Journal of
SWINE HEALTH & PRODUCTION
March and April 2020 • Volume 28, Number 2

Impact of weaning weight and early growth rate on nursery performance

Faccin JEG, Laskoski F, Cemin HS, et al

Effects of nutrient supplementation during a PRRSV infection

Colpoys JD, Curry SM, Schweer WP, et al

Retrospective investigation of Senecavirus A at a packing plant

Silva GS, Graham K, Novak V, et al

The Journal of the American Association of Swine Veterinarians

Journal of Swine Health and Production

(**ISSN 1537-209X**) Volume 28, Number 2; March and April 2020

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

Opinions expressed in this publication are those of the individual authors and do not necessarily reflect the endorsement, official attitude, or position of the American Association of Swine Veterinarians, the *Journal of Swine Health and Production*, or any Industry Support Council member.

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

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

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

DISCLAIMER

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

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

Download this issue to your iPad or Android tablet at
www.aasv.org/shap/issues/v28n2/v28n2jshap.pdf

Cover photo courtesy of Tina Smith.

AASV Resources online at aasv.org

Author guidelines
aasv.org/shap/guidelines

Journal of Swine Health and Production
aasv.org/shap

Membership information
aasv.org/aasv/membership

Subscription information
ecom.aasv.org/journal

Upcoming meetings
aasv.org/meetings

Table of contents

Errata ... 59

President's message ... 61

President-Elect's message ... 65

Executive Director's message ... 67

Executive Editor's message ... 69

Evaluating the impact of weaning weight and growth rate during the first week post weaning on overall nursery performance ... 70
Faccin JEG, Laskoski F, Cemin HS, et al

Nutrient supplementation effects on pig performance and sickness behavior during a porcine reproductive and respiratory syndrome virus infection ... 79
Colpoys JD, Curry SM, Schweer WP, et al

A retrospective investigation of risk factors associated with loads of pigs positive for Senecavirus A at a midwestern US packing plant during the summer of 2017 ... 87
Silva GS, Graham K, Novak V, et al

Conversion tables ... 93

News from the National Pork Board ... 95

AASV news ... 96

Advocacy in action ... 103

Upcoming meetings ... 107

Errata

In the article on page 12 of the January and February 2020 issue of the *Journal of Swine Health and Production* (Menegat et al), the citation was incorrectly reported as "*J Swine Health Prod*. 2019;28(1);12-20." The correct citation is *J Swine Health Prod*. 2020;28(1):12-20.

In the article on page 21 of the January and February 2020 issue of the *Journal of Swine Health and Production* (Free et al), the citation was incorrectly reported as "*J Swine Health Prod*. 2019;28(1);21-30." The correct citation is *J Swine Health Prod*. 2020;28(1):21-30.

Challenges and opportunities for the next decade

As we look forward to the next decade in 2020, I would like to offer some final thoughts regarding challenges and opportunities for the AASV in my final President's Message. Any confronting challenge is really an opportunity waiting to happen. Here are 3 areas of opportunity for our members and leadership going forward.

African swine fever

The swine industry's primary accomplishment over the last year was preventing African swine fever (ASF), or any other foreign animal disease, from entering the United States. This will also be our number one challenge in 2020 and beyond. The groundswell of activity and cooperation between government, industry, swine producers, and veterinarians over the last year has been exemplary – this hyper-vigilant attitude must continue. Even though ASF has now infected over 50 countries worldwide and has decimated approximately 25% of the world's pork supply, the risk of infecting North American swine has likely already peaked. While attending the Leman China Swine Conference last September, there was surprising optimism among China's swine industry that they have turned the corner in their fight for ASF control, as many farms were able to maintain ASF-negative pigs after cleaning, disinfecting, and proper down-time. A unique test-and-removal program called *tooth pull* showed promise due to quick clinical identification with pen-side polymerase chain reaction testing to allow for room or building elimination without entire farm depopulation methods. Although ASF vaccines were being used, they were not considered completely safe or effective, potentially causing more harm than good. Plum Island vaccinologists reported on a safe, efficacious gene-deleted Georgia 2 strain in early trials.[1] It will still take many years for China and Southeast Asian countries to rebuild their pork supply to previous levels, which could and should be a tremendous opportunity for the US pork export market.

Expanding on our current ASF active surveillance plan and determining better surveillance to enable early ASF detection is a paramount challenge. Identifying this lowly contagious, yet highly infectious virus before hundreds of farms are infected will enable a more rapid response and eventual eradication, if ASF were to occur. Our immediate opportunity is to enroll all our farms into the Secure Pork Supply Plan so each site is prepared for ASF and will allow for expeditious business continuity in case of an outbreak.

Swine welfare and you

Attending the 2nd biennial Pig Welfare Symposium in Minneapolis last November left me encouraged and optimistic for our swine industry's path forward with animal welfare. The AASV has at least 5 board certified members in the American College of Animal Welfare and a few more active residents. These scientists will be the animal welfare leaders for our industry and give us credibility and a voice regarding swine welfare with the American Veterinary Medical Association. The AASV, in collaboration with the US Food and Drug Administration, is also actively engaged in a pain mitigation research project to identify and validate objective standards to measure pain in pigs, and we look forward to the research results.

"Any confronting challenge is really an opportunity waiting to happen."

There are tremendous opportunities, and challenges, that exist for swine veterinarians at the grass-roots farm level regarding pig welfare:

Timely euthanasia. When to euthanize individual sick or lame pigs is very subjective and needs to be taught to our swine caretakers. Too many of these pigs are found during vet herd health checks that are either suffering, unresponsive to treatment and thus spreading disease, or of no economic value and should be humanely euthanized. It could be a subject for a subsequent welfare conference.

Disease elimination. Swine veterinarians inherently oversee swine welfare in our role of disease prevention, control, and treatment. We are experts at preventing and eliminating a plethora of serious pathogens such as porcine reproductive and respiratory syndrome, *Mycoplasma hyopneumoniae*, influenza A virus-swine, and yes, even ileitis. Our success is our client's success and it is just plain fun to witness the genetic potential of healthy, disease-free pigs.

Mortality is a welfare issue. When we examine industry benchmark records for mortality, 9.8% are stillborns, 17.8% occur preweaning, 4.8% occur in the nursery, and 5.2% occur in the finisher[2]. These are averages! There still can be 15% to 30% less mortality on half of our farms when we identify basic problems to save more pigs. What an opportunity for swine veterinarians.

No Antibiotics Ever or Raised Without Antibiotics systems. Our challenge with these systems is to provide professional oversight so that mortality and morbidity rates do not increase and that sick pigs are treated with antibiotics appropriately and sent to

President's message continued on page 63

President's message continued from page 61

another, often less economically lucrative, market. Our Veterinary Oath[3] requires us to "use our scientific knowledge and skills for the benefit of society through the protection of animal health and welfare, the prevention and relief of animal suffering,..." and is a powerful statement of our responsibility toward swine welfare that we must not forget.

Food insecurity and climate change

Food insecurity in developing countries and climate change are interrelated in as much as weather extremes, such as drought, effects poor countries more severely. The challenges of these issues are massive and on a global and existential scale. Brett Stuart explained at last year's AASV Annual Meeting that US pork is typically the most competitive in the world and there will be more mouths to feed. Global populations are rising by 78 million per year. Global incomes are rising and will pull nearly 3 billion people into the middle class from 2009 to 2030, creating rising demand for meat protein.[4] With increasing efficiencies and technology in pork production, pigs need to be reared in systems that promote animal welfare and minimize greenhouse gas (GHG) emissions and pollution. Ironically, although extensive systems might appear to be less taxing on the environment in relation to resource use, waste treatment, and GHG emissions, scientific analysis has shown that intensive systems can actually reduce these outputs.[5] Therefore, pork producers have the challenge to produce more pork to continue to feed a hungry world and the opportunity to do it in an environmental and welfare sustainable way. It is up to us to guide our clients in this endeavor.

Climate change is the greatest challenge and opportunity of our time. Let's all individually do something, take action, and do our part to mitigate this problem upon us. My personal example is that by investing in and utilizing alternative energy sources, 90% of the electric use for Swine Services Unlimited Inc's office and 122% of electric use for our research farm will be from solar energy by the end of 2020. This not only reduces my energy bill and income tax, it is also good for the planet by reducing GHG emissions and good for the economy. Minnesota is home to 61,000 clean energy jobs of which 3161 of these jobs are in the St Cloud area where I live.[6] This could be another opportunity for today's pig farmers to continue reducing their carbon footprint by switching to alternative and renewable energy sources. Opportunities and challenges abound for all of us.

Lastly, I consider myself blessed to be a veterinarian in this wonderful profession. Writing these messages was at times a bit painful for me because of my procrastiNATE nature, but in the end was a very rewarding experience. Thank you for the opportunity to serve the AASV in this capacity. It is an honor and privilege to be part of this great organization.

Nathan Winkelman, DVM
AASV President

References

1. Borca M, Medina ER, Silva E, Vuono E, Rai A, Pruitt S, Holinka L, Salinas LV, Zhu J, Gladue D. Development of a highly effective African swine fever virus vaccine by deletion of the I177L gene results in sterile immunity against the current epidemic Eurasia strain. bioRxiv. 2019. doi: https://doi.org/10.1101/86166

*2. Industry Benchmarks. Pork Checkoff website. https://www.pork.org/facts/stats/industry-benchmarks/#AverageWean-to-FinishProductivity. Published 2018. Accessed January 16, 2020.

*3. Nolen RS. Veterinarian's Oath revised to emphasize animal welfare commitment. AVMA website. https://www.avma.org/javma-news/2011-01-01/veterinarians-oath-revised-emphasize-animal-welfare-commitment. Published December 19, 2010. Accessed January 16, 2020.

*4. Stuart B. Landscape and outlook for US pork in the global markets. *Proc AASV*. Lake Buena Vista, FL. 2019:359-362.

*5. National Academies of Science, Engineering, and Medicine. *Science Breakthroughs to Advance Food and Agricultural Research by 2030*. Washington, DC: The National Academies Press. 2019:39.

*6. Mast G. Clean energy jobs, a St. Cloud success story. *St. Cloud Times*. December 22, 2019. https://www.sctimes.com/story/opinion/2019/12/22/clean-energy-jobs-st-cloud-success-story/2693111001/. Accessed January 16, 2020.

* Non-refereed references.

The adaptability strength

I am looking forward to seeing all my American Association of Swine Veterinarians (AASV) family at the Annual Meeting in Atlanta. As we prepared for this meeting it was mentioned several times that **if** a foreign animal disease comes to this continent, the Annual Meeting will need to have a lot of last-minute changes. Changes such as these require everyone involved to adapt to a new set of circumstances. Some people simply have more innate adaptability, but hopefully understanding how to better adapt to change will help us if the devastation of African swine fever (ASF) were to arrive on our shores.

Adaptability is 1 of 34 strengths in the Gallup StrengthsFinder personality survey.[1] Individuals strong in this trait easily adapt to change. They do this by being resourceful and having a strong will to face uncertainty. Change is stressful, adaptable people can use the pressure from the stress of change to produce their best work. Sometimes these individuals are viewed as procrastinators, but by waiting until the last minute the opportunity for further change is limited. With the threat of ASF being very real as we move into the next decade, excellent communication and planning will help decrease the stress that such a dramatic problem will present. Keeping an open mind to new solutions and methods to handle this new disease challenge will be important to the entire industry.

"In the end, change is inevitable, adaptable people and organizations will be the most successful if they readily accept change."

Successful businesses and organizations must also adapt to change over time. Sometimes even though the change is positive, there must be some adaptability to the new conditions. Instead of an individual being adaptable, the leadership of the group must think ahead and be willing to switch quickly to plan B when plan A doesn't work out. Over my career I have seen the swine industry adapt well to changes including sow housing, antibiotic use, market weights, technology, and new diseases. The next challenges are unknown at this point, but I am confident that our industry is well prepared to adapt as necessary to stay strong and continue to feed the world high quality protein.

The AASV has also adapted well to change in its 50-year existence. Most recently, the adaptation of electronic balloting has shown the willingness of our members and leadership to adopt new ideas and technologies. New technologies have allowed much more rapid communication with its members, embracing this change has helped AASV be successful. I am proud of the past AASV leadership for being forward thinkers and helping this organization adapt to change.

In the end, change is inevitable, adaptable people and organizations will be the most successful if they readily accept change. Quickly finding an effective new way to deal with change will determine if our industry and the AASV will continue to be successful over the next 50 years.

Reference

*1. Rath T. *StrengthsFinder 2.0*. New York: Gallup Press; 2007.

* Non-refereed reference.


Be Certain.
POWERED BY
ACCELERATED®
HYDROGEN PEROXIDE
Patented
INTERVENTION™ DISINFECTANTS
As a veterinarian, your job is to be certain. You're trained to eliminate the unknown, diagnose, and deliver care. So, you have to be certain about the environment in which you work. Intervention™ Disinfectants help prevent outbreaks before they start and create a clean, safe environment for all. And that's something to be certain about.
InterventionDisinfectants.com
INTERvention
Farm Animal Care
Disinfectant Cleaner & Deodorizer
Ready To Use Wipes
INTERvention
Farm Animal Care
Disinfectant Cleaner & Deodorizer
Concentrate
Proceed With Certainty.

"And that's the way it is"

We always stress that it is important that we in the swine industry tell our own story or someone else will tell it for us. A recent 60 Minutes episode highlighted why that is not always as easy as it sounds. The National Pork Producers Council (NPPC) was contacted about an opportunity to sit down with CBS's Leslie Stahl to discuss issues associated with the *Salmonella* outbreak that occurred a few years ago in the Pacific Northwest. In an effort to be transparent and tell our own story to a broad audience, NPPC offered up Dr Liz Wagstrom as the one most knowledgeable about the facts of the case and the circumstances surrounding the positions taken by the swine industry and animal health officials. Dr Wagstrom graciously agreed to participate in the interview.

I am sure those of you who know her would agree that Dr Wagstrom is rarely one to shy away from an opportunity to try to educate the public about what we do and why we do it. But, more importantly, she is also well-versed in the challenges our industry faces and the efforts we have undertaken to address those challenges. Working in Washington, DC, she is no stranger to interacting with those that disagree with the livestock industry or simply do not understand it. I think all of us would agree, however, that sitting one-on-one with a seasoned investigative reporter, who likely has an agenda, in an unfamiliar room with bright lights and video cameras would be a bit nerve-wracking. Now imagine doing it for 80 minutes.

I knew that Liz had agreed to do the interview. She was well prepared and understood the challenges such an interview posed. Having worked with Liz for more than 20 years in a myriad of situations (we always debate who is going to play nice vet or mean vet), I have every confidence in her knowledge and experience as a swine veterinarian and a staunch supporter of the pork industry. There is no one I would rely on more to effectively tell our story than her. I am entirely confident that Liz did a fantastic job answering the questions posed to her during the interview and was an effective advocate for swine veterinary medicine and the pork industry. It was potentially a good opportunity to explain the industry's position on the challenges associated with on-farm sampling following an outbreak of foodborne illness. Unfortunately, 60 Minutes had other ideas.

In the days following the broadcast, I received several calls from AASV members who either watched the program live or viewed it on the CBS website. The callers wanted to make sure that I was aware of the program and to let me know that it did not portray the swine industry in a fair or favorable light. I am not sure this was really a surprise to anyone who has tracked the portrayal of the swine industry in local and national media over the years. The level of bias evident in the mainstream media outlets these days is appalling and was on full display in the 60 Minutes broadcast. Of the 80 minutes Dr Wagstrom spent with Ms Stahl, the show's producers edited her interview to less than 150 seconds.

The US Constitution affords the press the freedom to distribute information and opinions without restraint or censorship. This is a unique and powerful attribute of a free democratic society and should be protected. The value of the information afforded the public, however, is directly related to the integrity of the journalist distributing the information.

