine in their country or region.

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Conversion tables

Weights and measures conversions

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

Temperature equivalents (approx)

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

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

Conversion chart, kg to lb (approx)

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

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

Methods and processes of developing the Strengthening the Reporting of Observational Studies in Epidemiology – Veterinary (STROBE-Vet) statement

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Abstract

Background: Reporting of observational studies in veterinary research presents challenges that often are not addressed in published reporting guidelines.

Objective: To develop an extension of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement that addresses unique reporting requirements for observational studies in veterinary medicine related to health, production, welfare, and food safety.

Design: Consensus meeting of experts.

Setting: Mississauga, Canada.

Participants: Seventeen experts from North America, Europe, and Australia.

Methods: Experts completed a pre-meeting survey about whether items in the STROBE statement should be added to or modified to address unique issues related to observational studies in animal species with health, production, welfare, or food-safety outcomes. During the meeting, each STROBE item was discussed to determine whether or not re-wording was recommended and whether additions were warranted. Anonymous voting was used to determine consensus.

Results: Six items required no modifications or additions. Modifications or additions were made to the STROBE items 1 (title and abstract), 3 (objectives), 5 (setting), 6 (participants), 7 (variables), 8 (data sources-measurement), 9 (bias), 10 (study size), 12 (statistical methods), 13 (participants), 14 (descriptive data), 15 (outcome data), 16 (main results), 17 (other analyses), 19 (limitations), and 22 (funding).

Conclusion: The methods and processes used were similar to those used for other extensions of the STROBE statement. The use of this STROBE statement extension should improve reporting of observational studies in veterinary research by recognizing unique features of observational studies involving food-producing and companion animals, products of animal origin, aquaculture, and wildlife.

Keywords: reporting guidelines, veterinary, observational study, animal

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Resumen - Métodos y procesos para desarrollo el Fortalecimiento de Reporte de Estudios Observacionales en Epidemiología – Veterinaria (STROBE-Vet por sus siglas en inglés)

Antecedentes: El reporte de estudios observacionales en la investigación veterinaria presenta retos que con frecuencia no son enfrentadas en las normas publicadas de reporte.

Objetivo: Desarrollar una extensión de la declaración de STROBE (Fortalecimiento del Reporte de Estudios Observacionales en Epidemiología) que se refiere a los requerimientos únicos de reporte para estudios observacionales en medicina veterinaria relacionados con la salud, producción, bienestar, y seguridad alimenticia.

Diseño: Reunión de consenso de expertos.

Escenario: Mississauga, Canadá.

Participantes: Diecisiete expertos de Norte América, Europa, y Australia.

Métodos: Los expertos realizaron un estudio pre-reunión para determinar si los puntos en la declaración STROBE deberían aumentarse o modificarse para tratar asuntos específicos relacionados con estudios observacionales en especies animales con resultados de salud, producción, bienestar, o seguridad

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Note: In order to encourage dissemination of the STROBE-Vet Statement, this article is published in the following journals: *Journal of Food Protection*, *Journal of Swine Health and Production*, *Journal of Veterinary Internal Medicine*, *Preventive Veterinary Medicine*, and *Zoonoses and Public Health*. The Explanation and Elaboration STROBE-Vet document for each checklist item is available in companion publications in *Journal of Veterinary Internal Medicine* and *Zoonoses and Public Health*. The original STROBE statement is published in the *Journal of Clinical Epidemiology* Web site (http://www.jclinepi.com), *Annals of Internal Medicine*, *BMJ*, *Bulletin of the World Health Organization*, *Epidemiology*, *The Lancet*, *PLoS Medicine*, and *Preventive Medicine*.

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

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alimentaria. Durante la reunión, se discutió cada punto de STROBE para determinar si se recomendaba o no la enunciación, y si se justificaban las extensiones. Se utilizó el voto anónimo para determinar el consenso.

Resultados: Seis puntos no necesitaron modificación ni adiciones. Se hicieron modificaciones o extensiones a los puntos de STROBE 1 (título y resumen), 3 (objetivos), 5 (escenario), 6 (participantes), 7 (variables), 8 (fuentes de información, medidas), 9 (parcialidad), 10 (tamaño de estudio), 12 (métodos estadísticos), 13 (participantes), 14 (información descriptiva), 15 (información resultante), 16 (resultados principales), 17 (otros análisis), 19 (limitaciones), y 22 (financiamiento).

Conclusión: Los métodos y procesos utilizados fueron similares a aquellos utilizados para otras extensiones de la declaración STROBE. El uso de esta extensión de la declaración STROBE debería mejorar el reportaje de estudios observacionales en la investigación veterinaria al reconocer las características únicas de los estudios observacionales que involucran animales de producción de alimentos y de compañía, productos de origen animal, acuacultura, y fauna salvaje.

Résumé - Méthodes et procédures pour développer le renforcement du rapportage d'études observationnelles en épidémiologie – Déclaration vétérinaire (STROBE-Vet)

Préambule: Rapporter des études observationnelles en recherche vétérinaire présente des défis qui sont souvent non discutés dans les directives de publication.

Objectif: Développer un ajout à la déclaration STROBE qui vise uniquement les exigences de publication pour des études observationnelles en médecine vétérinaire reliées à la santé, la production, le bien-être, et l'innocuité alimentaire.

Design: Rencontre de consensus d'experts.

Localisation: Mississauga, Canada.

Participants: Dix-sept experts provenant d'Amérique du Nord, d'Europe, et d'Australie.

Méthodes: Les experts ont complété un sondage pré-rencontre à savoir si des items dans la déclaration STROBE devraient être ajoutés ou modifiés pour ne viser que les sujets uniques aux études observationnelles chez des espèces animales avec des résultats en santé, production, bien-être, ou innocuité alimentaire. Durant la rencontre, chaque item STROBE était discuté afin de déterminer si une réécriture était recommandée et si des ajouts étaient requis. Un vote anonyme était utilisé pour déterminer un consensus.

Résultats: Six items n'ont requis aucune modification ou addition. Des modifications ou ajouts ont été faits aux items 1 (titre et résumé), 3 (objectifs), 5 (réglage), 6 (participants), 7 (variables), 8 (mesures des sources de données), 9 (biais), 10 (taille de l'étude), 12 (méthodes statistiques), 13 (participants), 14 (données descriptives), 15 (données sur les résultats), 16 (résultats principaux), 17 (autres analyses), 19 (limitations), et 22 (trouvailles).

Conclusion: Les méthodes et processus utilisés étaient similaires à ceux utilisés pour d'autres ajouts à la déclaration STROBE. L'utilisation de cet ajout à la déclaration STROBE devrait améliorer le rapportage d'études observationnelles en recherche vétérinaire en reconnaissant les caractéristiques uniques d'études observationnelles impliquant des animaux de rente et des animaux de compagnie, des produits d'origine animale, l'aquaculture, et la faune.

Observational studies are a common methodological approach in veterinary research and have been used to estimate the frequency of a disease or condition, test hypotheses, generate new hypotheses, or generate data suitable as input for systematic reviews and meta-analyses, risk assessments, and other data-dependent models, such as mathematical and simulated disease models. Thus, observational studies may be used to estimate the prevalence or incidence of a condition, to investigate the distribution of conditions in time and space, to explore risk factors and compare management options, to create explanatory models, or to evaluate diagnostic test accuracy. Comprehensive and transparent reporting of an observational study's design, execution, and results is essential for the interpretation of the research in terms of evaluating its applicability for the reader and its potential for bias and for the data to be used as input for other studies, such as meta-analyses and risk assessments. The peer-review process also benefits from guidelines describing appropriate reporting. In human healthcare, inadequacies in reporting of key information in observational studies have been documented.[1-3] Although there is less documented empirical evidence of deficiencies in reporting observational studies in veterinary medicine, absence of evidence is not evidence of absence. Indeed, some evidence of inadequate reporting exists in the literature on pre-harvest food safety.[4]

The STROBE statement (**www.strobe-statement.org**) was developed to provide guidance for reporting observational studies related to human health. It consists of a 22-item checklist that is accompanied by a document describing the development of the STROBE statement[5] and an elaboration document that provides explanations of each item, as well as examples of complete reporting of each item.[6] The STROBE guidelines focus on cohort, case-control, and cross-sectional studies of aspects of human medicine and public health, although many of the principles also apply to other observational study designs, such as hybrid designs or ecological studies. The STROBE statement has been modified for use in specific content areas within epidemiology, including genetic-association studies (STREGA),[7] molecular epidemiology (STROBE-ME),[8] and molecular epidemiology for infectious diseases (STROME-ID).[9]

Some nuances of conducting and reporting studies in animal populations are unique from other areas of epidemiology.[10] Thus, the CONsolidated Standards Of Reporting Trials (CONSORT) statement for reporting randomized controlled trials in human medicine[11]was previously modified for use in veterinary medicine. The result was the creation and publication of the reporting guidelines for randomized controlled trials for livestock and food safety (REFLECT) statement[12,13] Similarly, while the STROBE statement and the accompanying elaboration document provide an excellent resource for conducting, reporting, and reading observational studies, modifications to address specific issues in veterinary medicine will increase its applicability in this field.[10]

Here, we describe the methods and processes used to develop an extension of the STROBE statement that forms the basis for standardized reporting guidelines for observational studies in veterinary medicine (STROBE-Vet). As a separate companion paper, the STROBE-Vet Explanation and Elaboration document[14, 15] provides the methodological background for the items contained in the STROBE-Vet statement, as well as illustrative examples of appropriate reporting. We strongly recommend that the STROBE-Vet checklist be used in conjunction with the explanation and elaboration document for all observational studies related to animal-health, production, welfare, or food-safety outcomes.