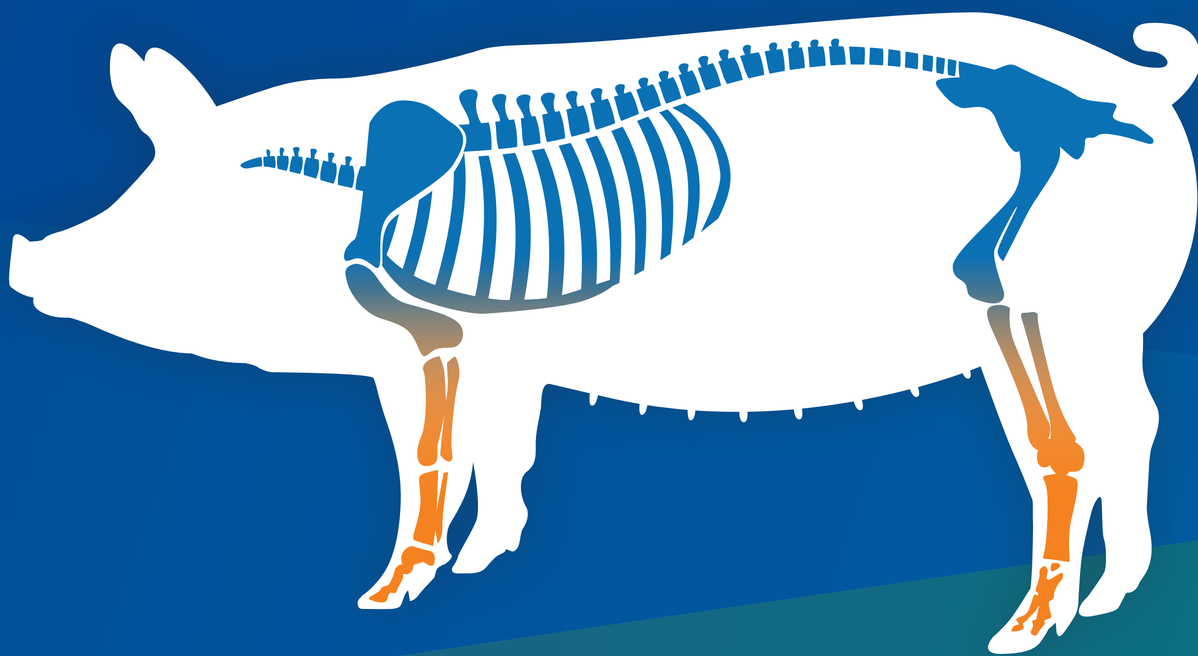
The 60 Minutes story is just an example of the abysmal state of journalistic ethics in society today. In a time when it has never been easier to store and distribute massive amounts of information via the internet, why don't media outlets make recordings, videos, or transcripts of interviews available to the public in their entirety and unedited? Let the public determine what to believe based on all the information that is available without the biased influence of a profit-driven media company.

"The US Constitution affords the press the freedom to distribute information and opinions without restraint or censorship."

As I see it, the role of journalists in society should be to provide the citizenry with the information they need in order to form their own opinions about an issue. To be effective, the journalist should ask questions that enlighten all sides of an issue and then make those responses available to the public in a transparent and unbiased manner. Journalists should not be the decider of an issue, but rather the resource that provides the information to educate the public.

As many of you of a certain generation will recognize, the title of this article is Walter Cronkite's famous sign off. Cronkite also famously said, "In seeking truth, you have to get both sides of a story." He was perhaps the last of the true journalists. I think he best summed up ethics in journalism by noting that, "The ethic of the journalist is to recognize one's prejudices, biases, and avoid getting them into print." Until that vision of journalistic utopia arrives, however, it remains important that we continue to offer our version of life one-on-one in an effort to educate those who will listen in the hope that each of those we reach will be better informed and capable of sharing a more informed version of the story. In the meantime, I would like to say thank you to Dr Wagstrom for her willingness to put herself on the front lines to tell our story.

Harry Snelson, DVM
Executive Director



Recognition

I recently read a blog published by a veterinarian where she praised her veterinary technicians and how her technicians and other support staff helped her to achieve excellence in her career. She went on in her story to say how all the people in her support group have helped her achieve her career goals and her desire to feel fulfilled in her daily contributions to veterinary medicine. I found myself thinking about all the veterinary technicians, kennel staff, answering service personnel, administrative staff, students, and colleagues whom I have worked with over the years. I have met many different people with different perspectives, different backgrounds, and different job descriptions, but all had a desire to be involved in veterinary medicine in some capacity. How have I managed to be so lucky to have worked with so many great people over my career?

It seems that today's work force is expected to do more with less and workload is increasing with a seemingly unlimited ceiling. Veterinary medicine, regardless of which area of the profession you are involved with, is not immune to such workload pressures. Personnel are the most valuable asset of any organization regardless of job description, ie, veterinary technician, administrative staff. There have been review papers published in the human nursing literature documenting that staff workload has a direct relationship with adverse patient outcomes, hospital mortality, and medical mistakes.[1] Other job satisfaction surveys have reported that employees would rather have more staff to allow for more time to be spent with patients or customers and better communication between staff and upper management.[2]

Administrative Professionals Day (previously referred to as Secretary's Day) is a day that is observed in many countries. In the United States and Canada, it is typically celebrated on the Wednesday of Administrative Professionals Week, the last full week of April – not that far away! In a time of increased workload and stressors in the workforce, I present this reminder to encourage you to recognize the work of your support team and support professionals this April 22, 2020.

Terri O'Sullivan, DVM, PhD
Executive Editor

"Personnel are the most valuable asset of any organization regardless of job description."

References

1. Osaro E, Chima N. Challenges of a negative work load and implications on morale, productivity and quality of service delivered in NHS laboratories in England. *Asian Pac J Trop Biomed*. 2014;4(6):421-429.

2. Pizzolon CN, Coe JB, Shar JR. Evaluation of team effectiveness and personal empathy for associations with professional quality of life and job satisfaction in companion animal practice personnel. *JAVMA*. 2019;254(10):1204-1217.

Evaluating the impact of weaning weight and growth rate during the first week post weaning on overall nursery performance

Jamil E. G. Faccin, DVM, MSc; Fernanda Laskoski, DVM, MSc; Henrique S. Cemin, DVM, MSc; Ana P. G. Mellagi, DVM, PhD; Mari L. Bernardi, DVM, PhD; Rafael R. Ulguim DVM, PhD; Fernando P. Bortolozzo, DVM, PhD; Mike D. Tokach, PhD

Summary

Objective: Determine the effects of nursery pig weaning weight (WW) and first week postweaning growth rate (ADG7) on average daily gain (ADG), final weight, removals, and mortality under field conditions.

Materials and methods: In this 42-day study, 1602 pigs (mean [SD] weight: 5.42 [0.9] kg) were weaned at 19 to 21 days of age. Four successive batches of weaned pigs were moved into the same nursery room. Within each batch, pigs were allotted by WW to have approximately one-third of each class (LightWW, MediumWW, and HeavyWW) in all pens. On day 7, pigs were individually weighed and designated according to their ADG7 into four classes within their batch: NegativeADG7, LowADG7, MediumADG7, and HighADG7. An equation was developed and validated to quantify the association between WW and ADG7 with ADG.

Results: Weaning weight had no effect on ADG7 (*P* = .42), but increasing WW and ADG7 increased (*P* < .001) ADG and final weight at 42 days. Pig removal was reduced if pigs had heavy WW or gained weight in the first week after weaning (≤ 3.2%) compared to pigs that lost weight during the first week in the LightWW (20.9%) or MediumWW (10.3%) categories. Overall mortality was 1.1% with no effects of WW, ADG7, or its interaction (*P* > .54). The equation generated indicated that WW and ADG7 together had moderate accuracy (R^2 = 0.54; *P* < .001) to predict ADG.

Implication: The WW and ADG7 are not correlated, but they affect and partially predict the overall nursery performance.

Keywords: swine, nursery, growth rate, weaning weight, first week.

Received: February 6, 2019
Accepted: December 4, 2019

Resumen - Evaluación del impacto del peso al destete y la tasa de crecimiento durante la primera semana después del destete en el rendimiento general del destete

Objetivo: Determinar los efectos del peso al destete (WW por sus siglas en inglés) y la tasa de crecimiento post-destete de la primera semana (ADG7 por sus siglas en inglés) sobre la ganancia diaria promedio (ADG por sus siglas en inglés), el peso final, las eliminaciones y la mortalidad en condiciones de campo.

Materiales y métodos: En este estudio de 42 días, 1602 cerdos (peso medio [DE]: 5.42 [0.9] kg) fueron destetados entre los 19 y 21 días de edad. Cuatro lotes consecutivos de cerdos destetados fueron trasladados a la misma sala de cría. Dentro de cada lote, los cerdos fueron asignados por peso al destete WW para tener aproximadamente un tercio de cada clase (WWBajo, WWMedio y WWAlto) en todos los corrales. El día 7, los cerdos se pesaron individualmente y se designaron de acuerdo con su ADG7 en cuatro clases dentro de su lote: ADG7Negativo, ADG7Bajo, ADG7Medio, y ADG7Alto. Se desarrolló y validó una ecuación para cuantificar la asociación entre WW y ADG7 con ADG.

Resultados: El peso al destete no tuvo efecto sobre ADG7 (*P* = .42), pero el aumento de WW y ADG7 aumentó (*P* < .001) ADG y el peso final a los 42 días. La eliminación de los cerdos se redujo si los cerdos tuvieron un WW pesado o aumentaron de peso en la primera semana después del destete (≤ 3.2%) en comparación con los cerdos que perdieron peso durante la primera semana en las categorías WWBajo (20.9%) o WWMedio (10.3%). La mortalidad general fue del 1.1% sin efectos de WW, ADG7 o su interacción (*P* > .54). La ecuación generada indicó que WW y ADG7 juntos tenían una precisión moderada (R^2 = 0.54; *P* < .001) para predecir ADG.

Implicación: El peso al destete y ADG7 no están correlacionados, pero afectan y predicen parcialmente el rendimiento general del destete.

JEGF, FL, APGM, MLB, RRU, FPB: Setor de Suínos, Faculdade de Veterinária, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.

HSC, MDT: Department of Animal Sciences and Industry, College of Agriculture, Kansas State University, Manhattan, Kansas.

Corresponding author: Dr Fernando P. Bortolozzo, Av. Bento Gonçalves, 9090, Porto Alegre, RS, Brazil 91540–000; Tel: 55 51 3308 6132; Email: fpbortol@ufrgs.br.

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

Faccin JEG, Laskoski F, Cemin HS, Mellagi APG, Bernardi ML, Ulguim RR, Bortolozzo FP, Tokach MD. Evaluating the impact of weaning weight and growth rate during the first week post weaning on overall nursery performance. *J Swine Health Prod.* 2020;28(2):70-78.

Résumé - Évaluation de l'impact du poids au sevrage et du taux de croissance durant la première semaine post-sevrage sur les performances globales en pouponnière

Objectif: Déterminer, chez des porcelets en pouponnière, les effets du poids au sevrage (WW) et le taux de croissance durant la première semaine post-sevrage (ADG7) sur le gain quotidien moyen (ADG), le poids final, les retraits, et la mortalité dans des conditions de champ.

Matériels et méthodes: Dans cette étude d'une durée de 42 jours, 1602 porcelets (poids moyen [SD]: 5.42 [0.9] kg) furent sevrés entre 19 et 21 jours d'âge. Quatre lots successifs de porcelets sevrés furent déplacés dans la même chambre de pouponnière. Dans chacun des lots, les porcs étaient répartis par WW pour avoir approximativement un tiers de chaque catégorie (LégerWW, MédiumWW, et LourdWW) dans tous les enclos. Au jour 7, les porcs furent pesés individuellement et désignés selon leur ADG7 en quatre classes au sein de leur lot: ADG7Négatif, ADG7Faible, ADG7Moyen, et ADG7Élevé. Une équation fut développée et validée pour quantifier l'association entre WW et ADG7 et ADG.

Résultats: Le poids au sevrage n'avait aucun effet sur ADG7 ($P = .42$), mais en augmentant WW et ADG7 il y avait augmentation ($P < .001$) de l'ADG et du poids final à 42 jours. Le retrait de porcs était réduit si les porcs étaient de la classe LourdWW ou avaient pris du poids dans la première semaine après le sevrage (≤ 3.2%) comparativement aux porcs qui perdirent du poids durant la première semaine dans les catégories LégerWW (20.9%) ou MédiumWW (10.3%). La mortalité globale a été de 1.1% sans effet du WW, ADG7, ou ses interactions ($P > .54$). L'équation générée indiquait que WW et ADG7 ensemble avaient une précision modérée ($R^2 = 0.54$; $P < .001$) pour prédire ADG.

Implication: Le WW et l'ADG7 ne sont pas corrélés, mais ils affectent et prédisent partiellement la performance globale en pouponnière.

Weaning is one of the most stressful moments of a pig's life. At this transition time, piglets face changes in environmental conditions, health, hierarchy, nutrition, and other challenges.[1] These factors contribute to a dramatic reduction in feed intake. Pigs usually attain the metabolizable energy (ME) intake equivalent to the preweaning level only by the end of the second week post weaning. In addition, the ME requirements for maintenance are not fulfilled until the fifth day after weaning.[2] Stress factors may result in poor growth performance during the overall nursery phase.[3] Even with the possibility of compensatory gain after the adaptation period, pigs that are more affected by nursery stress factors can be negatively impacted for a longer period and exhibit poor performance during subsequent phases.[4]

In the past decades, numerous studies were conducted aiming to show the importance of performance immediately after weaning caused by manipulating the first postweaning diet.[5-7] Research has shown that pigs supplemented with milk preweaning[8,9] or post weaning[10,11] can reach extremely high growth rate in the nursery, sometimes exceeding 500 g/d. However, commercial conditions and challenges cause pigs to perform much more poorly immediately after weaning when they no longer have access to milk. In some studies, the effect of weaning weight was investigated in association with dietary treatments[12] or feeding durations of a starter diet,[13] and time to reach market weight was more affected by weaning weight than by feeding strategies. Recently, Collins et al[14] reinforced that the impact of weaning weight on the performance of subsequent phases was greater than diet effects. The weight gain in the first 7 to 10 days after weaning has been shown to increase weight at 56 days for both light and heavy weaned pigs.[11] Although the growth performance until the end of the nursery period has been improved in pigs with higher early growth rate, weight at the end of the finishing phase or days to reach slaughter weight were unaffected.[11] The effect of growth rate immediately after weaning on subsequent pig growth performance has been scarcely studied, warranting investigation, especially under current pig production conditions. It would also be important to know whether growth rate immediately after weaning interacts with weaning weight to affect nursery growth performance.

The present study was performed using pigs with a small range (3 days) in weaning age to evaluate the effect of weaning weight and average daily gain (ADG) in the first 7 days post weaning on overall nursery performance (ADG and weight) as well as on removals and mortality during the 42 days post weaning. A second objective was to determine how much weaning weight and growth rate during the first week post weaning can predict overall ADG in the nursery phase in a commercial production system.

Materials and methods

The Institutional Animal Care and Use Committee of the Federal University of Rio Grande do Sul approved the protocols used in this experiment according to the process PROPESQ-UFRGS 35420.

Animals, housing, diets, and procedures

The study was conducted in a 5000-sow farm in midwestern Santa Catarina, Brazil. At weaning, 1602 barrows and gilts (PIC 337 × Camborough; Pig Improvement Company), from sows of parities 2 to 7, were identified with an ear tag and their individual weight was recorded. They had no access to creep feeding in the preweaning period. Four consecutive batches of pigs were weaned at 19 to 21 days of age and mean (SD) body weight was 5.4 (0.9) kg.

Pigs were housed in a double curtain-sided nursery room. Pens had solid concrete floor along the entire length of the feeder, and slatted plastic flooring in the remaining area. The room temperature was maintained at 28° C to 30° C in the first and second weeks after weaning, and 25° C to 26° C thereafter. Each pen had two nipple drinkers. Weaning batch 1 had 15 pigs/pen (20 pens), batch 2 had 22 (14 pens) or 23 pigs/pen (14 pens), and batch 3 had 24 pigs/pen (28 pens). Pens with 22 to 24 pigs had a feeder with four 16-cm wide feeder holes. In pens with 15 pigs, the feeder was adjusted so that pigs had access to three feeder holes. Adjustable pen gates were used to maintain a floor space allowance of 0.28 m^2/pig in all pens.

Pigs were allowed *ad libitum* access to feed and water. Diets were corn- and soybean-meal-based and a three-phase feeding program was formulated to meet the National Research Council[15] requirement estimates. All diets were manufactured at the on-farm feed mill and were fed in meal form. The feed budget was 1 kg/pig of Phase 1 diet (3.6 Mcal/kg of ME, 21.9% crude protein [CP], 1.46% standardized ileal digestible [SID] lysine, 18.0% lactose, and 180 ppm of colistin), 4 kg/pig of Phase 2 diet (3.6 Mcal/kg of ME, 21.4% CP, and 1.42% SID lysine, 12.0% lactose, 180 ppm of colistin, and 300 ppm of amoxicillin), followed by a Phase 3 diet (3.5 Mcal/kg of ME, 20.1% CP, and 1.30% SID lysine) with approximately 17 kg/pig fed until the end of the trial.

Three weaning batches allotted in the same nursery room were used to evaluate the nursery performance and develop an equation to predict overall ADG through the nursery phase. The pigs were individually weighed on days 0, 7, and 42 (end of the study). In each pen, pigs were allotted according to weaning weight (WW) with approximately one-third of each WW class (LightWW, MediumWW, and HeavyWW) in all pens. Based on the ADG during the first week in the nursery (ADG7), four classes were created (NegativeADG7, LowADG7, MediumADG7, and HighADG7) within each batch. The NegativeADG7, LowADG7, MediumADG7, and HighADG7 classes had 22%, 26%, 26%, and 26% of the total number of pigs, respectively.

Removal reasons were pigs that were nonambulatory, pigs not responding to antibiotic treatment, and pigs that lost weight for 2 consecutive weeks (without considering the first week). Weekly, 1 veterinarian visited the nursery room to evaluate the response of the pigs to the antibiotic treatments. Also, pigs visually classified with poor growth rate were weighed for 2 consecutive weeks to confirm they were not gaining weight. Using the continuous data of WW and ADG7 from the first three batches, an equation was developed by testing the linear and quadratic terms of WW and ADG7 as predictors of overall nursery ADG.

Statistical analysis

Data were analyzed using SAS software (version 9.4; SAS Institute Inc). In all analyses, means or percentages were considered significantly different at $P \leq .05$. Pigs that died or were removed during the first week after weaning could not be classified according to ADG7, thereby 1588 of 1602 pigs were used for the analyses.

The GLIMMIX procedure was used for the analysis of weight and ADG at different timepoints in the nursery phase. The models of analysis included the fixed effects of WW classes, ADG7 classes, and their interaction. Random effects included in the models were weaning batch and pen within batch. Batch was included as a random effect to account for random error associated with variation among batches. Pen within batch was used to account for random error observed between pens within the same batch. Least squares means were compared using the Tukey-Kramer procedure, which adjusts tests on multiple comparison and unbalanced designs.[16]

According to Petrie and Watson,[17] when a categorical explanatory variable has zero cell count in one or more of its categories, the problem can be overcome by running logistic regression models after combining one or more categories of this variable. The NegativeADG7 class was grouped with LowADG7 class because there were no dead pigs in the NegativeADG7 class. The same approach was used to group MediumADG7 and HighADG7 classes within each WW class because no HighADG7 pigs belonging to HeavyWW class were removed. These groupings were performed only after using the Fisher Exact test to confirm that they were not different. Thereafter, removals and mortality were analyzed as binary responses using logistic regression models. The independence assumption for logistic regression models was checked by dividing the deviance by the degrees of freedom to confirm it was not substantially greater than one.[17]

The CORR procedure was used to obtain Pearson's correlation coefficients regarding the relationships of WW and ADG7 with variables of growth performance. Partial correlation coefficients, controlling for the effects of WW or ADG7, were also obtained. A partial correlation analysis allows examining the strength of a linear bivariate relationship while holding constant another variable in the model.[18]

The MIXED procedure of SAS was used to develop a prediction equation for overall nursery ADG using the dataset from the first three batches. The variables tested as predictor variables were the linear and quadratic terms of WW and ADG7 and the interaction between WW and ADG7. The statistical significance for inclusion of terms in the model was determined at $P \leq .05$. The single variable model with the lowest Bayesian information criterion (BIC) was selected and additional terms were added in a stepwise manual forward selection. In order to be included in the model, a reduction of at least 2 points in BIC was required.[19] The model with the lowest BIC was considered the optimal and the method of residual maximum likelihood was used to obtain the parameter estimates. Following the recommendations of Petrie and Watson,[17] the assumption of homogeneity of variance was confirmed by the random scatter of residuals with no funnel effect when the studentized residuals were plotted against the fitted values of the dependent variable. A histogram of the residuals was examined to confirm the normality assumption. A fourth batch with 526 nursery pigs was used to evaluate the accuracy of the prediction equation. The accuracy of this model was examined using the coefficient of determination (R^2), in addition to the assessment of the closeness of the points (plot of actual vs predicted values) to the straight line, ie, the line of perfect agreement.

Results

The ranges of weight and ADG for WW and ADG7 classes of each weaning batch are shown in Table 1. The different ADG7 classes started with similar ($P = .74$) weaning weight (overall mean of 5.4 kg). The weight at 7 and 42 days after weaning were affected by WW and ADG7 but there was no evidence ($P = .84$) for interaction effect (Table 2). At weaning, HeavyWW pigs were 2.1 kg heavier than LightWW pigs, and the difference between HeavyWW and LightWW pigs increased to 5 kg on day 42 (Table 2). Pigs of the HighADG7 class were 3.7 kg heavier on day 42 compared to pigs who lost weight in the first week post weaning, despite their similar weight at weaning.

The WW classes did not differ ($P = .42$) in ADG7 (Table 3). The ADG between 8 and 42 days after weaning and overall ADG were affected by WW and ADG7 classes ($P < .001$), but there was no evidence ($P = .75$) for interaction (Table 3). LightWW pigs had the lowest ADG from day 8 to 42 and for the overall nursery period. MediumWW pigs were intermediate and HeavyWW pigs had the highest ($P = .01$) growth rates at all timepoints (Table 3). For each increase in ADG7 class, ADG from day 8 to 42 increased by 19 to 25 g/d, and overall ADG increased by 26 to 34 g/d.

The percentages of removals were similar ($P = .75$) between MediumADG7 and HighADG7 for LightWW (3.57% versus 2.78%), MediumWW (2.22% versus 1.48%), and HeavyWW (0.74% versus 0.0%) classes. When MediumADG7 and HighADG7 classes were grouped, a higher odds ratio (OR) for removal ($P = .05$) was observed in LightWW (OR = 11.2) and MediumWW (OR = 4.8) than in HeavyWW pigs for the NegativeADG7 class (Table 4). Pigs that lost

Table 1: Ranges of weaning weight and average daily gain in the first week post weaning for each weaning batch by class*

Batch	WW, kg			ADG7, g			
	LightWW	MediumWW	HeavyWW	NegativeADG7	LowADG7	MediumADG7	HighADG7
	n = 526	n = 530	n = 532	n = 357	n = 412	n = 410	n = 409
1	3.28 to 4.77	4.79 to 5.79	5.80 to 6.90	-138 to 0	1 to 60	61 to 116	117 to 287
2	3.65 to 4.95	4.96 to 5.87	5.88 to 8.00	-228 to 0	1 to 47	49 to 91	93 to 300
3	4.09 to 5.09	5.10 to 5.85	5.86 to 8.60	-177 to 0	1 to 106	107 to 168	170 to 367

* Within weaning batch, pigs were allotted into 3 classes according to WW. Subsequently within weaning batch, pigs were allotted into 4 classes according to their ADG7.

WW = weaning weight; ADG7 = average daily gain in the first week post weaning.

Table 2: Body weight of pigs at 7 and 42 days post weaning according to weaning weight and average daily gain in the first week post weaning*

Item	ADG7 Classes	WW classes			LS Means (SEM)
		LightWW	MediumWW	HeavyWW	
BW at 7 d, kg	NegativeADG7	4.1	5.1	6.2	5.1 (0.19)[d]
	LowADG7	4.6	5.6	6.8	5.7 (0.19)[c]
	MediumADG7	5.1	6.0	7.2	6.1 (0.19)[b]
	HighADG7	5.6	6.6	7.7	6.6 (0.19)[a]
	LS Means (SEM)	4.8 (0.19)[c]	5.8 (0.19)[b]	7.0 (0.19)[a]	
BW at 42 d, kg	NegativeADG7	15.1	17.1	20.3	17.5 (0.7)[h]
	LowADG7	16.5	18.7	21.4	18.9 (0.7)[g]
	MediumADG7	17.5	19.6	22.7	19.9 (0.7)[f]
	HighADG7	19.1	20.8	23.7	21.2 (0.7)[e]
	LS Means (SEM)	17.0 (0.7)[g]	19.1 (0.7)[f]	22.0 (0.7)[e]	

* Within weaning batch, pigs were allotted into 3 classes according to WW. Subsequently within weaning batch, pigs were allotted into 4 classes according to their ADG7.

[a-h] Different superscripts within the column or the row indicate statistical difference in LS Means at 7 d ([a-d]) and 42 d ([e-h]), respectively ($P < .05$). Comparisons were performed using the Tukey-Kramer test.

WW = weaning weight; ADG7 = average daily gain in the first week post weaning; SEM = standard error of the mean; BW = body weight.

weight had greater odds ($P = .02$) of being removed than those that gained weight in the first week after weaning, for LightWW (OR = 8.5 and 8.1) and MediumWW classes (OR = 8.1 and 6.1). On the other hand, for HeavyWW pigs, the ADG7 classes did not differ ($P = .43$). Within the classes with weight gain, removals were not affected ($P = .10$) by WW classes. The percentages of dead pigs are shown in Table 5. Mortality was not affected by WW, ADG7 or by their interaction ($P = .54$).

The correlation coefficients of WW and ADG7 with variables regarding nursery growth performance are shown in Table 6. The ADG7 was not correlated with WW. The weight at 42 days was strongly correlated with weaning weight and moderately correlated with ADG7. The ADG from 8 to 42 days and overall ADG were weakly or moderately correlated with both WW and ADG7. All partial correlation coefficients were higher than those observed without keeping WW or ADG7 constant.

For the overall nursery ADG prediction equation, only the linear terms for WW and ADG7 were significant predictors ($P < .001$). Quadratic terms and interaction between WW and ADG7 were not significant ($P = .10$) and were removed from the model. The final prediction equation (adjusted $R^2 = 0.44$) was: overall nursery ADG = (.03161 × WW) + (.4387 × ADG7) + .1308. It is important to note that the input variables must consist of values within the ranges used to generate the prediction equation. The prediction equation generated from the first three batches was used to predict the ADG of the fourth batch. Using R^2 as a measure of goodness of fit, the ADG prediction value had a moderate accuracy ($R^2 = 0.54$, $P = .01$) caused by a relative dispersion of the dots over the line (Figure 1).

Discussion

This study investigated the impact of weaning weight and ADG7 on the overall nursery performance. Weaning weight was not correlated with ADG7, but heavier pigs at

Table 3: Average daily gain in the nursery phase according to weaning weight and average daily gain in the first week post weaning*

Item	ADG7 classes	WW classes			LS Means (SEM)
		LightWW	MediumWW	HeavyWW	
0 to 7 d, g	NegativeADG7	-34.8	-46.0	-49.5	-43.4 (15.4)[d]
	LowADG7	36.6	39.4	38.9	38.3 (15.4)[c]
	MediumADG7	99.1	97.4	100.2	98.9 (15.4)[b]
	HighADG7	174.1	173.3	177.4	174.9 (15.4)[a]
	LS Means (SEM)	68.7 (15.4)	66.0 (15.4)	66.7 (15.4)	
8 to 42 d, g	NegativeADG7	312.4	342.1	400.2	351.6 (14.3)[h]
	LowADG7	337.9	373.3	419.0	376.7 (14.2)[g]
	MediumADG7	353.5	390.2	443.5	395.7 (14.2)[f]
	HighADG7	384.2	406.9	456.6	415.9 (14.2)[e]
	LS Means (SEM)	347.0 (14.1)[g]	378.1 (14.1)[f]	429.8 (14.1)[e]	
0 to 42 d, g	NegativeADG7	254.4	279.1	323.4	286.7 (14.3)[l]
	LowADG7	287.1	316.0	354.4	320.4 (14.2)[k]
	MediumADG7	310.5	341.2	385.7	346.2 (14.2)[j]
	HighADG7	350.3	370.0	409.7	375.6 (14.2)[i]
	LS Means (SEM)	301.1 (14.2)[k]	326.3 (14.2)[j]	369.3 (14.2)[i]	

* Within weaning batch, pigs were allotted into 3 classes according to WW. Subsequently within weaning batch, pigs were allotted into 4 classes according to their ADG7.

a-l Different superscripts within the column or the row indicate statistical difference in LS Means within 8 to 7 d (a-d), 8 to 42 d (e-h), and 0 to 42 d (i-l), respectively ($P < .05$). Comparisons were performed using the Tukey-Kramer test.

WW = weaning weight; ADG7 = average daily gain in the first week post weaning; SEM = standard error of the mean.

Table 4: Number and percentage of pigs removed between 7 and 42 days of the nursery period according to weaning weight and average daily gain in the first week post-weaning*

ADG7 classes	WW classes, No. of pigs (%)		
	LightWW	MediumWW	HeavyWW
NegativeADG7	23 (20.91)[a,x]	12 (10.26)[a,x]	3 (2.31)[y]
LowADG7	4 (3.03)[b]	2 (1.40)[b]	2 (1.46)
MediumADG7 + HighADG7†	9 (3.17)[b]	5 (1.85)[b]	1 (0.38)

* Within weaning batch, pigs were allotted into 3 classes according to WW. Subsequently within weaning batch, pigs were allotted into 4 classes according to their ADG7.

† MediumADG7 and HighADG7 classes were grouped to run the logistic regression analysis because no pigs were removed in HighADG7 class within HeavyWW class. Grouping was performed only after confirmation, using the Fisher Exact test, that these two ADG7 classes were not different.

a,b and x,y Superscripts a and b within a column and x and y within a row indicate statistical difference ($P < .05$). Groups were compared using a logistic regression analysis.

WW = weaning weight; ADG7 = average daily gain in the first week post weaning.

weaning had higher ADG from 8 to 42 days post weaning. Collins et al[14] also reported the influence of weaning weight on ADG only after day 7 post weaning. These results demonstrate the unsuccessful adaptation of piglets to challenges of the critical period of weaning, which imposes simultaneous stressors, including change in nutrition, separation from mother and littermates, new environment, and mixing. These stressors lead to low and variable feed intake, hence reducing the weight gain,[20] regardless of the weight at weaning.