Methods

The process for extending reporting-guideline statements (eg, STROBE and CONSORT) to meet the specific needs of individual disciplines has been documented.[16, 17] We used these reports to design the approach used for developing the statement reported herein.

Steering committee

A steering committee was responsible for development of the revised veterinary extension of the STROBE statement. This group, comprising four members (co-authors JMS, AMOC, HNE, and IRD), first met to discuss the idea in December 2012. The committee agreed to explore the need for modifying the original STROBE statement and to use the approach reported previously as a guideline for the modification.[17] The committee secured funding for the project, identified potential participants, invited the potential participants to attend a consensus meeting, organized the meeting, and was responsible for subsequent steps involved in preparation and publication of the papers as detailed below.

Funding

Funding was required to cover the costs of the consensus meeting (eg, travel, accommodations, and meeting rooms). The decision was made by the steering committee not to seek funding from pharmaceutical or biological companies commonly associated with veterinary research. Efforts to obtain funding were limited to not-for-profit non-government organizations, academic institutions, and a publishing company. Funding was received from the Canadian Association for Veterinary Epidemiology and Preventive Medicine, the Centre for Veterinary Epidemiology at the University of Prince Edward Island, the Centre for Public Health and Zoonoses at the University of Guelph, Iowa State University, Cornell University, and the publishing company VER Inc, Prince Edward Island, Canada. Sufficient funds were obtained to pay for all local expenses for the participants at the consensus meeting. Funds to cover travel costs for participants were not obtained; therefore, in general, participants fully funded their own travel and the sources of these funds were not identified.

Identification of participants

The committee's aim was to bring together a group of experts familiar with the design, conduct, and statistical analysis of observational studies concerning animal health, production, welfare, and food safety. Another aim was to include researchers with experience in a wide variety of areas, including food-animal production, companion-animal medicine, veterinary public health, and food safety. Representation from multiple countries was sought, with an effort to include several participants with relevant editorial experience.

The steering committee decided to limit the size of the meeting to approximately 20 participants, including the four committee members. The size limitation was based on funding and the need for a group size that facilitated interaction and active discussion. The steering committee identified experts for invitation on the basis of areas of expertise (many with multiple areas) and geographic locations. Invitations to attend the meeting were sent via e-mail by JMS to the first 20 individuals on the list. The e-mail invitation requested that individuals wishing to participate commit to a) completing a pre-meeting survey to determine whether modifications to the checklist items of the STROBE statement seemed necessary for veterinary medicine, and if so, to suggest appropriate modifications; b) attending a consensus meeting in Mississauga, Canada; and c) self-funding their travel to that meeting. If an initial invitation was declined, an alternative individual with similar expertise and from the same geographic region was contacted using the same e-mail invitation.

The steering committee also contacted the authors of the original STROBE statement papers to inform them of our interest in modifying the STROBE statement and to solicit support for, and participation in, the initiative.

Identification of specific issues

Using the approach described previously,[17] a survey was sent to the invitees soliciting input on each checklist item in the STROBE statement to improve relevance to observational studies related to animal health, production, welfare, and food safety. The intent of this survey was to guide discussion at the consensus meeting; thus, human ethics approval was not required. The survey was sent by e-mail as a spreadsheet attachment to the invitees, as well as to individuals who were invited but were unable to attend the meeting and had indicated that they still wished to provide input by completing the survey. The survey included the 22 items of the STROBE statement and asked the respondents to indicate if each item should be modified (yes or no), and if yes, to describe the modifications that the respondent felt would be appropriate. At the end of each section (abstract, introduction, methods, results, discussion, and conclusion), space was provided for the respondents to propose additional items of relevance for reporting on studies related to animal health, production, welfare, or food safety.

After the surveys were returned, the responses for each checklist item were anonymously compiled.

The consensus meeting

A 2½-day consensus meeting was held on May 11-13, 2014, in Mississauga, Ontario, Canada, with a total of 17 participants from Australia, Canada, Denmark, the United Kingdom, and the United States of America, as well as two assistants for logistical support and documentation. Prior to the meeting, participants were provided with an electronic copy of the STROBE statement[5] and its elaboration document,[6] as well as the results of the survey. At the meeting, participants were provided with the same materials in printed form.

The meeting began with an evening session consisting of introductions, an overview presentation on reporting guidelines in general and their relevance to veterinary medicine, and a discussion of the format for the meeting, the scope of the initiative, and the expectations of the participants in the guideline-development process. This included a discussion and vote on the approach that would be used to reach consensus. To facilitate confidential voting and recording of the voting results throughout the meeting, electronic remote voting devices were used. Three voting criteria were discussed as indicators of consensus: unanimous agreement among the 17 experts minus two (88%), minus three (82%), or minus five (70%). The participants agreed that a unanimous vote minus three persons would be required for consensus. In some instances, experts would leave the room for brief periods. In this case, at least 16 experts had to participate in each vote, with unanimous vote minus three still defining consensus.

At the start of the first full day of discussion, two of the authors of the STROBE statement papers (Myriam Cevallos and Matthias Egger) attended by teleconference.

They provided an overview of the process for developing the STROBE statement, common uses and misuses, and a discussion of STROBE statement extensions.

For the remainder of the meeting, the following approach was used for the STROBE statement checklist items 1 through 22. Initially, the moderator described the item, the key elements of that item as presented in the STROBE elaboration document, and the suggestions from the pre-meeting survey for modifying that item. The discussion sessions were moderated alternately by one of two members of the steering committee (JMS and AMOC). The moderator facilitated a group discussion of the key elements, including a discussion as to whether the proposed modifications should result in modification of the wording of the STROBE item. Following the discussion, participants (including both moderators) voted to accept or reject the modifications to the wording of the statement item. If no modifications were proposed, the vote was to accept the item as originally written. If an item received sufficient votes to indicate consensus, it was accepted. If the item did not receive a consensus vote, it was tabled for further discussion at the end of the meeting. After completion of voting on each item, the key elements that should be considered within the elaboration document were discussed. Participants were also asked to provide written suggestions for discussion points to include in the elaboration document. Two non-voting assistants served as record keepers to record the results of the voting, take notes of the discussion, and collect additional written suggestions on each item from the participants.

Preparation of reporting guidelines

After the meeting, the steering committee compiled a draft report that included the proposed modifications to the STROBE statement, a summary of the suggestions for the elaboration document, and a request for feedback from the participants. The steering committee collated the comments and suggested revisions, and developed the modified STROBE statement for observational studies in veterinary medicine related to animal health, production, welfare, or food-safety outcomes. A draft of the STROBE-Vet statement was previewed by graduate students (details provided in the Results section). A draft of the elaboration document was then prepared by the steering committee and circulated among the participants for input.

Results

In total, 23 experts were invited to participate in the consensus meeting and 14 accepted, though one invitee was subsequently unable to attend. The nine individuals who declined had other commitments, including teaching obligations during the time of the consensus meeting. All four steering committee members attended for a total of 17 participants. The methodological expertise of the participants included epidemiology, statistics, systematic review and meta-analysis, and risk assessment, with content expertise in food safety, health, production, and welfare in food-producing, companion, or recreation animals (eg, dogs, cats, and horses), aquaculture, and wildlife. The group comprised seven individuals working in Canada, five from the United States, four from Europe, and one from Australia. There were 13 academicians, three emeritus academicians, and one government employee. Members of the STROBE group were consulted throughout the process, and two members (Myriam Cevallos and Matthias Egger) participated in the first morning of the consensus meeting.

Nineteen pre-meeting surveys were completed by 12 of the 13 invitees, all four steering committee members, and three additional individuals who were invited to the consensus meeting but were unable to attend. The individual who accepted the invitation but was subsequently unable to attend the meeting did not complete the pre-meeting survey.

The participants agreed that the scope would include observational studies using samples or information of animal origin with outcomes related to animal health, production, welfare, or food safety. This wording was meant to encompass a broad range of veterinary research involving animals (including animal populations such as herds, farms, or flocks), products of animal origin (such as meat or milk), or samples from animals (such as blood or feces). Studies involving human-health outcomes related to animal exposure were considered outside the scope of this initiative. For these studies, the original STROBE statement would be the appropriate guideline to use.

The participants agreed that the scope would include both observational studies of hypotheses (hypothesis-driven or hypothesis-generating) and population-based descriptive studies, such as those estimating the frequency and distribution of disease. At least in the pre-harvest food-safety literature, it is common for disease-frequency estimates to be a key component of observational studies.[4]

The majority of items (whether modified or not) received a consensus vote the first time that a vote was undertaken. Consensus was not achieved on the first vote for two items: item 4 and item 9. For item 4, the discussion revolved around whether the "key elements" of study designs should be explicitly included in the item itself. For item 9, the discussion pertained to whether euthanasia represented a distinct source of bias (further discussion described below).

To meet the needs for a STROBE statement for observational studies in veterinary research, the consensus was that the following 16 items on the STROBE checklist needed modification to make them more appropriate for veterinary medicine: 1 (title and abstract), 3 (objectives), 5 (setting), 6 (participants), 7 (variables), 8 (data sources/measurement), 9 (bias), 10 (study size), 12 (statistical methods), 13 (participants), 14 (descriptive data), 15 (outcome data), 16 (main results), 17 (other analyses), 19 (limitations), and 22 (funding) (Table 1). The participants identified modification of these items as essential to the STROBE-Vet statement checklist, rather than solely having these issues discussed in the elaboration document.

Some proposed modifications to the STROBE statement were minor wording changes intended to provide more details for the veterinary community. For example, item 1b (abstract) was modified to include what the participants identified as key components of an "informative and balanced summary" (the wording used in the original STROBE statement).

Other modifications were more substantial. For instance, throughout the STROBE statement, reference is made to three common observational study designs (cohort, case-control, and cross-sectional), with the wording of some reporting recommendations different for the three designs. However, in veterinary medicine, many observational studies do not adhere strictly to one of these three classical designs, and large population cohort studies are rare. Therefore, the STROBE-Vet statement does not make reference to the three common observational study designs, but rather focuses on reporting the key features related to the observational research. This modification impacted items 1a, 6, 12, 14, and 15 (Table 1). An example of an addition is item 7 (variables), which now calls for specification of the putative causal structure

(with a causal diagram being highly encouraged) for all hypothesis-driven studies. Another example is item 8 (data sources), which now calls for information on questionnaire development (if relevant). Also, throughout the STROBE statement the word "participant" is used. In veterinary medicine, there generally are two components to the concept of "participant:" the owner or manager of the animals included in the study population and the animals themselves. Rather than modifying the wording for "participant" throughout the checklist, a footnote was added to note this point and to recommend that relevant information concerning both types of "participants" should be reported.

An issue that had relevance to several of the items was that of non-independence of observations (items 3, 5, 6, 7, 10, 12a, 13a, 13b, 13c, 14a, 14b, and 15). It is common in veterinary medicine, particularly in livestock and shelter medicine (where companion animals are kenneled), for animals to be housed or managed in groups. Individuals within groups will tend to be more similar to each other with respect to outcome status than to individuals in other groups, ie, non-independence of observational units. It is necessary to account for any non-independence of the observational units in the design, sampling strategy, and statistical analysis to avoid violating the assumption of independence underlying many statistical procedures. The non-independence of observational units may be hierarchical; for instance, animals within pens, pens within barns, barns within same-owner facilities. However, this is not always the case. For example, some organizational structures may not be purely hierarchical (eg, cross-classified data structures) and non-independence can also result from repeated samples taken over time from the same animal or facility.[18] To be consistent with the REFLECT statement[12,13] (**www.reflect-statement.org**), "organizational structure" was used rather than "hierarchy" throughout the STROBE-Vet statement. In addition to modifying the wording of relevant checklist items, the elaboration document includes discussion of this issue.

The final item in the STROBE checklist pertains to funding sources. The STROBE-Vet statement substantially expands this item to encompass the broader concept of "transparency." Using numbered sub-items, the transparency item addresses sources of funding, conflicts of interest, authors' roles, ethical approval (animal, human, or data use, as applicable), and the use of quality standards.

There was considerable discussion during the meeting on the significance of euthanasia in veterinary medicine. It is possible, and common under some disease or production circumstances, for animals to be euthanized or electively culled during studies. There is no equivalent to this in human medicine; therefore, much discussion was devoted to this topic. Although the participants agreed that the occurrence and frequency of euthanasia or culling should be reported in studies where it occurred, there were differing opinions as to whether euthanasia is a distinct issue related to the potential for information or selection bias, or whether it is just a component of a death or survival outcome that needs to be reported. At the end of the meeting, a vote was held, and the consensus was to include a discussion of euthanasia in the elaboration document, but not to modify the wording within the STROBE-Vet expansion.

The draft statement was previewed by 17 graduate students from two graduate-student journal clubs (Epidemiology Journal Club and Ruminant Group Journal Club) in the Department of Population Medicine at the University of Guelph. The students identified phrases for which they would like clarification or further explanation. Their comments were incorporated into the elaboration document.

Discussion

Here, the development of an extension to the STROBE statement for reporting observational studies in veterinary research is described. The intention of these guidelines, in concordance with the STROBE statement, is to provide guidance for authors when describing the design and results of observational studies. The guidelines are also useful for editors, peer-reviewers, and readers of observational-study reports. It is intended that these guidelines will be applicable to the broad range of research questions addressed in veterinary medicine using observational studies, including studies in which the objective was to describe disease occurrence, exploratory studies used to generate hypotheses, and hypothesis-driven studies. The guidelines are applicable to research conducted in both developed and developing nations. It is not the intention for these guidelines to be prescriptive regarding format or order of reporting on the basis of item number. The items in the STROBE-Vet expansion were ordered to correspond to the items in the STROBE statement, which follows the typical order of sections within a scientific manuscript. It is important that all of the relevant checklist items are addressed in sufficient detail within a manuscript.

The STROBE-Vet guidelines are also not intended to be prescriptive about the conduct of observational studies, but rather they focus on the clarity of reporting similar to that of the STROBE statement.[19] Likewise, the STROBE-Vet statement is also not intended to be used as a tool to assess the quality of the research design or execution.[5] Both the issue of prescriptive design and use for quality assessment have been identified in the literature as misuses of the STROBE statement.[20] There are several systematic reviews published on quality assessment tools for observational research.[21-23]

The guidelines presented herein represent the consensus of a group of individuals deemed to be experts in observational studies in veterinary research, and thus the results represent expert opinion. A systematic review of published literature was not conducted for any of the items, and published evidence was not always available to support modification to, or inclusion of, an item. The steering committee attempted to balance content expertise, and, to some extent, geographical location of the selected participants. However, the existing networks of the steering committee members influenced participant selection, the necessity for the experts to self-fund their travel resulted in a predominance of North American experts, and the steering committee members knew each other professionally prior to this initiative. Therefore, there is the potential for selection bias to have impacted our results. We expect that these guidelines will evolve over time and we welcome comments or suggestions. When used in conjunction with the Explanation and Elaboration document,[14,15] we expect that these guidelines will lead to improved reporting of observational research in veterinary medicine.

Participating members of the consensus meeting and steering committee

Steering committee

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Table 1: Modifications to the original STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement checklist for the STROBE-Vet statement*

	Item	STROBE recommendation	STROBE-Vet recommendation*
Title and Abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	(a) Indicate that the study was an observational study, and if applicable, use a common study design term
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	(b) Indicate why the study was conducted, the design, the results, the limitations, and the relevance of the findings
Introduction			
Background and Rationale	2	Explain the scientific background and rationale for the investigation being reported	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses	(a) State specific objectives, including any primary or secondary prespecified hypotheses or their absence
			(b) Ensure that the level of organization† is clear for each objective and hypothesis
Methods			
Study design	4	Present key elements of study design early in the paper	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	(a) Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
			(b) If applicable, include information at each level of organization
Participants‡	6	(a) **Cohort study**–Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	(a) Describe the eligibility criteria for the owners-managers and for the animals at each relevant level of organization
		Case-control study–Give the eligibility criteria and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	
		Cross-sectional study–Give the eligibility criteria and the sources and methods of selection of participants	
		(b) **Cohort study**–For matched studies, give matching criteria and number of exposed and unexposed	(b) Describe the sources and methods of selection for the owners-managers and for the animals at each relevant level of organization
		Case-control study–For matched studies, give matching criteria and the number of controls per case	
			(c) Describe the method of follow-up
			(d) For matched studies, describe matching criteria and the number of matched individuals per subject (eg, number of controls per case)

	Item	STROBE recommendation	STROBE-Vet recommendation*
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria if applicable	(a) Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. If applicable, give diagnostic criteria (b) Describe the level of organization at which each variable was measured (c) For hypothesis-driven studies, the putative causal-structure among variables should be described (a diagram is strongly encouraged)
Data sources, measurement	8§	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	(a) For each variable of interest, give sources of data and details of methods of assessment (measurement). If applicable, describe comparability of assessment methods among groups and over time (b) If a questionnaire was used to collect data, describe its development, validation, and administration (c) Describe whether or not individuals involved in data collection were blinded, when applicable (d) Describe any efforts to assess the accuracy of the data (including methods used for "data cleaning" in primary research, or methods used for validating secondary data)
Bias	9	Describe any efforts to address potential sources of bias	Describe any efforts to address potential sources of bias due to confounding, selection, or information bias
Study size	10	Describe how the study size was arrived at	(a) Describe how the study size was arrived at for each relevant level of organization (b) Describe how non-independence of measurements was incorporated into sample-size considerations, if applicable (c) If a formal sample-size calculation was used, describe the parameters, assumptions, and methods that were used, including a justification for the effect size selected
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why