Increasing the weaning weight may have a greater impact on nursery performance than feeding and management strategies that aim to accelerate growth rate immediately after weaning.[5,11-13] The difference in initial weight (2.1 kg) between LightWW and HeavyWW pigs more than doubled on day 42 (5.0 kg), showing the importance of WW on subsequent performance. Wolter and Ellis[11] observed that heavy-weight pigs at weaning have higher ADG in the nursery phase, are heavier at 56 days of age, and take less time to reach market weight than light-weight pigs. Similarly, other studies show that fewer days are required for heavier-weight pigs at weaning to reach a final weight of 105 kg than for light-weight pigs at weaning, irrespective of postweaning diets or feeding programs.[12,13] Recently, Collins et al[14] confirmed the remarkable impact of weaning weight on lifetime growth performance, with a difference of 4.1 kg at weaning between light and heavy pigs increasing to 7.3 and 11.7 kg at 39 and 123 days after weaning, respectively. Nevertheless, the same study showed that more complex diets can be used for lighter pigs at weaning to maximize their lifetime growth performance.[14]

Overcoming stressors associated with weaning is a challenge to the pigs during the first week in the nursery. If stress is surpassed and the weight is at least maintained during the first week, then pigs can reach market weight 15 days before pigs that lose weight.[21] In the present study, pigs that gained more weight during the first week were 3.8 kg heavier on day 42 than those that lost weight in the first week. Kats et al[22] also observed a weight difference of 2.9 kg at 56 days post weaning in favor of pigs that gained weight during the first week. Wolter and Ellis[11] used improved environmental conditions and provided liquid milk replacer during two weeks after weaning to accelerate the growth in nursery phase. Although pigs with accelerated growth were 1.3 kg heavier at 56 days of age, the early growth rate had no effect on growth from day 35 onwards

Table 5: Number and percentage of pigs that died between 7 and 42 days of the nursery period according to weaning weight and average daily gain in the first week post weaning*

	WW classes, No. of pigs (%)			
ADG7 classes	**LightWW**	**MediumWW**	**HeavyWW**	**Total**
NegativeADG7 + LowADG7†	3 (1.24)	3 (1.15)	2 (0.75)	8 (1.04)
MediumADG7	2 (1.43)	1 (0.74)	2 (1.48)	5 (1.22)
HighADG7	3 (2.08)	1 (0.74)	1 (0.77)	5 (1.22)
Total	8 (1.52)	5 (0.94)	5 (0.94)	

* Within weaning batch, pigs were allotted into 3 classes according to WW. Subsequently within weaning batch, pigs were allotted into 4 classes according to their ADG7.

† NegativeADG7 and LowADG7 classes were grouped to run the logistic regression analysis because no pigs died in NegativeADG7 class. Grouping was performed only after confirmation, using the Fisher Exact test, that these two ADG7 classes were not different.

WW = weaning weight; ADG7 = average daily gain in the first week post weaning.

Table 6: Pearson correlation coefficients of weaning weight and average daily gain in the first week post weaning with the growth performance of nursery pigs

	ADG7	**ADG 8-42 d**	**ADG 0-42 d**	**Weight at 42 d**
WW	-0.005	0.432	0.389	0.598
P	.86	< .001	< .001	< .001
WW*	-	0.475	0.475	0.684
P		< .001	< .001	< .001
ADG7	-	0.357	0.521	0.445
P		< .001	< .001	< .001
ADG7†	-	0.411	0.579	0.580
P		< .001	< .001	< .001

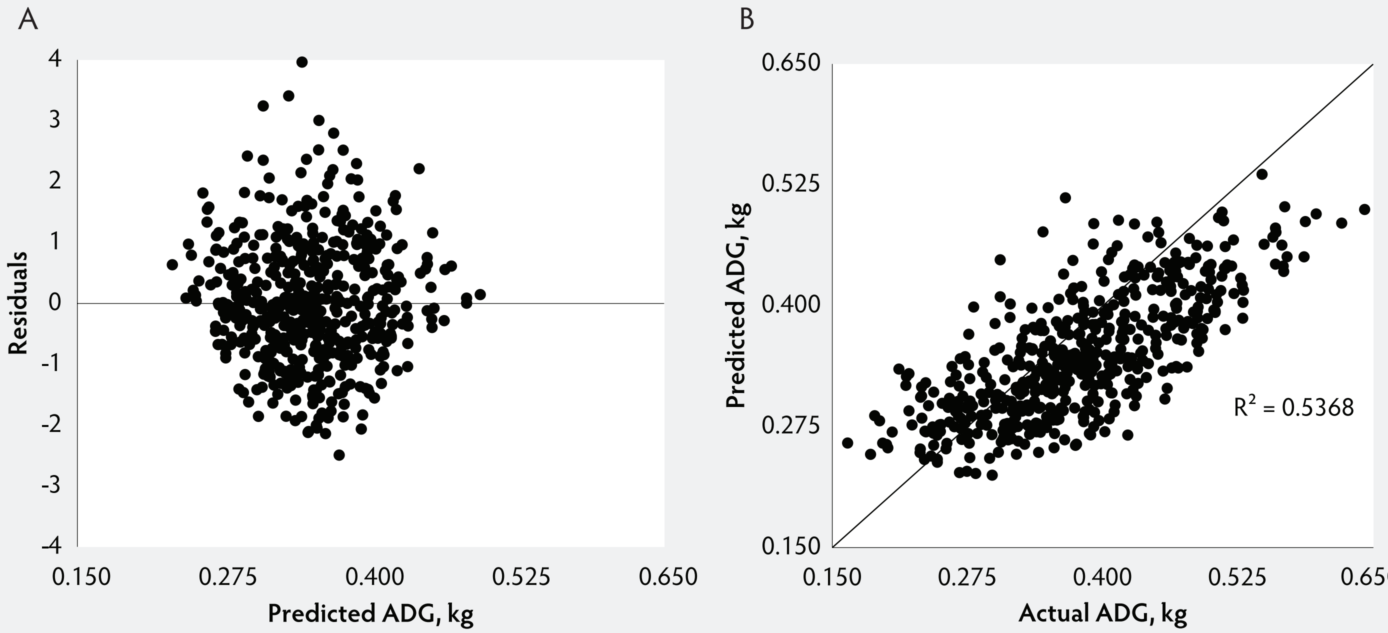
* Partial correlation coefficient while controlling for the effect of ADG7.

† Partial correlation coefficient while controlling for the effect of WW.

ADG7 = average daily gain in the first week post weaning; ADG = average daily gain; WW = weaning weight.

Figure 1: A) Studentized residual plots when modeling the effect of weaning weight (WW) and average daily gain at day 7 (ADG7) values on overall nursery average daily gain (ADG) and B) plots of actual values vs predicted values relative to the line of equality. The plots for ADG are based on 526 pigs from the fourth batch. Data from the first three batches were used to develop the equation. The following equation was used for the prediction of overall ADG:

$$\text{Overall nursery ADG} = (0.03161 \times \text{WW}) + (0.4387 \times \text{ADG7}) + 0.1308.$$



or days to reach slaughter weight. The difference in ADG between the accelerated and conventional group was 86 g/d at the end of 14 days of treatment, which could explain why advantages in growth were not sustained to slaughter weight.[11] In the present study, despite the narrow amplitude in weaning age, the difference in ADG7 between the two extreme ADG7 classes was 218 g/d, suggesting that the advantages in growth rate would more likely be maintained until the end of the finishing phase.

Mortality was not affected by WW and ADG7. However, the combined effect of WW and ADG7 was evidenced by a drastic reduction in removals if pigs were heavier at weaning or gained weight in the first week after weaning. The lower percentage of removals observed in pigs that gained weight in the first week, regardless of their weaning weight, is probably related to enhanced postweaning feed intake preventing villous atrophy and stimulating growth.[1] Indeed, detrimental changes in gut structure and function of weaned pigs are mainly driven by inadequate feed intake.[20] Higher losses (mortality and removal) have been reported for pigs with lower weight (< 4.1 kg) on day 7 after weaning compared with those with higher weight.[23] Higher removal rates of light-weight pigs are probably also associated with the possibility of harboring more infectious pathogens.[24]

The variation in weaning age is difficult to control in nursery studies performed under field conditions. Pigs in a batch often originate from sows with a range in farrowing dates, and individual weaning age is usually unknown when they enter nursery facilities. In some studies in which the effects of WW and weight gain on nursery performance were investigated, the weaning age differences ranged from 5 to 8 days,[7,11,14,22] being a potential confounding variable for outcomes if its effect is not taken into account. The performance in the nursery is affected by the weaning age,[23,25] and for each day of increase in weaning age, overall ADG is increased by 22 g in the nursery phase.[25] Thus, individual pig age should be considered as an important variable to be recorded in nursery studies, otherwise a great variation in weaning age can be a confounding factor for growth performance evaluation. In the study by Kats et al,[22] a range of 8 days in weaning age (17 to 25 days) was used. In the current study, we tried to minimize the possible confounding effect of different weaning ages by evaluating pigs within a range as narrow as possible, ie, 3 days (19 to 21 days).

Other factors not investigated herein could also affect nursery performance. Variables such as dam parity and litter of origin can be confounding factors, but they are difficult to control in studies performed under field conditions. Sow-to-sow differences explain more of the variation in weight at 7 weeks of age than farm-to-farm differences.[23] Piglets reared by parity 1 females have increased odds of being lighter at the end of the nursery phase,[26] and those reared by mid-parity sows (parity 3 to 5) are heavier at 10 weeks of age than those reared by primiparous sows.[27] Although the individual parity number of dams was not available for analysis, we consider that the influence of dam parity was minimized because pigs reared by primiparous sows were not included in the present study. To minimize the confounding effect of litter, Wolter et al[5] equally distributed littermates to different treatments. Larriestra et al[26] confirmed the importance of including litter, which can be a source of variation related to size, weight variation, and other dam attributes, as a random effect in logistic models for the analysis of mortality and likelihood of being light at nursery exit, but this strategy was not considered in the present study. Nursery growth performance can also be influenced by health status[23] or the use of antibiotics in the diet. Growth performance during the nursery period has been improved by antibiotic use.[7] The fact that diets used in the present study contained antibiotics may limit extrapolation of the findings to commercial units where antibiotic-free diets are used.

The conduction of on-farm research in commercial units is justified by de Grau et al[23] due to the wide variation observed in the within-farm coefficient of variation (CV) of weaning weight in 8 commercial farms (from 17.4% to 40.7%). In the present study, the within-batch CV of weaning weight varied from 16.7% to 19.1%. Large variation in within-farm (8 herds) growth rate at all stages of growth has also been reported by Magowan et al,[28] even though the same diets were offered from birth to slaughter. This denotes that several factors affect the expression of genetic potential in pigs raised under commercial conditions. Magowan et al[28] postulated that differences in pig genotype may be a significant contributor to the variable growth rate observed between pigs from different herds, even when managed in a common environment. Variation in growth rate could not be attributed to differences in genotype since a single commercial unit, with the same genotype, was evaluated in the present study.

Prediction equations have been used previously in the swine industry, especially for the estimation of farrowing weight[29] and growth performance rates.[30] Also, the precision of a predictor variable on a given outcome can be obtained through the equations. However, the use of equations requires caution to avoid generating incorrect conclusions.[31] The WW was previously considered a precise predictor of weight at 42 days, demonstrating that it was highly correlated with postweaning performance[32] and a major determinant of lifetime growth performance.[33] The fact that partial correlation coefficients did not change markedly and were not weaker than bivariate coefficients, shows that there is a direct relationship between WW or ADG7 with growth performance variables.[18] Although WW and ADG7 are important variables that positively influence nursery performance, using solely them to predict the overall nursery ADG does not explain all the variation in this variable. In a comprehensive study where a large number of factors were included in a risk factor analysis, approximately 70% of the variation in weight at the end of the nursery period (10 weeks of age) was explained by season of birth, weight at birth, weight at weaning, and weight at 6 weeks of age.[34] In the present study, 44% of the variation of nursery ADG was explained by the WW and ADG7. When the equation was validated with the dataset of the fourth batch, the coefficient of determination ($R^2 = 0.54$) suggested that 54% of the variation observed in the actual values were explained by the model-predicted values. The equation seems to underestimate the performance of the fastest growing pigs and overestimate the performance of some of the slowest growing pigs. The advantage in weight at the end of the nursery period is usually maintained until the end of growing-finishing.[35] Therefore, predicting growth rate in the nursery phase based on weaning weight and performance in the first week could help to estimate the number of days needed for pigs to reach market weight.

Increasing the weaning weight and performance during the first week post weaning may be considered a goal to improve growth performance in the nursery phase. Strategies for increasing feed intake or preventing the low feed intake problems immediately after weaning should be considered. Increasing water intake,[36] providing an ideal proportion of pigs per feeder hole,[37] improving diet digestibility,[1] and providing adequate health conditions to weaned pigs[23] may be useful strategies to support weight gain immediately after weaning as would focusing on light pigs in the earlier stages to identify those that do not exhibit feed intake or appear to lose weight.

Implications

Under the conditions of the present study:

- The ADG7 and WW were not associated.
- The overall ADG in the nursery phase was moderately predicted by WW and ADG7.
- Removals were reduced by increasing ADG7 in LightWW and MediumWW pigs.

Acknowledgments

This study was financed, in part by CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) Grant No. 430206/2018-6. The authors are grateful to Master Agroindustrial and Agroceres PIC for providing facilities and funding to perform this study. The first author was sponsored by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES, Brasil.

Conflict of interest

None reported.

Disclaimer

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

References

1. Dong GZ, Pluske JR. The low feed intake in newly-weaned pigs: problems and possible solutions. *Asian-Aust J Anim Sci*. 2007;20:440-452.

2. Le Dividich I, Herpin P. Effects of climatic conditions on the performance, metabolism and health status of weaned piglets: a review. *Livest Prod Sci*. 1994;38:79-90.

3. King RH, Pluske JR. Nutritional management of the pig in preparation for weaning. In: Pluske JR, Le Dividich J, Verstegen MWA, eds. *Weaning the pig: concepts and consequences.* The Netherlands: Wageningen Academic Publishers. 2003:37-51.

4. Clark AB, De Jong JA, DeRouchey JM, Tokach MD, Dritz SS, Goodband RD, Woodworth JC. Effects of creep feed pellet diameter on suckling and nursery pig performance. *J Anim Sci.* 2016;94 (Suppl 2):100-101.

5. Wolter BF, Ellis M, Corrigan BP, Dedecker JM, Curtis SE, Parr EN, Webel WM. Impact of early postweaning growth rate as affected by diet complexity and space allocation on subsequent growth performance of pigs in a wean-to-finish production system. *J Anim Sci.* 2003;81:353-359.

6. Wellock IJ, Houdijk JG, Miller AC, Gill BP, Kyriazakis I. The effect of weaner diet protein content and diet quality on the long-term performance of pigs to slaughter. *J Anim Sci*. 2009;87:1261-1269.

7. Skinner LD, Levesque CL, Wey D, Rudar M, Zhu J, Hooda S, de Lange CFM. Impact of nursery feeding program on subsequent growth performance, carcass quality, meat quality, and physical and chemical body composition of growing-finishing pigs. *J Anim Sci*. 2014;92:1044-1054.

*8. Williams IH. Nutrition of the young pig in relation to body composition [PhD thesis]. Victoria, Australia: University of Melbourne; 1976.

*9. Harrell RJ, Thomas MJ, Boyd RD. Limitations of sow milk yield on baby pig growth. *Proc 1993 Cornell Nutrition Conference for Feed Manufacturers*. Rochester, NY. 1993;156-164.

10. Pluske JR, Williams IH, Aherne FX. Villous height and crypt depth in piglets in response to increases in the intake of cow's milk after weaning. *Anim Sci*. 1996;62:145-158.

11. Wolter B, Ellis M. The effects of weaning weight and rate of growth immediately after weaning on subsequent pig growth performance and carcass characteristics. *Can J Anim Sci.* 2001;81:363-369.

12. Mahan DC, Lepine AJ. Effect of pig weaning weight and associated nursery feeding programs on subsequent performance to 105 kilograms body weight. *J Anim Sci.* 1991;69:1370-1378.

13. Mahan DC, Cromwell GL, Ewan RC, Hamilton CR, Yen JT. Evaluation of the feeding duration of a phase 1 nursery diet to three-week-old pigs of two weaning weights. *J Anim Sci.* 1998;76:578-583.

14. Collins CL, Pluske JR, Morrison RS, McDonald TN, Smits RJ, Henman DJ, Stensand I, Dunshea FR. Post-weaning and whole-of-life performance of pigs is determined by live weight at weaning and the complexity of the diet fed after weaning. *Anim Nutr*. 2017;3:372-379.

15. National Research Council. *Nutrient Requirements of Swine*. 11th ed. Washington, DC: National Academies Press; 2012.

16. Kaps M, Lamberson WR. More about blocking. In: Kaps M, Lamberson WR, eds. *Biostatistics for animal science*. Wallingford, Oxfordshire: CABI Publishing; 2004:331-341.

17. Petrie A, Watson P. Further regression analyses. In: Petrie A, Watson P, eds. *Statistics for veterinary and animal science*. 3rd ed. West Sussex, UK: Wiley-Blackwell; 2013:146-164.

18. Healey JF. Partial correlation and multiple regression and correlation. In: Healy, JF, ed. *Statistics: a tool for social research*. 9th ed. Belmont, CA: Wadsworth; 2012:433-467.

19. Kass RE, Raftery AE. Bayes factors. *J Am Stat Assoc.* 1995;90:773-795.

20. Pluske JR, Hampson DJ, Williams IH. Factors influencing the structure and function of the small intestine in the weaned pig: a review. *Livest Prod Sci*. 1997;51:215-236.

*21. Pollmann DS. Effects of nursery feeding programs on subsequent grower-finisher pig performance. *Proc 14th Western Nutrition Conf*. Edmonton, Alberta, Canada. 1993:243-254.

*22. Kats LJ, Tokach MD, Goodband RD, Nelssen JL. Influence of weaning weight and growth during the first week postweaning on subsequent pig performance. *Proc Kansas State University Swine Day*. Manhattan, KS. 1992:15-17.

23. de Grau A, Dewey C, Friendship R, de Lange K. Observational study of factors associated with nursery pig performance. *Can J Vet Res.* 2005;69:241-245.

*24. Deen J. The problem of lightweight market hogs. *Proc Allen D. Leman Swine Conference.* Minneapolis, MN. 2000;192-193.

25. Main RG, Dritz SS, Tokach MD, Goodband RD, Nelssen JL. Increasing weaning age improves pig performance in a multisite production system. *J Anim Sci.* 2004;82:1499-1507.

26. Larriestra AJ, Wattanaphansak S, Neumann EJ, Bradford J, Morrison RB, Deen J. Pig characteristics associated with mortality and light exit weight for the nursery phase. *Can Vet J*. 2006;47:560-566.

27. Huting AMS, Sakkas P, Kyriazakis I. Sows in mid parity are best foster mothers for the pre- and post-weaning performance of both light and heavy piglets. *J Anim Sci*. 2019;97:1656-1670.

28. Magowan E, McCann MEE, Beattie VE, McCracken KJ, Henry W, Smyth S, Bradford R, Gordon FJ, Mayne CS. Investigation of growth rate variation between commercial pig herds. *Animal*. 2007;1:1219-1226.

29. Mallmann AL, Oliveira GDS, Rampi JZ, Betiolo FB, Fagundes DP, Faccin JEG, Andretta I, Ulguim RR, Mellagi APG, Bortolozzo FP. Proposal of equations for predicting post-farrowing sow weight. *Acta Sci Vet*. 2018;46:1574-1582.

30. Flohr JR, Dritz SS, Tokach MD, Woodworth JC, DeRouchey JM, Goodband RD. Development of equations to predict the influence of floor space on average daily gain, average daily feed intake and gain:feed ratio of finishing pigs. *Animal*. 2018;12:1022-1029.

*31. Thomas LL, Dritz SS, Goodband RD, Tokach MD, DeRouchey JM, Woodworth JC. Generating an equation to predict post-farrow maternal weight in multiple parity sows. *Kansas Agricultural Experiment Station Research Reports*. 2016;2:8.

32. Smith AL, Stalder KJ, Serenius TV, Baas TJ, Mabry JW. Effect of piglet birth weight on weights at weaning and 42 days post weaning. *J Swine Health Prod*. 2007;15:213-218.

33. Lawlor PG, Lynch PB, Caffrey PJ, O'Doherty JV. Effect of pre- and post-weaning management on subsequent pig performance to slaughter and carcass quality. *Anim Sci*. 2002;75:245-256.

34. Paredes SP, Jansman AJM, Verstegen MWA, Awati A, Buist W, den Hartog LA, van Hees HMJ, Quiniou N, Hendriks WH, Gerrits WJJ. Analysis of factors to predict piglet body weight at the end of the nursery phase. *J Anim Sci*. 2012;90:3243-3251.

35. O'Quinn PR, Dritz SS, Goodband RD, Tokach MD, Swanson JC, Nelseen JL, Musser RE. Sorting growing-finishing pigs by weight fails to improve growth performance or weight variation. *J Swine Health Prod*. 2001;9:11-16.

36. Dybkjaer L, Jacobsen AP, Tøgersen, FA, Poulsen HD. Eating and drinking activity of newly weaned piglets: effects of individual characteristics, social mixing, and addition of extra zinc to the feed. *J Anim Sci.* 2006;84:702-711.

37. Laskoski F, Faccin JEG, Vier CM, Gonçalves MAD, Orlando U, Kummer R, Mellagi APG, Bernardi ML, Wentz I, Bortolozzo FP. Effects of pigs per feeder hole and group size on feed intake onset, growth performance, and ear and tail lesions in nursery pigs with consistent space allowance. *J Swine Health Prod.* 2019;27:12-18.

* Non-refereed references.

Nutrient supplementation effects on pig performance and sickness behavior during a porcine reproductive and respiratory syndrome virus infection

Jessica D. Colpoys, PhD; Shelby M. Curry, PhD; Wesley P. Schweer, PhD; Nicholas K. Gabler, PhD

Summary

Objective: Investigate how nutrient additive inclusion impacts performance and sickness behavior in pigs infected with porcine reproductive and respiratory syndrome virus (PRRSV).

Materials and methods: At 10 weeks of age, 108 PRRSV naïve barrows (mean [SD] body weight: 31 [1.4] kg) were allotted into 18 pens in a commercial barn and enrolled in a 35-day PRRSV challenge study. After a 5-day acclimation period, all pigs were inoculated intranasally and intramuscularly with a field strain of PRRSV and began nutrient supplement treatments. Treatments included no nutrient supplement (control; n = 6 pens), water nutrient supplement (water; n = 6 pens), and water and feed nutrient supplement (water+feed; n = 6 pens). Pen performance was recorded weekly at 0, 7, 14, 21, 28, and 35 days post inoculation (dpi). Pig home-pen behavior was recorded on -1, 3, 6, 9, 12, 15, and 18 dpi.

Results: Over the 35-day challenge, no significant differences in pig viremia or performance were reported due to treatment. Compared to control, water+feed additive increased sitting in pigs; however, no other sickness behavior treatment differences were observed. Decreased activity was observed 6 and 9 dpi. Eating was decreased 6 dpi whereas drinking was decreased from 6 dpi throughout the rest of the behavioral observation period at 18 dpi.

Implications: The addition of a nutrient additive in water and water+feed had minimal effect on sickness behavior and no observed effect on viremia or performance of PRRSV-infected pigs. Decreased activity, eating, and drinking may help caretakers identify health-challenged pigs.

Keywords: swine, porcine reproductive and respiratory syndrome virus, sickness behavior, welfare, growth

Received: July 3, 2019
Accepted: November 20, 2019

Resumen - Efectos de la suplementación de nutrientes en el rendimiento del cerdo y el comportamiento de la enfermedad durante una infección por el virus del síndrome reproductivo y respiratorio

Objetivo: Investigar cómo la inclusión de aditivos nutritivos impacta el rendimiento y el comportamiento de enfermedad en cerdos infectados con el virus del síndrome reproductivo y respiratorio porcino (PRRSV).

Materiales y métodos: A las 10 semanas de edad, 108 corrales de machos libres del PRRSV (peso corporal medio [DE]: 31 [1.4] kg) se asignaron a 18 corrales en un edificio comercial y se asignaron a un estudio de desafío del PRRSV con duración de 35 días. Después de un período de aclimatación de 5 días, todos los cerdos se inocularon por vía intranasal e intramuscular con una cepa de campo del PRRSV e iniciaron los tratamientos con suplementos nutricionales. Los tratamientos incluyeron: ningún suplemento de nutrientes (control; n = 6 corrales), suplemento de nutrientes en agua (agua; n = 6 corrales) y suplemento de nutrientes en agua y alimento (agua+alimento; n = 6 corrales). El rendimiento en los corrales se registró semanalmente a los 0, 7, 14, 21, 28 y 35 días post-inoculación (dpi). El comportamiento de los cerdos por corral se registró los días -1, 3, 6, 9, 12, 15 y 18 dpi.

Resultados: Durante el periodo de desafío de 35 días, no se detectaron diferencias significativas en la viremia o en el rendimiento de los cerdos debido al tratamiento. En comparación con el control, el aditivo de agua+alimento aumentó el sentado en los cerdos; sin embargo, no se observaron otras diferencias de tratamiento en el comportamiento debido a la enfermedad. Se observó disminución en la actividad los días 6 y 9 pi. El consumo de alimento disminuyó el día 6 pi mientras que el consumo de agua disminuyó a partir del día 6 pi y durante el resto del período de observación conductual a 18 dpi.

Implicaciones: Agregar un aditivo de nutrientes en agua y agua+alimento tuvo un efecto mínimo sobre el comportamiento de la enfermedad y no se observó ningún efecto sobre la viremia o el rendimiento de los cerdos infectados con el PRRSV. La disminución de la actividad, consumo de alimento y agua de bebida puede ayudar a los trabajadores a identificar cerdos con problemas de salud.

JDC: Department of Agricultural Science, Truman State University, Kirksville, Missouri.

SMC, WPS, NKG: Department of Animal Science, Iowa State University, Ames, Iowa.

Corresponding author: Dr Jessica D. Colpoys, 100 E Normal Ave, Kirksville, MO 63501 Tel: 660-785-4593; Email: jcolpoys@truman.edu.

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

Colpoys JD, Curry SM, Schweer WP, Gabler NK. Nutrient supplementation effects on pig performance and sickness behavior during a porcine reproductive and respiratory syndrome virus infection. *J Swine Health Prod.* 2020;28(2):79-86.

Résumé - Effets de suppléments nutritifs sur les performances de porcs et leur comportement maladif durant une infection par le virus du syndrome reproducteur et respiratoire porcin

Objectif: Étudier comment l'inclusion de suppléments nutritifs affecte les performances et le comportement maladif de porcs infectés par le virus du syndrome reproducteur et respiratoire porcin (PRRSV).

Matériels et méthodes: À 10 semaines d'âge, 108 castrats naïfs pour le PRRSV (moyenne de poids corporel [SD]: 31 [1.4] kg) furent répartis dans 18 enclos dans une porcherie commerciale et recrutés pour une étude sur une infection défi avec le PRRSV. À la suite d'une période d'acclimatation de 5 jours, tous les porcs furent inoculés par voies intranasale et intramusculaire avec une souche sauvage de PRRSV et ont débuté les traitements avec les suppléments nutritifs. Les traitements incluaient aucun supplément nutritif (témoin; n = 6 enclos), supplément nutritif dans l'eau (eau; n = 6 enclos), et supplément nutritif dans l'eau et les aliments (eau+aliments; n = 6 enclos). Les performances par enclos furent notées de manière hebdomadaire à 0, 7, 14, 21, 28, et 35 jours post-inoculation (dpi). Le comportement des porcs dans l'enclos fut noté aux jours -1, 3, 6, 9, 12, 15, et 18 dpi.

Résultats: Durant les 35 jours de l'essai, aucune différence significative dans la virémie ou les performances des porcs ne fut rapportée due au traitement. Comparativement aux témoins, le supplément eau+aliment augmenta la position assise chez les porcs; toutefois, aucune autre différence dans le comportement maladif ne fut notée. Une diminution de l'activité fut observée aux jours 6 et 9 dpi. Laprise d'aliment était diminuée au jour 6 dpi alors que la prise d'eau était diminuée à compter du jour 6 dpi jusqu'à la fin de la période d'observation du comportement au jour 18 dpi.

Implications: L'ajout de suppléments nutritifs dans l'eau et dans l'eau+aliment avait un effet minimal sur le comportement maladif et aucun effet observable sur la virémie ou les performances des porcs infectés avec le PRRSV. Une diminution de l'activité, de la prise d'aliment et d'eau pourrait aider les personnes soignant les animaux à identifier les porcs dont la santé est affectée.

Improving swine health is essential for increasing swine welfare and sustainable pork production. Swine health can be challenged by common pathogens such as porcine reproductive and respiratory syndrome virus (PRRSV), costing the US swine industry approximately $664 million per year.[1] These losses are partially explained by reduced growth performance, feed intake, and feed efficiency,[2-4] and the increased occurrence of secondary viral and bacterial infections.[5,6] Little is known about how swine health impacts nutrient utilization; thus, sick pigs may have altered nutrient requirements.[7] An improved understanding of the nutrient requirements of health-challenged pigs can aid in developing solutions for improving swine health and productivity.

Production losses in health-challenged pigs can be partially explained by changes in swine behavior.[8] Sickness behavior is linked to secretion of cytokines which motivate a sick animal to rest and recover.[9] Swine sickness behaviors often include decreased activity and exploratory behaviors, decreased maintenance behaviors such as eating, drinking, and grooming, and increased thermoregulatory behaviors such as huddling and shivering.[10] These behaviors can be important for recovering from immune system challenges.[8] While general swine sickness behavior is well described, little is known about how PRRSV specifically impacts pig behavior. Since reduced eating and drinking behaviors are common in sick pigs, these behavioral differences could alter the efficacy of delivering nutrient additives through feed and water. Further, an improved understanding of the progression of PRRSV sickness behavior could be a valuable tool for early identification of sick pigs.

The objectives of this study were to 1) investigate how nutrient additive inclusion impacts viremia, growth performance, and sickness behavior of pigs infected with PRRSV and 2) evaluate the progression of pig sickness behavior over time during a PRRSV infection.

Materials and methods

Experimental procedures were approved by the Iowa State University Animal Care and Use Committee (IACUC No. 4-15-7993-S). Pigs were housed in a conventional confinement unit with curtain sides and slatted concrete flooring. One hundred eight barrows (PIC Cambro × Landrace and Landrace × PIC Cambro, 31 [1.4] kg mean [SD] body weight [BW], 10-week old, and negative for PRRSV) were evenly blocked by BW and genetics (2 genetic lines were used in this study) into 18 pens (6 pigs/pen). Each pen measured 1.8 × 2.4 m and contained one 0.3 m wide feeder and 1 cup system waterer. Pigs were maintained at thermal neutral temperatures and had *ad libitum* access to feed and water. The diet was formulated to meet or exceed the NRC nutrient and energy requirements for this size pig.[7]

All pigs were PRRSV negative (virus and antibodies) before the start of the study. After a 5-day acclimation to treatment pens, all pigs were inoculated intranasally and intramuscularly with 775 million genomic units of a live field strain of PRRSV (open reading frame 5 sequence 1-18-4) on 0 day post inoculation (dpi). Three nutrient supplement treatments were evaluated: 1) no nutrient supplement (control; n = 6 pens), 2) water nutrient supplement (water; n = 6 pens), and 3) water and feed nutrient supplement (water+feed; n = 6 pens). The water and feed supplements consisted of a liquid nutrient and electrolyte suspension or a dry supplement powder, respectively. Both supplements on a dry matter basis consisted of a proprietary blend of sugar foods by-products, betaine, soy protein isolates, monosodium glutamate, sodium saccharin, L-lysine, DL-methionine, L-threonine, isoleucine, phenylalanine, aspartic acid, valine, ascorbic acid, zinc oxide, and artificial flavors (Techmix LLC). The proprietary liquid suspension stock was suitable for delivery through a 1:128 water medicator and the dry supplement was used per the manufacturer's instructions. The liquid stock was 8.53% crude protein and the powder 32.25% crude protein.