	Item	STROBE recommendation	STROBE-Vet recommendation*
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	(a) Describe all statistical methods for each objective, at a level of detail sufficient for a knowledgeable reader to replicate the methods. Include a description of the approaches to variable selection, control of confounding, and methods used to control for non-independence of observations
		(b) Describe any methods used to examine subgroups and interactions	(b) Describe the rationale for examining subgroups and interactions and the methods used
		(c) Explain how missing data were addressed	(c) Explain how missing data were addressed
		(d) **Cohort study**–If applicable, explain how loss to follow-up was addressed **Case-control study**–If applicable, explain how matching of cases and controls was addressed **Cross-sectional study**–If applicable, describe analytical methods, taking account of sampling strategy	(d) If applicable, describe the analytical approach to loss to follow-up, matching, complex sampling, and multiplicity of analyses
		(e) Describe any sensitivity analyses	(e) Describe any methods used to assess the robustness of the analyses (eg, sensitivity analyses or quantitative bias assessment)
Results			
Participants	13§	(a) Report the numbers of individuals at each stage of study, eg, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	(a) Report the numbers of owners-managers and animals at each stage of study and at each relevant level of organization, eg, numbers eligible, included in the study, completing follow-up, and analyzed
		(b) Give reasons for non-participation at each stage	(b) Give reasons for non-participation at each stage and at each relevant level of organization
		(c) Consider use of a flow diagram	(c) Consider use of a flow diagram and (or) a diagram of the organizational structure
Descriptive data on exposures and potential confounders	14§	(a) Give characteristics of study participants (eg, demographic, clinical, social) and information on exposures and potential confounders	(a) Give characteristics of study participants (eg, demographic, clinical, social) and information on exposures and potential confounders by group and level of organization, if applicable
		(b) Indicate number of participants with missing data for each variable of interest	(b) Indicate number of participants with missing data for each variable of interest and at all relevant levels of organization
		(c) **Cohort study**–Summarize follow-up time (eg, average and total amount)	(c) Summarize follow-up time (eg, average and total amount), if appropriate to the study design
Outcome data	15§	**Cohort study**–Report numbers of outcome events or summary measures over time	(a) Report outcomes as appropriate for the study design and summarize at all relevant levels of organization
		Case-control study–Report numbers in each exposure category, or summary measures of exposure	(b) For proportions and rates, report the numerator and denominator
		Cross-sectional study–Report numbers of outcome events or summary measures	(c) For continuous outcomes, report the number of observations and a measure of variability

	Item	STROBE recommendation	STROBE-Vet recommendation*
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	(a) Give unadjusted estimates and, if applicable, adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders and interactions were adjusted. Report all relevant parameters that were part of the model
		(b) Report category boundaries when continuous variables were categorized	(b) Report category boundaries when continuous variables were categorized
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done, eg, analyses of subgroups and interactions, and sensitivity analyses	Report other analyses done, such as sensitivity/robustness analysis and analysis of subgroups
Discussion			
Key results	18	Summarize key results with reference to study objectives	Summarize key results with reference to study objectives
Strengths and limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discuss strengths and limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalizability	21	Discuss the generalizability (external validity) of the study results	Discuss the generalizability (external validity) of the study results
Other information			
~~Funding~~ Transparency	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	(a) Funding–Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (b) Conflicts of interest–Describe any conflicts of interest, or lack thereof, for each author (c) Describe the authors' roles–Provision of an author's declaration of transparency is recommended (d) Ethical approval–Include information on ethical approval for use of animal and human subjects (e) Quality standards–Describe any quality standards used in the conduct of the research

* Underlined text represents modifications or additions to the original STROBE wording.

† Level of organization recognizes that observational studies in veterinary research often deal with repeated measures (within an animal or herd) or animals that are maintained in groups (such as pens and herds); thus, the observations are not statistically independent. This non-independence has profound implications for the design, analysis, and results of these studies.

‡ The word "participant" is used in the STROBE statement. However, for the veterinary version, it is understood that "participant" should be addressed for both the animal owner-manager and for the animals themselves.

§ Give such information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

and Production Animal Medicine, Iowa State University, Ames, Iowa); Ian R. Dohoo (Department of Health Management, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, Prince Edward Island, Canada); and Hollis N. Erb (Department of Population Medicine and Diagnostic Sciences, Cornell University College of Veterinary Medicine, Ithaca, New York).

Meeting participants (in alphabetical order)

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STROBE participants at the veterinary workshop

Myriam Cevallos (Institute of Social and Preventive Medicine, University of Bern, Bern, Switzerland) and Matthias Egger (Professor of Epidemiology and Public Health, ISPM, University of Bern, Bern, Switzerland).

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Potential conflicts of interest

Jan M. Sargeant: No conflicts to declare.
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Ian R. Dohoo: No conflicts to declare.
Hollis N. Erb: No conflicts to declare.
Annette Ersbøll: No conflicts to declare.
S. Wayne Martin: No conflicts to declare.
Liza R. Nielsen: No conflicts to declare.
David L. Pearl: No conflicts to declare.
Dirk U. Pfeiffer: No conflicts to declare.
Javier Sanchez: No conflicts to declare.
Mary E. Torrence: No conflicts to declare.
Håkan Vigre: No conflicts to declare.
Cheryl Waldner: No conflicts to declare.
Michael P. Ward: No conflicts to declare.

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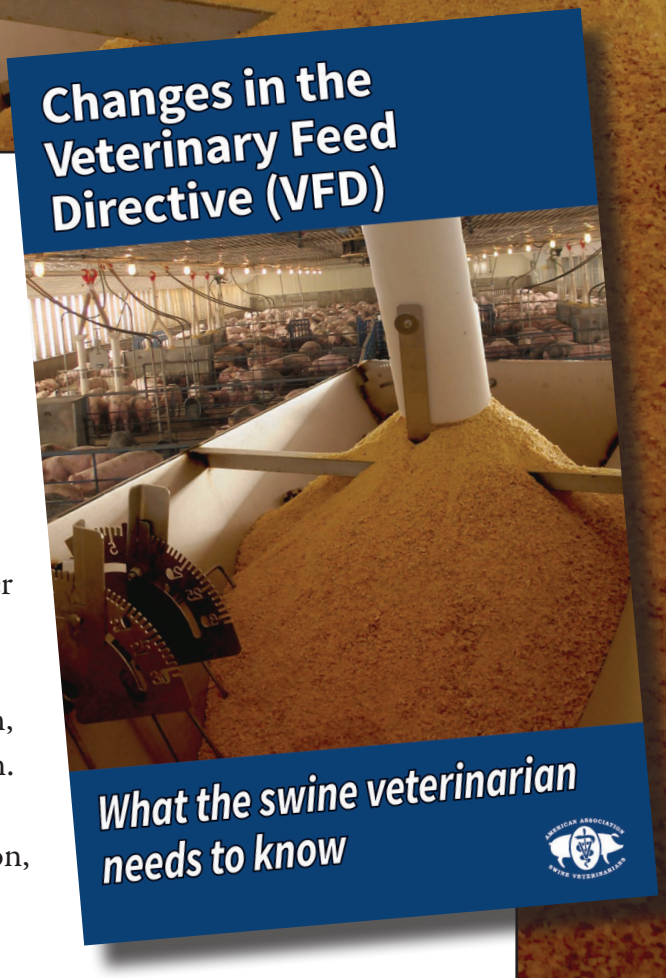
The US Veterinary Feed Directive (VFD) has changed



The new VFD regulation became effective October 1, 2015

The use of any feed-grade antimicrobial with a VFD label is now subject to the new regulation. This includes tilmicosin, florfenicol, and avilamycin, which are already VFD drugs labeled for use in swine.

Pharmaceutical manufacturers will transition other medically important, feed-grade antimicrobials to VFD labels by December 2016. Essentially all swine antibiotics will be affected, except bacitracin, carbadox, bambermycin, ionophores, and tiamulin. These antibiotics will remain available for growth promotion or over-the-counter (OTC) distribution, or both.

The AASV has prepared and mailed a brochure to all US members that highlights the responsibilities of the veterinarian issuing a VFD, the information required on a VFD, the need for a veterinary-client-patient relationship, and additional items of interest. The brochure is available online at **www.aasv.org/aasv/publications.htm**.

The AASV urges swine veterinarians to become familiar with the regulation, which is available – along with additional information and updates – on the FDA's Veterinary Feed Directive Web page: **http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm071807.htm**.

Extra-label use of feed-grade antimicrobials remains ILLEGAL.

Questions about VFDs?

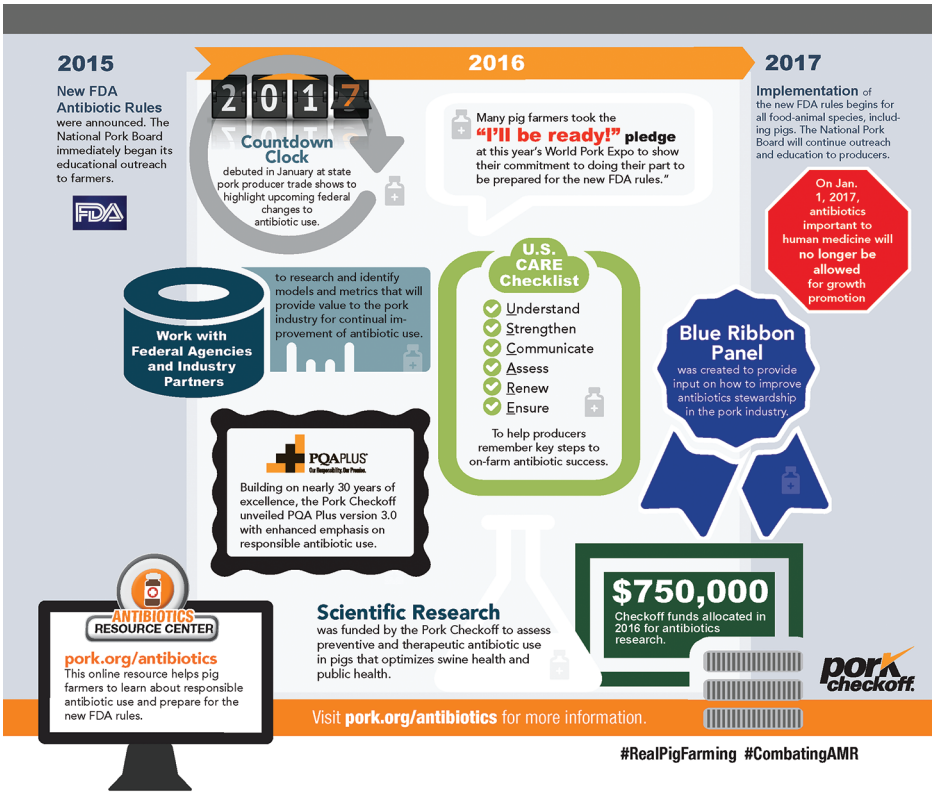
Contact:
AskCVM@fda.hhs.gov

Infographic highlights Pork Checkoff's 2016 Antibiotics Work

The National Pork Board is leading the conversation to combat antibiotic-resistant bacteria and preserve the responsible on-farm use of antibiotics in pork production. The Pork Checkoff, funded directly by America's 60,000 pig farmers, defined its three-point antibiotic stewardship plan in mid-2015 and has delivered on its pledge of promoting research, pig-farmer education, and consumer and influencer outreach during 2016. This infographic highlights that work.