Figure 1 outlines the timeline of PRRSV inoculation and administration of treatments. The control treatment received no added supplement throughout the study. Water additive was provided from 1 to 4 dpi at 1:128 inclusion (1 ounce stock liquid per gallon of water) and increased to 3% inclusion (3.8 ounces stock liquid per gallon of water) from 5 dpi to 8 dpi to account for expected changes in water intake. Water treatment received no supplement from 9 to 13 dpi. A liquid supplement (55% stock plus 45% water) was included at 3% of water intake from 14 to 18 dpi. Water treatment received no nutrient supplementation thereafter. The water+feed treatment received the same 1:128 inclusion of the liquid stock in the water from 1 to 4 dpi and the 3% inclusion rate of liquid stock from 5 to 8 dpi. From 9 to 35 dpi, water+feed treatment was top-dressed with the dry powder at 1.25% of diet or 25 lbs/ton per manufacturer's instructions by hand mixing it into

Figure 1: Water and water+feed treatment nutrient additive schedule. The gray shaded numbers indicate the dpi where sickness behavior was analyzed. The black shaded numbers indicate the dpi where pen feed disappearance, pig BW, and blood samples were collected. Dpi = days post inoculation; BW = body weight.

Treatment	Additive inclusion																								
Water			1:128 Water				3% Water				None					3% of a 55% Diluted water					None				
DPI	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	28	35
Water+ Feed			1:128 Water				3% Water				1.25% Feed														

the mash feed. The top-dress began later (9 dpi) to test if extra nutrients in the diet would enhance pig performance post peak viremia and into recovery as average daily feed intake (ADFI) would increase.

Pigs were snared weekly and blood samples were collected (10 mL) via jugular venipuncture for analysis on 7, 14, 21, 28, and 35 dpi. Blood was allowed to clot and then centrifuged at 2000*g* for 10 minutes at 4° C. Serum was stored at -80° C until analysis at the Iowa State University Veterinary Diagnostic Laboratory for PRRSV serology. Briefly, reverse transcription-polymerase chain reaction (RT-PCR) and serum antibody testing for PRRSV was performed using commercial reagents (VetMAX NA and EU PRRSV RT-PCR, Thermo Fisher Scientific) and a commercial ELISA kit (HerdCheck PRRS X3, IDEXX Laboratories, Inc), respectively. A negative serum viremia cycle threshold (Ct) was ≥ 37 and serology antibody was considered negative with a sample to positive ratio (S:P) ≤ 0.40.

Pig BW and pen feed disappearance was recorded at 7, 14, 21, 28, and 35 dpi. Pig BW was averaged by pen and pen feed efficiency (G:F) was calculated. No pig mortalities occurred over the performance period studied and during the PRRSV challenge.

Home-pen behavior of 10 pens of pigs (control n = 3 pens; water n = 3 pens; water+feed n = 4 pens) was recorded with color cameras (Panasonic, Model WV-CP-484, Matsushita Co LTD) that were positioned above the pens. The cameras fed into a multiplexer using Noldus Portable Lab (Noldus Information Technology, Wageningen, The Netherlands) and time-lapse video was collected onto a computer using HandyAVI (version 4.3, Anderson's AZcendant Software) at 10 frames/s. Video was collected on -1, 3, 6, 9, 12, 15, and 18 dpi (Figure 1). Video observations were recorded using a 10-minute scan sampling interval from 7:00 AM to 7:00 PM daily by one trained observer who was blind to treatments. Percent of pigs standing, lying, sitting, eating, and drinking within each pen was collected (Table 1).

Shapiro-Wilk test and Q-Q plots were used to evaluate the data for normality in SAS (SAS version 9.4, SAS Institute Inc). Performance and serology data were analyzed using the Mixed procedure with treatment, dpi, and the interaction of treatment and dpi used as fixed effects, and pen was the experimental unit. Behavior data were analyzed using the Glimmix procedure of SAS with a beta distribution. Treatment, dpi, and their interaction were included as fixed effects and the number of pigs visible per pen on camera was used as a covariate. Pen was used as a random effect and was considered the experimental unit. Data are reported as treatment least squares means and the significance level was fixed at $P < .05$.

Results

Pig viremia and serology

Pig viremia and antibody titer data are presented in Table 2. All animals were naïve for PRRSV prior to starting the trial. At 7 dpi, all pigs were positive for PRRSV as determined by RT-PCR Ct values on serum samples. There was an effect of dpi on PRRSV titers ($P < .001$), where Ct was the lowest at 7 dpi. The S:P ratio was used to assess PRRSV antibody in the serum. There was an effect of dpi ($P < .001$) on antibody levels where there was no circulating antibody at 7 dpi, but antibody was present from 14 dpi and weekly thereafter. There was no effect of treatment or an interaction on PRRSV titers ($P \geq .12$) or serology ($P \geq .24$, Table 2).

Pig performance and behavior

There was no difference in BW, average daily gain (ADG), ADFI, or G:F during weekly or overall performance among treatments ($P \geq .07$; Table 3). Water+feed treatment pens were observed sitting more than control pens ($P = .008$); however, water treatment did not differ from control or water+feed treatments ($P \geq .13$; Figure 2). No other postures or activities differed by treatment ($P \geq .51$). A dpi by treatment interaction was observed for lying ($P = .01$), but no other dpi by treatment interactions were observed ($P \geq .08$).

Lying, sitting, and standing postures differed across dpi ($P < .001$). On -1 dpi, 75.5% of pigs per pen were observed lying, 0.8% of pigs per pen were observed sitting, and 22.7% of pigs per pen were observed standing. No posture differences were observed from -1 to 3 dpi ($P \geq .19$). Compared to -1 dpi, lying increased and standing decreased 6 and 9 dpi ($P < .001$), and both returned to pre-inoculation rates by 12 dpi ($P \geq .38$; Figure 3A and B). Sitting 3 to 12 dpi was similar to pre-inoculation rates ($P \geq .19$) and increased on 15 and 18 dpi compared to -1 dpi ($P \leq .02$; Figure 3C). Eating and drinking behaviors differed across dpi ($P < .001$). On -1 dpi, 11.5% of pigs per pen were observed eating and 4.1% of pigs per pen were observed drinking. No differences in eating behavior were observed from -1 to 3, 9, 12, or 15 dpi ($P \geq .08$). Compared to -1 dpi, eating decreased at 6 dpi and increased at 18 dpi ($P \leq .02$; Figure 4A). Drinking behavior was similar to pre-inoculation rates on 3 dpi ($P = .67$) but was decreased 6 through 18 dpi compared to -1 dpi ($P \leq .02$; Fig. 4B).

Discussion

It was hypothesized that the addition of a nutrient and electrolyte additive through the water or top-dressed in the feed would reduce the negative impact of PRRSV. However, the nutrient additive had minimal effects on sickness behavior and no observed effects on viremia or performance of pigs infected with PRRSV. The ability of diets and feed additives to modulate PRRSV-challenged

Table 1: Ethogram of behaviors recorded via 10-minute scan sampling

Behavior	Definition
Standing	All four hooves were on the pen floor with limbs extended or the pig was walking with limbs in both extension and flexion.
Lying	The pig's body and limbs were in contact with the pen floor.
Sitting	The front limbs were extended and bearing weight and the rear limbs and body were in contact with the pen floor.
Eating	The pig's mouth and nose were inside the feeder.
Drinking	The pig's mouth and nose were inside the waterer.

Table 2: Viremia and antibody titers of barrows inoculated with PRRSV and supplemented with a water only or water and feed additive

		Additive			*P**		
Parameter	**Control**	**Water**†	**Water+Feed**†‡	**SEM**	**TRT**	**DPI**	**TRT × DPI**
PRRSV titer (RT-PCR Ct§)							
7 dpi	20.47[c]	20.78[c]	20.92[c]	0.53	.12	< .001	.99
14 dpi	29.08[b]	31.22[b]	30.90[b]				
21 dpi	29.58[b]	30.88[b]	30.98[b]				
28 dpi	35.92[a]	36.02[a]	36.62[a]				
35 dpi	35.65[a]	36.85[a]	36.63[a]				
PRRSV antibody (S:P ratio¶)							
7 dpi	0.38[b]	0.52[b]	0.36[b]	0.10	.24	< .001	.69
14 dpi	1.91[a]	1.77[a]	1.91[a]				
21 dpi	1.91[a]	1.75[a]	1.98[a]				
28 dpi	2.00[a]	1.82[a]	1.94[a]				
35 dpi	1.90[a]	1.79[a]	1.90[a]				

* Data were analyzed using the Mixed procedure of SAS with treatment, dpi, and the interaction of treatment and dpi used as fixed effects, and pen was the experimental unit.

† Water additive provided from 1 to 4 dpi at 1:128 inclusion, increased to 3% inclusion from 5 to 8 dpi. A 55% additive (45% water) was included at 3% from 14 to 18 dpi. Water+feed treatment did not receive water additive after 8 dpi.

‡ Feed additive was included at 1.25% of diet. It was hand mixed into diet from 9 to 35 dpi.

§ A Ct ≥ 37 is considered negative.

¶ An S:P ratio ≤ 0.40 is considered negative.

a,b,c Values followed by different superscripts differ statistically ($P < .05$).

PRRSV = porcine reproductive and respiratory syndrome virus; SEM = standard error of the mean; TRT = treatment; dpi = days post inoculation; RT-PCR = reverse transcription-polymerase chain reaction; Ct = cycle threshold; S:P = sample to positive ratio.

pig growth performance,[11-13] viremia, and seroconversion have had mixed results. Studies evaluating the impact of dietary modifications on PRRSV observed improved immune response of pigs receiving high soybean meal diets[11] and soy-derived isoflavones.[12,14,15] In the current study, however, there was no effect of treatment or an interaction on PRRSV titers or serology, which is consistent with other work from our group.[13] The results of the current study could be due to inadequate additive dosage, timing, or nutrient blend.

All animals were naïve for PRRSV prior to starting the trial. At 7 dpi, all pigs were positive for PRRSV as determined by RT-PCR Ct values on serum samples. Cycle threshold was the lowest at 7 dpi, indicating greater virus present in serum at 7 dpi compared with all other time points. Peak PRRSV viremia is typically within the first 7 dpi,[16] but can persist up to 15 dpi.[17] There was no circulating antibody at 7 dpi, but antibody was present from 14 dpi and weekly thereafter. This is consistent with other studies evaluating PRRSV antibody production.[18,19] Circulating antibodies have been detected for PRRSV as early as 9 dpi and have persisted through 105 dpi.[17]

From 0 to 7 dpi, all treatments were on average gaining 46% less and consuming 32% less than the predicted ADG and ADFI, respectively for 25 to 50 kg pigs.[7] This agrees with data where 0 to 14 dpi ADG and ADFI was reduced by 43% and 30%, respectively in pigs challenged with PRRSV compared with naïve pigs.[18] From 7 to 14 dpi, all treatments were improving performance, but were still

Table 3: Growth performance of barrows inoculated with PRRSV and supplemented with a water only or water and feed additive

Parameter	Control	Additive		SEM	P[‡]
		Water*	Water+Feed*[†]		
Start BW, kg	31.67	31.55	30.92	0.73	.77
0 – 7 dpi					
End BW, kg	34.84	34.59	34.50	0.90	.96
ADG, kg/d	0.45	0.44	0.51	0.06	.63
ADFI, kg/d	1.07	1.08	1.07	0.03	.93
G:F	0.43	0.39	0.48	0.05	.52
7 – 14 dpi					
End BW, kg	38.57	38.70	37.90	0.79	.75
ADG, kg/d	0.54	0.59	0.49	0.05	.34
ADFI, kg/d	1.12	1.17	1.13	0.03	.43
G:F	0.48	0.50	0.43	0.04	.46
14 – 21 dpi					
End BW, kg	43.20	44.18	43.41	0.69	.59
ADG, kg/d	0.66	0.78	0.72	0.05	.30
ADFI, kg/d	1.61	1.63	1.48	0.05	.07
G:F	0.41	0.48	0.48	0.03	.19
21 – 28 dpi					
End BW, kg	52.24	52.87	52.15	0.86	.82
ADG, kg/d	1.29	1.15	1.25	0.06	.27
ADFI, kg/d	2.23	2.05	2.09	0.05	.08
G:F	0.58	0.56	0.60	0.03	.74
28 – 35 dpi					
End BW, kg	58.35	59.80	58.28	0.82	.36
ADG, kg/d	0.88	0.99	0.88	0.05	.14
ADFI, kg/d	2.20	2.28	2.30	0.08	.66
G:F	0.40	0.44	0.38	0.02	.32
Overall (0-35)					
ADG, kg/d	0.76	0.81	0.78	0.02	.25
ADFI, kg/d	1.65	1.65	1.61	0.03	.69
G:F	0.46	0.49	0.49	0.01	.29

* Water additive provided from 1 to 4 dpi at 1:128 inclusion, increased to 3% inclusion from 5 to 8 dpi. A 55% additive (45% water) was included at 3% from 14 to 18 dpi. Water+feed treatment did not receive water additive after 8 dpi.

† Feed additive was included at 1.25% of diet. It was hand mixed into diet from 9 to 35 dpi.

‡ Data were analyzed using the Mixed procedure of SAS with treatment, dpi, and the interaction of treatment and dpi used as fixed effects, and pen was the experimental unit.

PRRSV = porcine reproductive and respiratory syndrome virus; SEM = standard error or the mean; BW = body weight; dpi = days post inoculation; ADG = average daily gain; ADFI = average daily feed intake; G:F = pen feed efficiency.

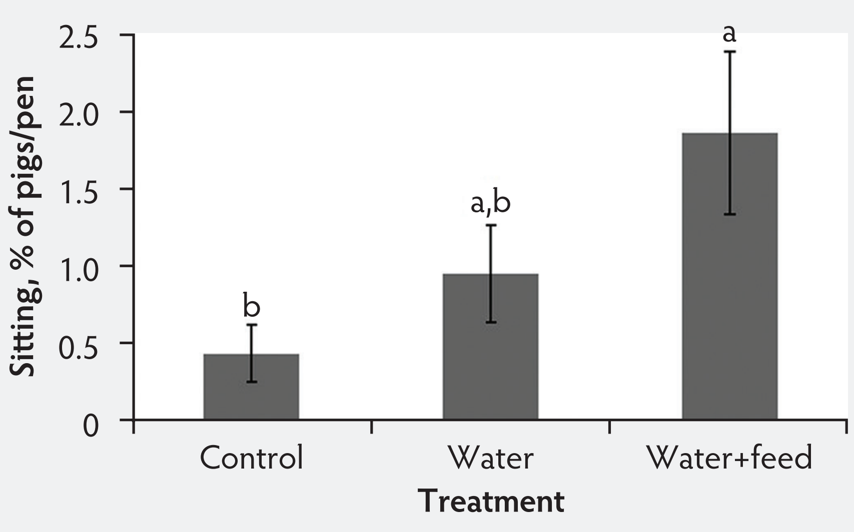
gaining 29% less and consuming 28% less than predicted performance for 25 to 50 kg pigs.[7] This is similar to previous research that has shown PRRSV-infected pigs had decreased ADFI within the first 14 dpi.[11] From 28 to 35 dpi, pigs were on average performing similar to predicted performance for 25 to 50 kg pigs.[7]

Activity differed across dpi, as pigs were observed lying more and standing less on 6 and 9 dpi compared to pre-inoculation rates. Decreased activity is a classic sickness response that is important for facilitating recovery.[8] In the current study, no posture differences were identified until 6 dpi. This is in contrast to a PRRSV infection in 6-week old pigs, where activity differences were observed starting at 2 dpi.[20] As peak viremia occurred 7 dpi in the current study and typically occurs within the first 7 dpi,[16] these postures did not give an early indication of PRRS infection. Sitting was increased on 15 and 18 dpi compared to -1 dpi, which may be related to seroconversion and viral clearance or recovery.