For more information, contact Mike King at MKing@pork.org or 515-223-3532.

A recently created infographic helps to visually show the multifaceted approach taken by National Pork Board over the past 12 months on the antibiotics issue.



Bachmeier joins National Pork Board

Laura Bachmeier, who recently completed a Master of Science degree in meat science and muscle biology from North Dakota State University, has joined the National Pork Board as director of pork safety. Her master's research project focused on benchmarking pork quality at the retail level and in-laboratory from major retailers. As an undergraduate, the native Minnesotan held various swine-related internships, including those with Murphy-Brown LLC and Audubon Manning Veterinarian Clinic.

For more information, contact LBachmeier@pork.org.

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MERCK Animal Health

May I borrow a cup of data?

I have been involved in planning for and responding to animal-health disasters for much of my career as a veterinarian. My initial foray into large-scale disease response occurred in the early 1990s. I was tasked with responding to a classical swine fever outbreak in a large production facility in Mexico. There were initial struggles just to get an accurate diagnosis, followed by significant challenges associated with working with local and federal government agencies to develop and implement an eradication program.

My second major experience with disaster response occurred in the late 1990s. A series of damaging hurricanes and tropical storms hit eastern North Carolina. I remember well standing in a flooded field watching representatives of no fewer than six government agencies arguing over how to dispose of large numbers of livestock carcasses. Following these events, the North Carolina Department of Agriculture worked closely with the livestock industries and other government agencies to develop a strategy to address future large-scale animal disasters.

In 2001, I spent a month in Wales working with the United Kingdom's Ministry of Agriculture, Forestry and Fisheries (MAFF) to eradicate foot-and-mouth disease. The challenges evident in this response involved the ability to locate farms and manage the logistics associated with mass depopulations and disposal of carcasses incumbent when adopting a stamping-out response. This was my first experience with an animal disaster on a national scale, and it emphasized the need for rapid, efficient, real-time access to accurate data from producers, diagnostic laboratories, and government officials. MAFF, now the Department for Environment, Food and Rural Affairs, was actually well-prepared for locating farms. They had very effective mapping capabilities and a pre-existing premises and animal identification system. Much of the data transfer, however, was still conducted via phone and hardcopy.

There has been significant progress in planning and preparing for an animal-health emergency. The ability to efficiently transfer data between pertinent stakeholders, however, remains a significant weakness limiting our ability to rapidly respond and maximize business continuity. The recent outbreak of highly pathogenic avian influenza (HPAI) highlighted this gap. The size, design, and scope of modern animal agriculture in the United States necessitates the adoption of technology that enables real-time access to data housed in remote locations and in disparate databases. Sharing data by spreadsheet will significantly limit our ability to respond and ensure business opportunities remain for livestock producers.

The inability to access data as rapidly as we would like has previously been blamed on the fact that the technology was not available or not widely in use. Not so long ago, producers kept their records in a shoe box or filed documents with the government in hard copy. Lack of technology is no longer an acceptable excuse, however. Today, producers often keep and access records electronically.

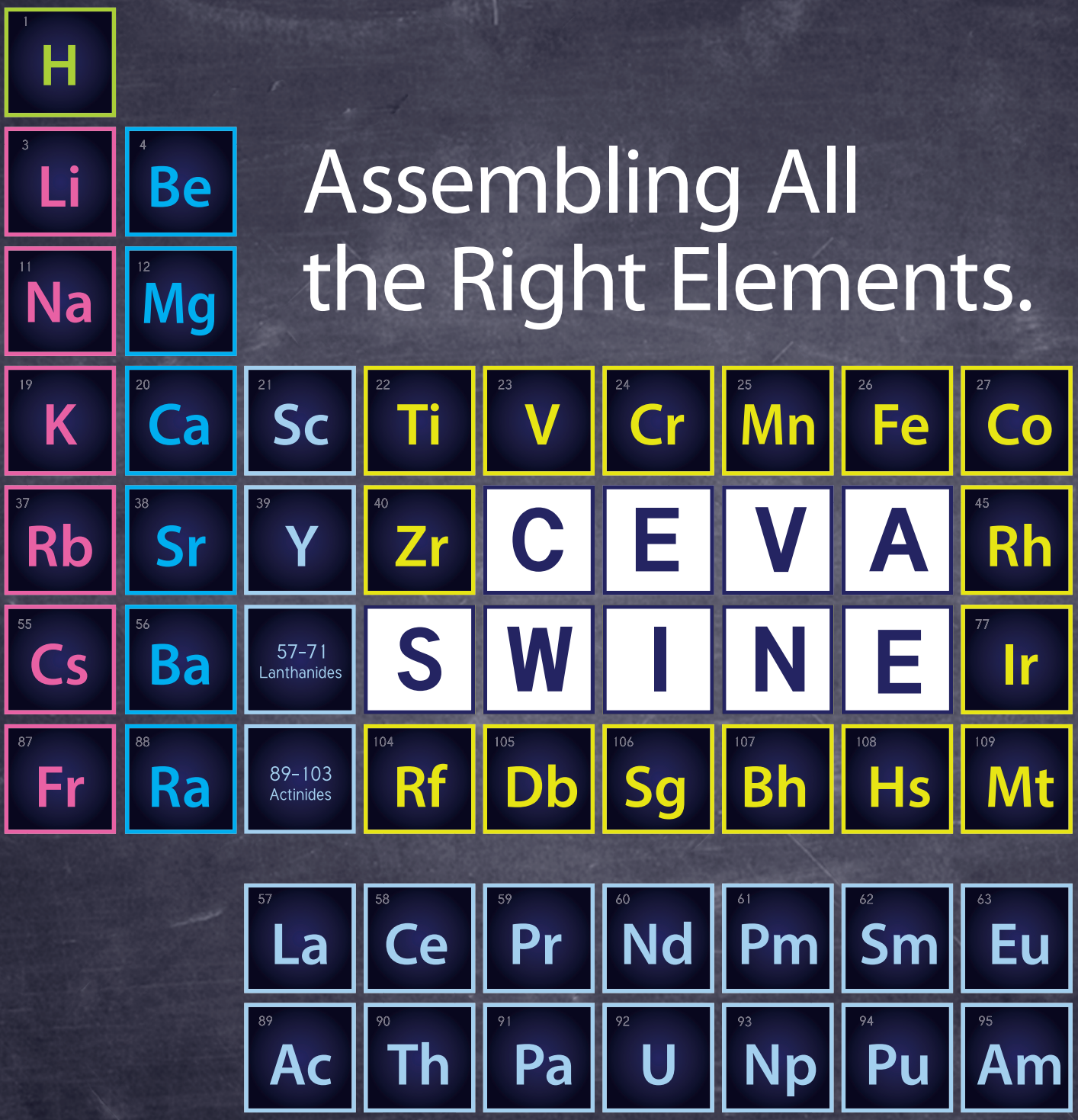
I recently had the opportunity to participate in two foreign animal disease response exercises. Both highlighted the need for timely and accurate data access and the technology available to achieve those goals. The impact on response associated with the ability to utilize technology to access and interpret data was also on display in the recent HPAI outbreak. The more efficiently and rapidly state and federal animal health officials can obtain needed data and respond to industry needs, the more effective the disaster response.

One of the exercises I participated in showcased the AgConnect technology developed at the Institute for Infectious Animal Diseases (IIAD) at Texas A&M University. This served as an example of the technological capabilities available to facilitate data access and analysis. AgConnect facilitates permissioned access to disparate databases (including producer, laboratory, transportation, government, etc) to allow for the visualization of the information necessary for disease control and permitted animal movements. Ownership and control of the data itself remains with the original owner and minimal resources are necessary on the part of the owner to facilitate the data connection. Utilization of this technology allows state and federal animal-health officials to work with real-time data on demand to make decisions regarding control zone placement, movement permitting for live animals and products, and laboratory updates on surveillance testing.

The IIAD exercise was particularly enlightening by demonstrating use of the technology to analyze routine production data in addition to emergency response. Dr Maryn Ptaschinski provided an overview of how veterinarians at JBS Pork routinely utilize the tool to better understand disease challenges. The ability to share production data such as diagnostic reports, animal movements, and mortalities in the format in which it is routinely collected greatly enhances the response efficiency during an animal-health emergency.

Although we have made progress, gaps still remain in our response capabilities and efficiency. We now have the technology available to close some of these gaps, particularly associated with data access and visualization. The challenge we face now is adoption of this technology and incorporating its use in our response planning. There is no reason producers, laboratories, and animal-health officials should not adopt this technology and remove the policy barriers preventing its widespread use. Experience has shown that when data can be readily accessed with minimal handling and manipulation, disease response efficiency and accuracy is markedly improved.

Harry Snelson, DVM
Director of Communications



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AASV NEWS

AASV awards nominations due December 15

Do you know an AASV member whose dedication to the association and the swine industry is worthy of recognition? The AASV Awards Committee requests nominations for the following five awards to be presented at the upcoming AASV Annual Meeting in Denver.

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

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

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

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

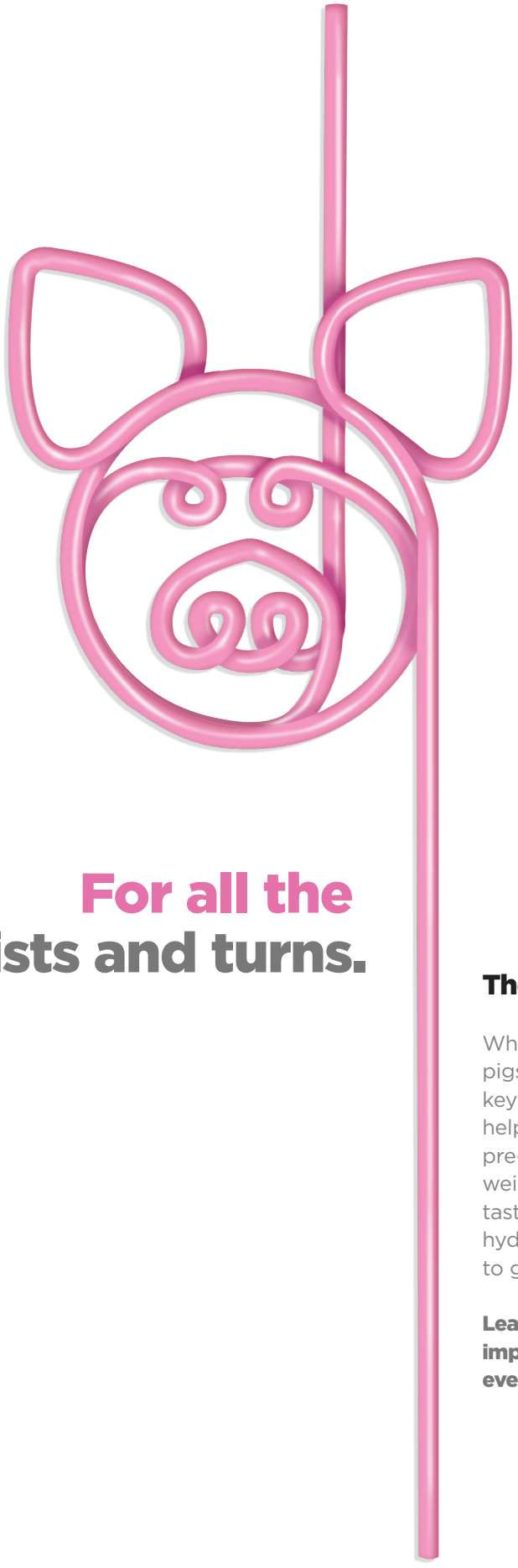
Young Swine Veterinarian of the Year – Given annually to a swine veterinarian who is an AASV member, 5 years or less post graduation, who has demonstrated the ideals of exemplary service and proficiency early in his or her career.

Nominations are due December 15. The nomination letter should specify the award and cite the qualifications of the candidate for the award. Submit to AASV, 830 26th Street, Perry, IA 50220-2328, Fax: 515-465-3832, E-mail: **aasv@aasv.org**.

VFD Frequently Asked Questions

As you know by now, the Food and Drug Administration (FDA) recently revised the regulations governing the Veterinary Feed Directive (VFD). The revised regulations went into effect in 2015, and all medically important feed-grade antibiotics will transition to VFD status by January 1, 2017. This transition has raised a lot of questions from stakeholders, which FDA has been attempting to answer. Unfortunately, the responses to these questions are found in a number of different places, including the FDA Web site, stakeholder Web sites, and academic Web sites, among others. The AASV has attempted to compile these responses into a "Frequently Asked Questions" page on our Web site for your convenience (**https://www.aasv.org/documents/vfdfaq.php**).

We will continue to update this page as FDA makes additional responses available. You can also pose additional questions to FDA at **AskCVM@fda.hhs.gov** to receive an official answer.



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AASV Annual Meeting Program
"One World, One Health, One Passion for Pigs"

SATURDAY, FEBRUARY 25

7:30 AM – 12:30 PM

Web-based PRRS risk assessment training for the breeding herd

8:00 AM

Entrance examination: American Board of Veterinary Practitioners, Swine Health Management

Pre-conference seminars

1:00 PM – 5:00 PM

Seminar #1:	AASV's got talent *Jeff Harker, chair*
Seminar #2	Influenza sequence analysis and phylogenetics *Phil Gauger, chair*
Seminar #3	Current topics of boar stud health, management, and technology *Ron Brodersen, chair*
Seminar #4	Biosecurity *Daniel Linhares, chair*
Seminar #5	Operation Main Street training *Al Eidson, chair*
Seminar #6	Antibiotic-free pork production *John E. Baker, chair*

SUNDAY, FEBRUARY 26

Canadian Association of Swine Veterinarians

Annual business meeting

8:00 AM – 12:00 noon

Pre-conference seminars

8:00 AM – 12:00 noon

Seminar #7	Electronic sow feeding from A to Z *Tom Parsons and Meghann Pierdon, co-chairs*
Seminar #8	The Common Swine Industry Audit: What you need to know *Monique Pairis-Garcia, chair*
Seminar #9	Diagnostics *Jane Christopher-Hennings, chair*
Seminar #10	Swine medicine for students *Jeremy Pittman and Angela Supple, co-chairs*
Seminar #11	Feed: Commanding new focus *Dwain Guggenbiller, chair*

Research topics

8:00 AM – 12:00 noon

Session chair: Chris Rademacher

8:00 AM	Land coverage and elevation as risk factors for PRRS outbreaks *Andreia Arruda*
8:15 AM	Broadly neutralizing antibodies to recent, virulent type 2 PRRSV isolates *Michael Murtaugh*
8:30 AM	Characterization of the memory immune response to PRRSV infection *Michael Rahe*
8:45 AM	Proof of concept: PRRSV IgM/IgA ELISA detects infection in the face of circulating maternal IgG antibody *Marisa Rotolo*

Current program information is online at https://www.aasv.org/annmtg

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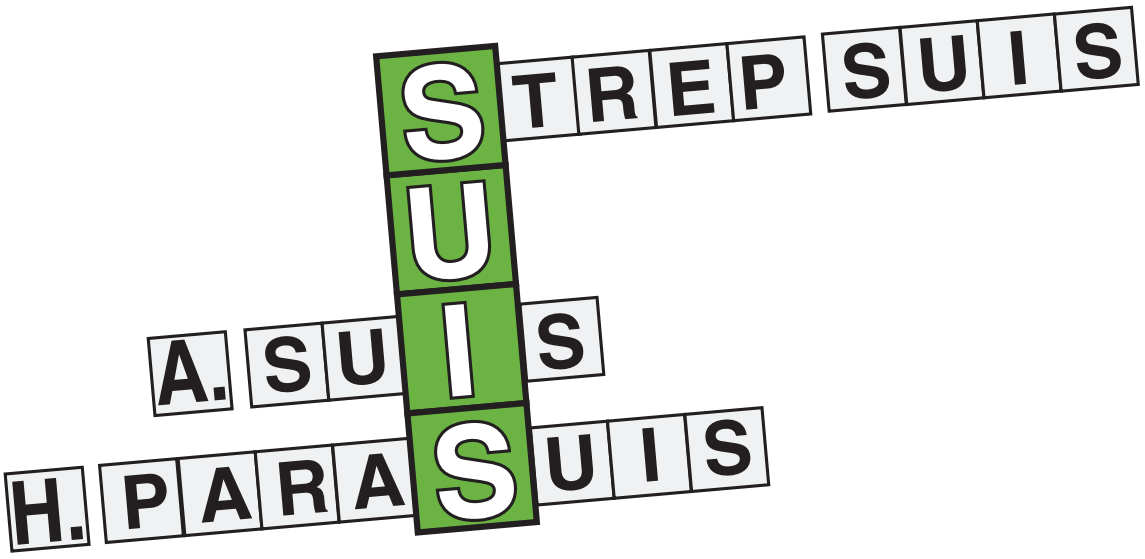

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9:00 AM	Spatial autocorrelation and implications for oral fluid-based PRRS surveillance *Marisa Rotolo*
9:15 AM	Comparative pathogenesis and characterization of contemporary 1-7-4 PRRSV isolates in weanling-age piglets *Albert Van Geelen*
9:30 AM	Application of next-generation sequencing technology to whole genome sequencing of PRRSV under diagnostic setting *Jianqiang Zhang*
9:45 AM	BREAK
10:00 AM	Effects of pain mitigation during piglet castration *Rachel Park*
10:15 AM	Effect of influenza prevalence at weaning on transmission, clinical signs and performance after weaning *Fabian Chamba Pardo*
10:30 AM	Senecavirus A: Overview of experimental studies *Alexandra Buckley*
10:45 AM	*Mycoplasma hyorhinis* associated with conjunctivitis in pigs *Talita Resende*
11:00 AM	*Mycoplasma hyorhinis* and *Mycoplasma hyosynoviae* dual colonization of dams and piglets prior to weaning *Luiza Roos*
11:15 AM	A commercial G2b-based porcine epidemic diarrhea virus vaccine is effective against homologous challenge but experimental G1b-based vaccines are not *Tanja Opriessnig*
11:30 AM	Serum and mammary secretion antibody responses in PEDV-exposed gilts following PEDV vaccination *Katie Woodard*
11:45 AM	Modeling the transboundary survival of foreign animal disease pathogens in contaminated feed ingredients *Scott Dee*
12:00 noon	Session concludes