Eating and drinking behaviors differed across dpi. Compared to -1 dpi, eating decreased at 6 dpi and increased at 18 dpi. This is in contrast to 6-week old pigs infected with PRRSV, which exhibited decreased time spent eating and average daily feed intake 1 to 13 dpi.[20] Increased eating behavior at 18 dpi may be related to seroconversion commonly seen by 21 dpi in PRRSV-infected pigs,[4] or a natural change in eating behavior as pigs grew.[21] Drinking behavior was decreased 6 through 18 dpi compared to -1 dpi. Since pigs regained normal eating behavior quicker than drinking behavior, it could suggest that feed delivery of supplements would increase consumption compared to water delivery. However, it is possible that drinking patterns changed as the pigs grew;[21] thus, inclusion of an uninfected, negative control group and water meters affixed to individual pens would have been beneficial. Nevertheless, as water delivery of supplements and medications are common within the swine industry, further investigation of PRRSV impacts on drinking behavior and nutrient delivery are warranted.

In conclusion, the addition of a nutrient and electrolyte additive through the water or top-dressed in the feed had minimal effects on sickness behavior and no observed effects on viremia or performance of pigs infected with PRRSV. However, this study helped improve our understanding of behavioral changes during a PRRSV infection in 10-week old pigs. When behavior was evaluated every 3 days, decreased activity was observed 6 and 9 dpi. While these behaviors did not serve as an early indication of PRRSV infection (ie, before the approximate time of peak viremia), they may help caretakers identify pigs currently undergoing a PRRSV infection. Eating behavior was decreased 6 dpi whereas drinking behavior was decreased from 6 dpi throughout the rest of the behavioral observation period at 18 dpi. Thus, reduced drinking behavior in pigs undergoing a PRRSV infection could impact the efficacy of nutrient supplement delivery.

Figure 2. Percent of pigs observed sitting per pen (least squares means and SE) across all observation days when given no nutrient supplement (control; n = 3 pens), water nutrient supplement (water; n = 3 pens), and water and feed nutrient supplement (water+feed; n = 4 pens). Different superscripts indicate significance at *P* < .05.



Implications

Under the conditions of this study:

- Nutrient additives minimally impacted PRRSV-infected pig performance.
- Nutrient additives minimally impacted PRRSV-infected pig behavior.
- Decreased activity and ingestive behaviors can be indicative of sick pigs.

Acknowledgments

This project was supported by the National Pork Board Grant No.15-099 and Truman State University's Grants-in-Aid of Scholarship and Research. We would like to thank the undergraduate research assistants and Dr Anna Johnson for assistance in data collection and Dr Caitlyn Bruns for statistical consulting.

Conflict of interest

None reported.

Disclaimer

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

References

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

2. Greiner LL, Stahly TS, Stabel TJ. Quantitative relationship of systemic virus concentration on growth and immune response in pigs. *J Anim Sci*. 2000;78(10):2690-2695. doi:10.2527/2000.78102690x

3. Escobar J, Van Alstine WG, Baker DH, Johnson RW. Decreased protein accretion in pigs with viral and bacterial pneumonia is associated with increased myostatin expression in muscle. *J Nutr*. 2004;134(11):3047-3053. doi:10.1093/jn/134.11.3047

Figure 3: Percent of pigs observed A) lying, B) standing, and C) sitting per pen (least squares means and SE) across days post inoculation (dpi) with porcine reproductive and respiratory syndrome virus. Different superscripts indicate significance at $P < .05$.

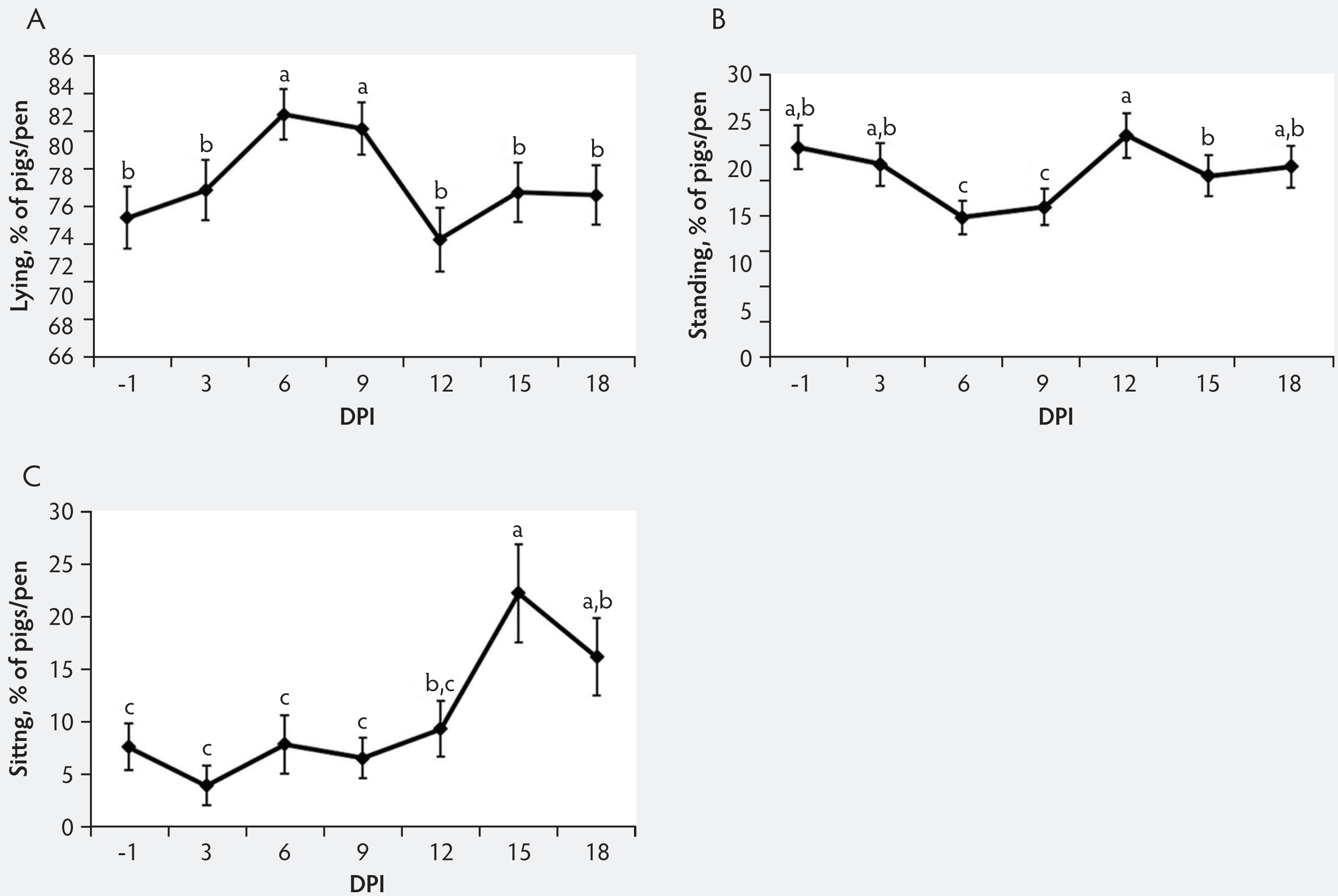
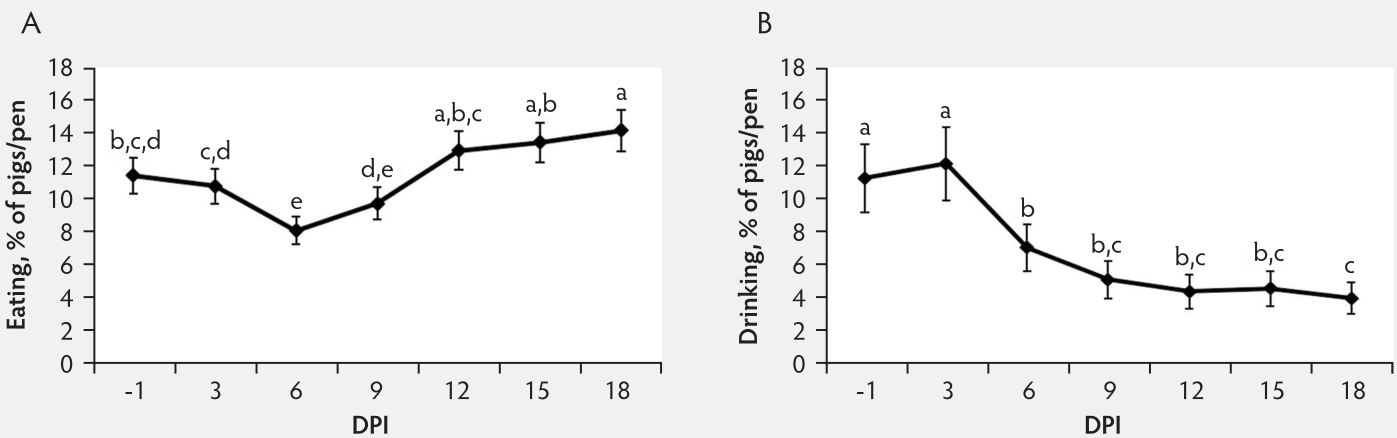


Figure 4: Percent of pigs observed A) eating and B) drinking per pen (least squares means and SE) across days post inoculation (dpi) with porcine reproductive and respiratory syndrome virus. Different superscripts indicate significance at $P < .05$.



4. Schweer WP, Schwartz K, Burrough ER, Yoon KJ, Sparks JC, Gabler NK. The effect of porcine reproductive and respiratory syndrome virus and porcine epidemic diarrhea virus challenge on growing pigs I: Growth performance and digestibility. *J Anim Sci*. 2016;94(2):514-522. doi:10.2527/jas.2015-9834

5. Van Reeth K, Nauwynck H, Pensaert M. Dual infections of feeder pigs with porcine reproductive and respiratory syndrome virus followed by porcine respiratory coronavirus or swine influenza virus: a clinical and virological study. *Vet Microbiol*. 1996;48(3):325-335. doi:10.1016/0378-1135(95)00145-X

6. Nakamine M, Kono Y, Abe S, Hoshino C, Shirai J, Ezaki T. Dual infection with enterotoxigenic *Escherichia coli* and porcine reproductive and respiratory syndrome virus observed in weaning pigs that died suddenly. *J Vet Med Sci*. 1998;60(5):555-561. doi:10.1292/jvms.60.555

7. National Research Council (NRC). *Nutrient Requirements of Swine*. 11th ed. Washington, DC: National Academies Press; 2012.

8. Hart BL. Biological basis of the behavior of sick animals. *Neurosci Biobehav Rev*. 1988;12(2):123-137. doi:10.1016/S0149-7634(88)80004-6

9. Johnson RW. The concept of sickness behavior: a brief chronological account of four key discoveries. *Vet Immunol Immunopathol*. 2002;87:443-450. doi:10.1016/S0165-2427(02)00069-7

10. Millman ST. Sickness behaviour and its relevance to animal welfare assessment at the group level. *Anim Welf*. 2007;16(2):123-125.

11. Rochell SJ, Alexander LS, Rocha GC, Van Alstine WG, Boyd RD, Pettigrew JE, Dilger RN. Effects of dietary soybean meal concentration on growth and immune response of pigs infected with porcine reproductive and respiratory syndrome virus. *J Anim Sci*. 2015;93(6):2987-2997. doi:10.2527/jas.2014-8462

12. Smith BN, Morris A, Oelschlager ML, Connor J, Dilger RN. Effects of dietary soy isoflavones and soy protein source on response of weanling pigs to porcine reproductive and respiratory syndrome viral infection. *J Anim Sci*. 2019;97(7):2989-3006.

13. Schweer WP, Mendoza OF, Shull CM, Lehman J, Gaines A, Schwartz K, Gabler NK. Increased lysine: metabolizable energy ratio improves grower pig performance during a porcine reproductive and respiratory syndrome virus challenge. *Transl Anim Sci*. 2019;3(1):393-407. doi:10.1093/tas/txy108

14. Greiner LL, Stahly TS, Stabel TJ. The effect of dietary soy genistein on pig growth and viral replication during a viral challenge. *J Anim Sci*. 2001;79:1272-1279.

15. Greiner LL, Stahly TS, Stabel TJ. The effect of dietary soy daidzein on pig growth and viral replication during a viral challenge. *J Anim Sci*. 2001;79:3113-3119.

16. Islam ZU, Bishop SC, Savill NJ, Rowland RR, Lunney JK, Trible B, Doeschl-Wilson AB. Quantitative analysis of porcine reproductive and respiratory syndrome (PRRS) viremia profiles from experimental infection: A statistical modelling approach. *PLoS One*. 2013;8(12):e83567. doi:10.1371/journal.pone.0083567

17. Yoon K-J, Zimmerman JJ, Swenson SL, McGinley MJ, Eernisse KA, Brevik A, Rinehart LL, Frey ML, Hill HT, Platt KB. Characterization of the humoral immune response to porcine reproductive and respiratory syndrome (PRRS) virus infection. *J Vet Diagn Invest*. 1995;7(3):305-312. doi:10.1177/104063879500700302

*18. Schweer WP. Impact of PRRS and PED viruses on grower pig performance and intestinal function [MS Thesis]. Ames: Iowa State University; 2015. https://lib.dr.iastate.edu/etd/14492.

19. Schweer WP, Patience JF, Burrough ER, Kerr BJ, Gabler NK. Impact of PRRSV infection and dietary soybean meal on ileal amino acid digestibility and endogenous amino acid losses in growing pigs. *J Anim Sci*. 2018;96(5):1846-1859. doi:10.1093/jas/sky093

20. Escobar J, Van Alstine WG, Baker DH, Johnson RW. Behaviour of pigs with viral and bacterial pneumonia. *Appl Anim Behav Sci*. 2007;105(1):42-50. doi:10.1016/j.applanim.2006.06.005

21. Bigelow JA, Houpt TR. Feeding and drinking patterns in young pigs. *Physiol Behav*. 1988;43(1):99-109.

* Non-refereed reference.

A retrospective investigation of risk factors associated with loads of pigs positive for Senecavirus A at a midwestern US packing plant during the summer of 2017

Gustavo S. Silva, DVM, MS, PhD; Katyann Graham; Victoria Novak, MS; Derald J. Holtkamp, DVM, MS; Daniel C. L. Linhares, DVM, MBA, PhD

Summary

This study describes a spatio-temporal cluster of Senecavirus A (SVA) outbreaks reported in a midwestern US slaughter plant during the summer of 2017. Data was collected on multiple site characteristics to conduct risk factor analysis. On June 8, 2017, 6 of 10 finishing pig lots delivered to the plant tested positive by reverse transcription-polymerase chain reaction for SVA RNA. Subsequently, 88 lots presented vesicular lesions at the plant, and 74 lots tested positive between June 8 and July 10, 2017, which was a significant temporal cluster.

Keywords: swine, Senecavirus A, vesicular disease, market pigs, packing plants.