Poster session: Veterinary Students, Research Topics, and Industrial Partners

12:00 noon – 5:00 PM

Poster authors present from 12:00 noon to 1:00 PM
Poster session continues on Monday, 9:00 AM to 5:00 PM

Concurrent sessions

1:00 PM – 5:15 PM

Session #1	**Student Seminar** *Maria Pieters and Andrew Bowman, co-chairs*
Session #2	**Industrial Partners**
Session #3	**Industrial Partners**
Session #4	**Industrial Partners**

MONDAY, FEBRUARY 27

General session: One World, One Health, One Passion for Pigs

8:00 AM – 12:15 PM

Program chair: Alex Ramirez

8:00 AM	**Howard Dunne Memorial Lecture** Swine medicine in the 21st century: Immovable object meets unstoppable force *Jeff Zimmerman*
9:00 AM	**Alex Hogg Memorial Lecture** One health: Roles, responsibilities, and opportunities for swine veterinarians *Matthew Turner*
10:00 AM	BREAK
10:30 AM	Canadian perspective on porcine epidemic diarrhea *Egan Brockhoff*
11:00 AM	Avian influenza: Lessons learned *Jill Nezworski*
11:30 AM	Consumers, pigs, vets, and zoonoses: The critical role you play in earning trust with consumers *J. J. Jones*
12:15 PM	LUNCHEON

Concurrent session #1: Swine Diseases

2:00 PM – 5:30 PM

Session chair: Kate Dion

2:00 PM	Opportunistic bacterial pathogens: Battles fought in daily practice *Cameron Schmitt*
2:30 PM	Batch farrowing for disease control *Elise Toohill*
2:45 PM	Determining optimum PRRSV management *Clayton Johnson*
3:30 PM	BREAK
4:00 PM	Emerging genetic strategies for disease control *Matt Culbertson*
4:30 PM	Swine Disease Matrix, rapid response, diagnostic fee support, and other progress from the Swine Health Information Center *Paul Sundberg*
5:00 PM	Experiences with FMD and CSF in Korea *Wonil Kim*
5:30 PM	Session concludes

Current program information is online at https://www.aasv.org/annmtg

Concurrent session #2: Antibiotics

2:00 PM – 5:30 PM

Session chair: Sam Holst

2:00 PM	Antibiotic resistance mechanisms *Randy Singer*
2:25 PM	Antibiotic use metrics *Peter Davies*
2:50 PM	Human models to reduce antibiotic use *Michael Sadowsky*
3:15 PM	BREAK
3:45 PM	Feed industry experience with implemented VFD rule *Richard Sellers*
4:05 PM	Practitioner experience with implemented VFD rule *Paul Ruen*
4:25 PM	GlobalVetLINK experience with implemented VFD rule *Tyler Holck*
4:45 PM	On-farm inspections and VFD pilot project *Michael Murphy*
5:05 PM	Roundtable Q&A *All speakers*
5:30 PM	Session concludes

Concurrent session #3: Managing the reproductive herd for high health and productivity

2:00 PM – 5:30 PM

Session chair: Tom Gillespie

2:00 PM	Economic impact: Fitness traits in post-weaning pigs and sows in lieu of genetic improvement in litter size and leanness *John Mabry*
2:30 PM	Semen supplier contributions to sow herd performance *Gary Althouse*
3:00 PM	A pig's early challenges *Maria Pieters*
3:30 PM	BREAK
4:00 PM	Considerations for batch production *Scanlon Daniels*
4:30 PM	Managing Danish nurseries in prolific sow herds with minimal antibiotic use *Michael Agerley*
5:30 PM	Session concludes

TUESDAY, FEBRUARY 28

General session: AASV's Stand: Control/ Elimination

8:00 AM – 12:00 noon

Session chair: Alex Ramirez

8:00 AM	Biosecurity: The strengths and weaknesses in our industry *Butch Baker*
9:00 AM	Practical PED elimination and surveillance: Quebec's experiences *Julie Menard*
9:45 AM	BREAK
10:15 AM	US swine industry structure and disease control: A "wicked" problem *Mike Lemmon*
11:00 AM	Voluntary regional PRRS control: Pitfalls and progress *Dave Wright*
11:45 AM	Discussion: What should AASV's stance be? *Moderated by Alex Ramirez*
12:00 noon	Session and meeting conclude

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Dr Jeff Zimmerman

Alex Hogg Memorial Lecture

Dr Matthew Turner

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FOUNDATION NEWS

Golfers tee off to support AASV Foundation

An overcast sky and comfortable temperatures provided enjoyable conditions for the 11 teams of golfers who participated in the 2016 AASV Foundation Golf Outing. The event was held August 25 at the Veenker Memorial Golf Course in Ames, Iowa. Top honors in the best-ball tournament went to the Boehringer Ingelheim Vetmedica team of Keith Bretey, Jeff OKones, Justin Rustvold, and Matt Sexton, with a score of 61. The second- and third-place teams were only three strokes behind, with matching team scores of 64. The Zoetis team, composed of AMVC veterinarians Josh Ellingson, Steve Schmitz, Paul Thomas, and Nick Weiss, took second place, while the Hog Slat foursome of Jim Crane, Chad Grouwinkel, Ryan Pudenz, and Fritz Richards secured third place overall.

The fundraising event benefited from the strong support of sponsors. Lunch was provided by APC, while Pharmgate Animal Health hosted the beverage cart to keep participants hydrated. Throughout the course, golfers enjoyed a variety of contests and giveaways offered by golf-hole sponsors Huvepharma, Insight Wealth Group, Merck Animal Health, Norbrook, NPPC, Phibro Animal Health, and Zoetis. To conclude the event, golfers enjoyed a smoked pork-loin dinner sponsored by Boehringer Ingleheim Vetmedica, while event coordinator Josh Ellingson recognized the following team and individual contest winners.

Championship flight

First place team hosted by Boehringer Ingelheim Vetmedica (score of 61): Keith Bretey, Jeff OKones, Justin Rustvold, Matt Sexton

Second place team hosted by Zoetis (score of 64): Josh Ellingson, Steve Schmitz, Paul Thomas, Nick Weiss

Third place team hosted by Hog Slat (score of 64): Jim Crane, Chad Grouwinkel, Ryan Pudenz, Fritz Richards

The team hosted by Boehringer Ingelheim Vetmedica, Inc took first place honors in the AASV Foundation golf outing with a score of 61. L to R: Justin Rustvold, Matt Sexton, Jeff OKones, Keith Bretey.

First flight

First place team hosted by Iowa State University Veterinary Diagnostic Laboratory (score of 68): Eric Burrough, Franco Matias Ferreyra, Adam Krull, Drew Magstadt

Second place team hosted by Fast Genetics (score of 68): Darrell Neuberger, Kent Schwartz, Steve Sornsen, Jeff Zimmerman

Third place team hosted by NPPC (score of 71): Jack Bair, Steph Carlson, Pete Houska, Greg Thornton

Second flight

First place team hosted by Phibro Animal Health (score of 71): Grant Weaver, Mark Weaver, Doug Weiss

Second place team hosted by Topigs Norsvin (score of 71): Mitch Christensen, Chelcee Hindman, Randy Leete, Adam Uittenbogaard

Third place team hosted by Merck Animal Health (score of 73): Jack Creel, Rick Sibbel, Michelle Sprague, Steve Sprague

Individual contests

Hole #3, Longest putt: Dan Rosener

Hole #5, Closest to the pin, 2nd shot: Mark Weaver

Hole #8, Closest to the pin: Chad Grouwinkel

Hole #9, Longest drive: Steph Carlson

Hole #12, Longest putt: Mitch Christensen

Hole #15, Closest to the pin, 2nd shot: Matt Sexton

Hole #17, Closest to the pin: Matt Sexton

Hole #18, Longest drive in fairway: Josh Ellingson

Aim for the Sky in the Mile High – Give generously in Denver!

What better place than Denver to support the AASV Foundation? Denver's beginnings were all about gold. In 1858, a small group of prospectors from Georgia discovered gold at the base of the Rocky Mountains. The gold rush that followed brought both prospectors and speculators to the area, and "Denver City" was born. After the Civil War, the discovery of silver brought a second onslaught of fortune seekers. With that history in mind, bring your own sacks of gold and silver to Denver and support the AASV Foundation! The AASV Foundation Auction Committee invites you to relax and enjoy the mountain scenery and vibrant way of life so evident in the Mile High City.

Please be generous investing in the future of the AASV. Our success depends on you, the membership, so help us put together another fun-filled auction night at our annual meeting. We are confident of our endeavor and the commitment of AASV members.

Donate auction item(s) by December 1

The committee is currently working on putting together donations, so make your commitments as soon as possible. If you have questions or just want to discuss possibilities, please contact any of the committee members. Download the donation form at **https://www.aasv.org/foundation/2017/Donationform.pdf** and submit a description and image of your item(s) by December 1. Your contribution will be recognized in the printed auction catalog as well as on the auction Web site, and your name will appear in the JSHAP full-page spread recognizing all of our auction-item donors. If that's not enough, there's a good chance Dr Harry Snelson will say something witty about your donation in the AASV e-Letter, too!

The AASV Foundation is committed to ensuring the future of the swine veterinary profession. Proceeds from the auction enable funding for AASV Foundation programs, including

- Administering endowments for the Howard Dunne and Alex Hogg Memorial Lectures
- Administering the Hogg Scholarship for a swine veterinarian pursuing an MS or PhD
- Administering funding for Veterinary Student Scholarships
- Scholarships for veterinarians pursuing board certification in the American College of Animal Welfare
- Co-sponsoring travel stipends for veterinary students attending the AASV Annual Meeting
- Providing swine externship grants to veterinary students
- Funding swine research with direct application to the profession
- Providing support for Heritage Videos
- Providing tuition support for out-of-state veterinary students to attend the Swine Medicine Education Center.

AASV Foundation Auction Committee

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Joe Connor
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$5000 scholarships available to sophomore and junior veterinary students

The AASV Foundation is pleased to announce that Merck Animal Health has renewed its support for the $25,000 AASVF-Merck Veterinary Student Scholarship Program. Now in its second year, the program seeks to identify and assist future swine veterinarians with their educational expenses. Applications are due December 31, 2016, for scholarships that will be awarded in early 2017.

Second- and third-year veterinary students enrolled in AVMA-accredited or -recognized colleges of veterinary medicine in the United States, Canada, Mexico, South America, or the Caribbean Islands are eligible to apply for one of five $5000 scholarships.

All applicants must be current (2016-2017) student members of AASV. To apply, students must submit a resume and the name of a faculty member or AASV member to serve as a reference, along with written answers to four essay questions. The application and instructions are available at **https://www.aasv.org/foundation/2017/AASVF-MerckScholarships.php**.

The selection process will be conducted by a committee of four, which includes two AASV Foundation Board members and two AASV members-at-large. On the basis of the submitted materials, the student applicants will be scored and ranked on their past and current activities, level of interest in swine veterinary medicine, future career plans, and financial need. The five scholarship recipients will be announced during the 2017 AASV Annual Meeting in Denver, and the scholarship funds will be disbursed in March, after the conference.

The AASVF-Merck Veterinary Student Scholarship Program provides yet another opportunity for the AASV Foundation to fulfill its mission of "supporting the development and scholarship of students and veterinarians interested in the swine industry." For more information on scholarships and other AASV Foundation programs, see **www.aasv.org/foundation**.

AASV Foundation news continued on page 341

One injection of EXCEDE® for Swine (ceftiofur crystalline free acid) treats and controls swine respiratory disease for 7 days. It continuously attacks a broad range of pathogens.* And EXCEDE is proven effective for both weaning and nursery—the 2 critical stages in a young pig's development. So you can have a healthy pig—and a healthy herd—for the long term.

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AASV Foundation news continued from page 339

Research proposals sought for funding in 2017

As part of its mission to fund research with direct application to the profession, the American Association of Swine Veterinarians Foundation seeks research proposals for funding in 2017. Proposals are **due January 16, 2017**, and may request a maximum of $30,000 (US$) per project. A maximum of $60,000 will be awarded across two or more projects. The announcement of projects selected for funding will take place at the AASV Foundation Luncheon in Denver, Colorado, on Sunday, February 26, 2017 (awardees will be notified in advance).

Proposed research should fit one of the five action areas stated in the AASV Foundation Mission Statement (see sidebar).

The instructions for submitting proposals are available on the AASV Foundation Web site at **https://www.aasv.org/foundation/2017/research.php**. Proposals may be submitted by mail or e-mail (preferred).

A panel of AASV members will evaluate and select proposals for funding, on the basis of the following scoring system:

* Potential benefit to swine veterinarians/swine industry (40 points)
* Probability of success within timeline (35 points)
* Scientific/investigative quality (15 points)
* Budget justification (5 points)
* Originality (5 points)

AASV Foundation Mission Statement

The mission of the American Association of Swine Veterinarians Foundation is 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.

For more information, or to submit a proposal:

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

Swine veterinarians invited to apply for Hogg Scholarship

The American Association of Swine Veterinarians Foundation is pleased to offer the Hogg Scholarship, established to honor the memory of longtime AASV member and swine industry leader Dr Alex Hogg. Applications for the $10,000 scholarship will be accepted until February 1, 2017, and the scholarship recipient will be announced on Sunday, February 26, during the Foundation Luncheon at the AASV 2017 Annual Meeting in Denver.

The intent of the scholarship is to assist a swine veterinarian in his or her efforts to return to school for graduate education (resulting in a master's degree or higher) in an academic field of study related to swine health and production.

Dr Alex Hogg's career serves as the ideal model for successful applicants. After 20 years in mixed-animal practice, Dr Hogg pursued a master's degree in veterinary pathology. He subsequently became Nebraska swine extension veterinarian and professor at the University of Nebraska. Upon "retirement," Dr Hogg capped off his career with his work for MVP Laboratories. Always an enthusiastic learner, at age 75 he graduated from the Executive Veterinary Program offered at the University of Illinois.

The scholarship application requirements are outlined below, and on the AASV Web site at **http://www.aasv.org/foundation/hoggscholarship.htm**.

Hogg Scholarship application requirements

An applicant for the Hogg Scholarship shall have

1. Five or more years of experience as a swine veterinarian, either in a private practice or in an integrated production setting; and
2. Five or more years of continuous membership in the American Association of Swine Veterinarians.

Applicants are required to submit the following for consideration as a Hogg Scholar:

1. Current curriculum vitae,
2. Letter of intent detailing his or her plans for graduate education and future plans for participation and employment within the swine industry, and
3. Two letters of reference from AASV members attesting to the applicant's qualifications to be a Hogg Scholar.

Applications and requests for information may be addressed to AASV Foundation, 830 26th Street, Perry, IA 50220-2328; Tel: 515-465-5255; E-mail: **aasv@aasv.org**.

Thank you, reviewers

Working together and creating a journal to be proud of!

The editorial staff of the Journal of Swine Health and Production *would like to acknowledge the invaluable assistance of the following individuals for their service as referees for the manuscripts that were reviewed between September 23, 2015, and September 22, 2016.*

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We apologize if we have inadvertently left a reviewer's name off the list.

Cumulative index

The *Journal of Swine Health and Production* cumulative index is updated online throughout the year as issues go to press. Articles can be accessed via the "Search" function and from the Abstracts page, **http://www.aasv.org/shap/abstracts/**.

Index by title 2016

* Corrected citation for the Perri et al erratum is *J Swine Health Prod*. 2016;24(1):10-20; † Corrected citation for the Scherba et al erratum is *J Swine Health Prod*. 2016;24(1):29-35; ‡ Corrected citation for the Greiner erratum is *J Swine Health Prod*. 2016;24(4):198-204.

Index by author 2016

* Corrected citation for the Greiner erratum is *J Swine Health Prod*. 2016;24(4):198-204; † Corrected citation for the Perri et al erratum is *J Swine Health Prod*. 2016;24(1):10-20; ‡ Corrected citation for the Scherba et al erratum is *J Swine Health Prod*. 2016;24(1):29-35.

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Web: http://register.extension.iastate.edu/swinedisease
Dr Chris Rademacher, Conference Chair
Iowa State University
E-mail: cjrdvm@iastate.edu

Passion for Pigs 2016 Seminar & Trade Show Tour

November 17-December 6, 2016 (Thu-Tue)

Here are the dates and locations for the 2016 tour series:

November 17 (Thurs)
Minnesota Swine Reproduction Center
Mankato, Minnesota

November 29 (Tues)
North Central Veterinary Services
Findlay, Ohio

December 6 (Tues)
Passion for Pigs
Columbia, Missouri

For more information:
Julie Lolli
Tel: 660-651-0570
E-mail: julie.nevets@nevetsrv.com
Web: http://www.passionforpigs.com

2016 North American PRRS Symposium (NA-PRRS) Emerging and Foreign Animal Diseases

December 3-4, 2016 (Sat-Sun)
Intercontinental Hotel and Downtown Marriott
Magnificent Mile in Chicago, Illinois

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

Banff Pork Seminar

January 10-12, 2017 (Tue-Thu)
Banff, Alberta, Canada

For more information:
Tel: 780-492-3651
E-mail: pork@ualberta.ca
Web: http://www.banffpork.ca

2017 Pig-Group Ski Seminar

February 8-10, 2017 (Wed-Fri)
Copper Mountain, Colorado

For more information:
Lori Yeske
Pig Group
39109 375th Ave
St Peter, MN 56082
Tel: 507-381-1647
E-mail: pyeske@swinevetcenter.com

American Association of Swine Veterinarians 48th Annual Meeting

February 25-28, 2017 (Sat-Tue)
Hyatt Regency Denver
Denver, Colorado

For more information:
American Association of Swine Veterinarians
830 26th Street
Perry, IA 50220-2328
Tel: 515-465-5255; Fax: 515-465-3832
E-mail: aasv@aasv.org

World Pork Expo

June 7-9, 2017 (Wed-Fri)
Iowa State Fairgrounds
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Hosted by the National Pork Producers Council

For more information:
National Pork Producers Council
10676 Justin Drive
Urbandale, IA 50322
Web: http://www.worldpork.org

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/

American Association of Swine Veterinarians
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A pair of spotted pigs in an Iowa barn

Photo courtesy of Tina Smith

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