Received: June 1, 2019
Accepted: November 11, 2019

Resumen - Una investigación retrospectiva de los factores de riesgo asociados con embarques de cerdos positivos para el Senecavirus A en una planta empacadora del medio oeste de los EE UU durante el verano de 2017

Este estudio describe un grupo espacio-temporal de brotes del Senecavirus A (SVA) notificados en una planta de sacrificio del medio oeste de los EE UU durante el verano de 2017. Se recopilaron datos sobre las características de múltiples sitios para realizar un análisis de factores de riesgo. El 8 de junio de 2017, 6 de cada 10 lotes de cerdos de engorda entregados a la planta dieron positivo por reacción en cadena de transcripción reversa de la polimerasa para el ARN del SVA. Posteriormente, 88 lotes presentaron lesiones vesiculares en la planta, y 74 lotes dieron positivo entre el 8 de junio y el 10 de julio de 2017, siendo un grupo temporal significativo.

Résumé - Enquête rétrospective sur les facteurs de risque associés avec des chargements de porcs positifs pour le Senecavirus A dans un abattoir du midwest Américain durant l'été 2017

La présente étude décrit un regroupement spatio-temporel de poussées de cas de Senecavirus A (SVA) rapportées dans un abattoir du midwest Américain durant l'été 2017. Les données furent amassées sur les caractéristiques de sites multiples afin de mener une analyse des facteurs de risque. Le 8 juin 2017, 6 des 10 lots de porcs amenés à l'abattoir testèrent positifs par réaction d'amplification en chaîne par la polymérase avec la transcriptase réverse pour l'ARN de SVA. Subséquemment, 88 lots amenés à l'abattoir ont présenté des lésions vésiculaires, et 74 lots ont testé positif entre le 8 juin et le 10 juillet 2017, ce qui représente un regroupement temporel significatif.

Senecavirus A (SVA) is a virus of the genus *Senecavirus* of the family Picornaviridae. The virus causes vesicular lesions around the snout, mouth, and hooves of pigs,[1] and was first identified in North America in 2002 as a cell culture contaminant.[2,3] In 2014 and 2015, SVA infection was also associated with outbreaks of neonatal pig mortality in Brazil and in the United States.[4-7]

Clinical signs associated with SVA include erosions, ulcerations, and vesicular lesions of the snout, oral mucosa, and coronary band of distal limbs. Clinically, SVA may be indistinguishable from foot-and-mouth disease (FMD) and other swine vesicular diseases. Since FMD is designated as a foreign animal disease (FAD) by the US Department of Agriculture (USDA), every clinical case with lesions characteristic of SVA or FMD, including cases recognized at packing plants, must be investigated to rule out the occurrence of an FAD. According to the USDA's Veterinary Services Guidance Document 7406.3, an FAD investigation must be conducted by state or federal animal health officials.[8] These investigations take time and resources from state and federal animal health officials and market personnel because pigs and products cannot move until tests confirm the absence of an FAD.

GSS, KG, DJH, DCLL: Veterinary Diagnostic and Production Animal Medicine Department, College of Veterinary Medicine, Iowa State University, Ames, Iowa.

VN: College of Veterinary Medicine, University of Missouri, Columbia, Missouri.

Corresponding author: Dr Gustavo S. Silva, 1809 S Riverside Drive, Ames, IA 50011; Tel: 515-708-6622; Email: gustavos@iastate.edu.

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

Silva GS, Graham K, Novak V, Holtkamp DJ, Linhares DCL. A retrospective investigation of risk factors associated with loads of pigs positive for Senecavirus A at a midwestern US packing plant during the summer of 2017. *J Swine Health Prod.* 2020;28(2):87-92.

Currently, there is limited data on the transmission and spread of SVA in the swine industry. This report describes an assessment of spatio-temporal dynamics, as well as an investigation of risk factors associated with a spike in the number of lots of pigs testing positive for Senecavirus A at a midwestern US packing plant during the summer of 2017. The retrospective analysis conducted of all farms that provided animals to the packing plant during the investigation period (April 24, 2017 to August 8, 2017). The investigation, which was completed after the USDA ruled out FMD and confirmed SVA, aimed to describe epidemiological factors associated with the spike in the number of lots of pigs testing positive for Senecavirus A at a packing plant.

Case description

SVA investigation background

On June 8, 2017, 10 lots of finishing pigs were detected with vesicular lesions at a midwestern US packing plant. After the FAD Diagnostic Laboratory (FADDL) ruled out FMD, the lots were tested by reverse transcription-polymerase chain reaction (RT-PCR) for SVA RNA and 6 of the 10 lots were confirmed SVA positive. Between June 9, 2017 and July 10, 2017, 74 lots presenting vesicular lesions at the same plant were confirmed SVA positive by RT-PCR. All cases were negative for FMD based on diagnostic testing at an FADDL. Following the confirmation of SVA-positive cases, an investigation was conducted to describe the cluster of cases and to identify factors that may have contributed to the spread of the virus. The investigation was conducted using data provided by the packing plant. The suppliers of pigs to the plant were not contacted nor were any of the sites from which pigs originated visited.

Case definition

A lot of pigs was defined as all pigs from a single supplier in a truck load, consisting of up to approximately 170 market weight pigs. For the purpose of this study, the SVA status of each lot was used to classify the pig supplier (farm of origin). A case was defined as a pig supplier, which had a lot of pigs test positive for SVA RNA by RT-PCR after arriving at the packing plant. A single truck load with pigs from multiple suppliers would have multiple lots. During the investigation period, all lots that had clinical signs suggestive of vesicular disease were tested for SVA RNA by RT-PCR unless a previous test on pigs from the same supplier had already tested positive.

Data

During the investigation period (April 24 to August 8, 2017) retrospective information on all suppliers that delivered pigs to the study packing plant were obtained from the plant records. The investigation period was broken into 3 periods based on the data obtained by the packing plant, the pre-outbreak period from April 24 to June 7 (45 days), the outbreak period when SVA-positive cases were reported from June 8 to July 10 (32 days), and the post-outbreak period after the last positive case was reported from July 11 to August 8 (35 days). The supplier code, supplier address, and harvest date were provided for 237 suppliers that delivered lots of pigs to the packing plant during the investigation period. For each lot, the packing plant identified if the pigs were delivered to the packing plant through a buying station and whether the pigs for a single supplier originated from multiple sites. For suppliers with multiple sites, the exact number and address of all the sites was unknown. Therefore, the single address provided for the supplier by the packing plant was used to represent the multiple sites within the same geographic area. The harvest dates of the lots were collected to evaluate spatial-temporal clusters of SVA-associated swine vesicular disease cases during the outbreak. The address of each pig supplier was provided by the packing plant and subjectively assessed using Google Earth maps to verify that it was a swine site and to assess if pigs were raised outdoors (absence of confinement buildings, presence of fences and walls forming outdoor pens, or presence of hoop structures) or indoors (presence of a confinement barn). This assessment was subjectively based on the type of animal housing facilities present in the satellite image.

To describe weather conditions during the investigation period, mean daily measurements were compared against the mean from 30-year historical data on a weekly basis and described as a percentage of the mean historical value. The data for temperature, relative humidity, and rainfall precipitation were collected from a single weather station 25 kilometers north of the packing plant using Iowa Environmental Mesonet.[9] The mean historical data for temperature and rainfall at the same weather station was extracted from Weather Underground[10] and for humidity from Current Results.[11]

Data analysis

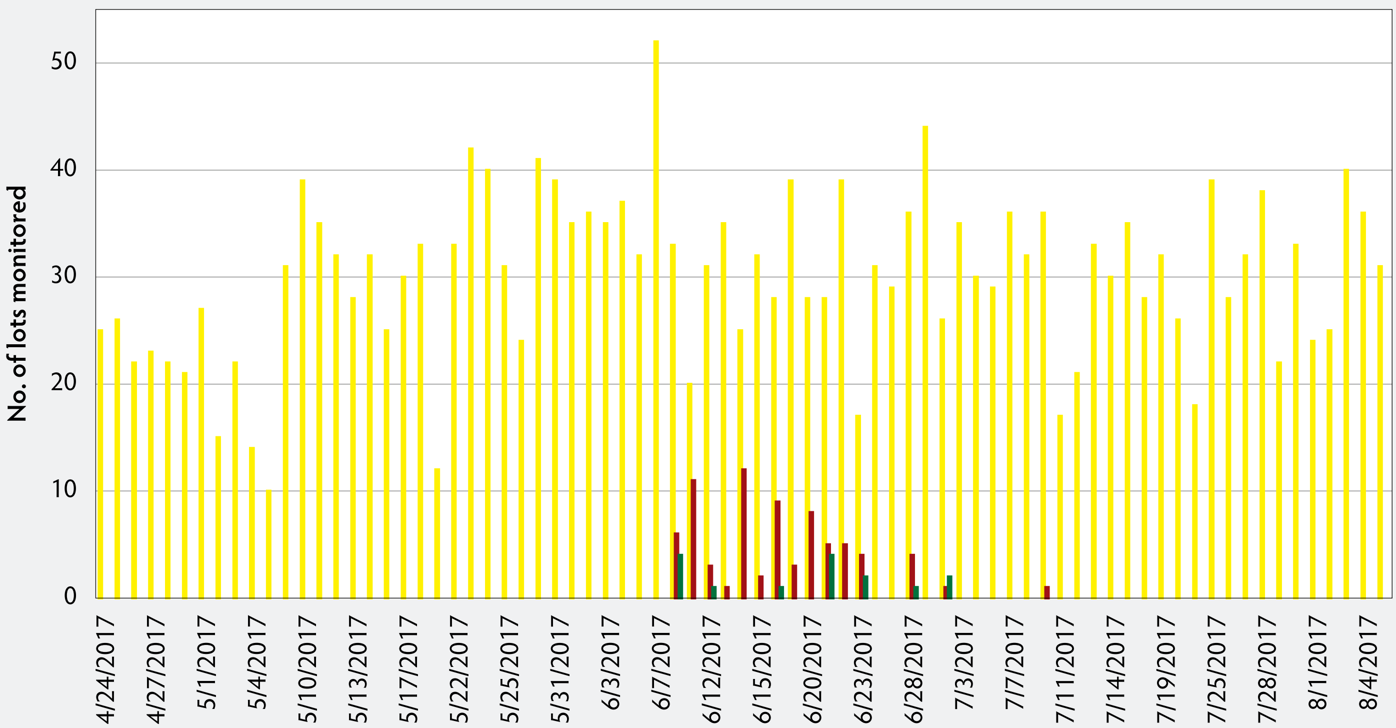
Descriptive analysis was performed on all data collected and odds ratios from univariate logistic regressions were computed to assess risk factors ($P < .05$). The univariate analyses were done using the R software (version 3.3.3; R Core Team) and the R Stats Package. The risk factors were: if the supplier raised pigs outdoors (Yes or No), if the pigs from the supplier were delivered to the packing plant through a buying station (Yes or No), and the supplier location type (multiple or single). Pigs from suppliers with a single location type all originated from a single site. Pigs from suppliers with a multiple location type originated from multiple sites within the same 1-mile geographic area.

Retrospective local space-time clustering was evaluated using the Bernoulli model of the space-time scan statistic, which compares the number of observed cases occurring within all possible cylindrical windows with the expected number of cases falling in that window under the null hypothesis of random distribution of cases. The scan analysis was run assuming a maximum window size set for up to 50% of the population at risk and with a temporal window of 1 day because the outbreak investigation period was short. The spatial-temporal analyses were performed using SaTScan software (Kulldorf and Information Management Services) and the spatialization of the sites were performed in QGIS software (QGIS Development Team). Eligibility criteria to include suppliers in the analyses were: 1) the address listed for the supplier could be located in Google Earth, 2) swine facilities were present at the location, and 3) the supplier had delivered one or more lots of pigs to the study packing plant during the investigation period.

Results and Discussion

Data was obtained from the packing plant for 237 suppliers who sent pigs to the plant during the investigation period (Figure 1). Data on lots of pigs from 44 of the suppliers were excluded from the analysis because the address listed for the supplier could not be located using Google Earth or because the location at the address appeared to lack

Figure 1: Lots of finishing pigs monitored for SVA at a midwestern US packing plant from April 24 to August 8, 2017. Lots tested positive for SVA by RT-PCR (n = 74; red bars), tested negative for SVA by RT-PCR (n = 14; green bars), or not tested (n = 2290; yellow bars) throughout the investigation period. SVA = Senecavirus A; RT-PCR = reverse transcription-polymerase chain reaction.



swine facilities. The remaining 193 suppliers sent 2378 lots of pigs to the packing plant during the investigation period. Of the 193 suppliers, 66 had at least 1 lot of pigs that was tested for SVA by RT-PCR because vesicular lesions were observed at the packing plant, and 61 had lots that were confirmed SVA positive by RT-PCR between June 8, 2017 and July 10, 2017. The onset of the outbreak and all the lots monitored during the investigation period are described in Figure 1. The timing of SVA cases was consistent with a seasonal peak in cases during the summer months.[12]

Of the 193 suppliers, 38 raised pigs outdoors, 22 sent pigs through a buying station, and 60 sent pigs from multiple sites (Table 1). One of the risk factors evaluated was the frequency of SVA-positive pigs from lots going through buying stations compared to those coming directly to the plant from the site where the pigs were raised. However, there was no difference in the odds of testing positive for SVA by RT-PCR between lots of pigs delivered through a buying station and those directly shipped from the site where they were raised. The odds of a supplier that raised pigs outdoors having a lot that tested positive for SVA was 0.34 (95% CI, 0.12-0.81, $P = .01$), or 66% less compared to suppliers that raised pigs indoors. The odds of suppliers with single type sites having a lot that tested SVA positive was 0.58 (95% CI, 0.34-1.1, $P = .09$), or 42% less compared to suppliers with multiple type sites.

Combined, those 2 'protective' risk factors (outdoor pigs and originating from single sites) may be explained by these suppliers likely being smaller, not part of a larger production system, and having less contact with other sites (eg, shared equipment or trucks). Fewer connections may serve as a protective factor since the frequency of events in a swine farm (eg, frequency of feed delivery and rendering dead pigs) has been shown to be a significant risk factor for disease transmission and spread.[13,14]

The relative humidity in weeks 1 to 6 was above the mean historical values. In weeks 2, 3, and 6, daily high temperatures were above historical mean values and greater than mean historical rainfall events occurred in weeks 1 and 4 (Table 2). While it is unclear why cases of SVA tend to increase in summer months, one possible hypothesis is that SVA is transmitted from one herd to another by flying insects. However, vectors are of negligible importance in the epidemiology of the disease.

Joshi et al[15] conducted a diagnostic investigation in 2 SVA-affected herds and detected SVA in environmental samples, mice, and houseflies. The results of this investigation do not challenge that hypothesis since the warm and humid weather conditions before and during the cluster of SVA cases at the packing plant were favorable for flying insects to live and reproduce.[16] Humidity and temperatures remained at or above the 30-year mean during the outbreak and another rainfall event led to above normal rainfall in week 8. Although descriptive, our findings support that weather conditions were favorable for the reproduction of flying insects, which may have contributed to the spread of SVA between sites. However, the finding that pigs raised outdoors was a protective risk factor may contradict that hypothesis since pigs raised outdoors are generally more accessible to flying insects.

Table 1: Risk factors associated with lots testing positive for SVA by RT-PCR at a midwestern US pork plant between April 24 to August 8, 2017

	Lots tested for SVA by RT-PCR					
	Negative or not tested, No.*	Negative or not tested, %	Positive, No.	Positive, %	OR (95% CI)†	*P*‡
Pigs raised outdoors						
Yes (n = 38)	32	84.2	6	15.8	0.34 (0.12-0.81)	.01
No (n = 155)	100	64.5	55	35.5		
Buying station						
Yes (n = 22)	17	77.3	5	22.7	0.60 (0.19-1.61)	.34
No (n = 171)	115	67.3	56	32.7		
Supplier location type						
Single site (n = 133)	96	72.2	37	27.8	0.58 (0.34-1.10)	.09
Multiple sites (n = 60)	36	60.0	24	40.0		

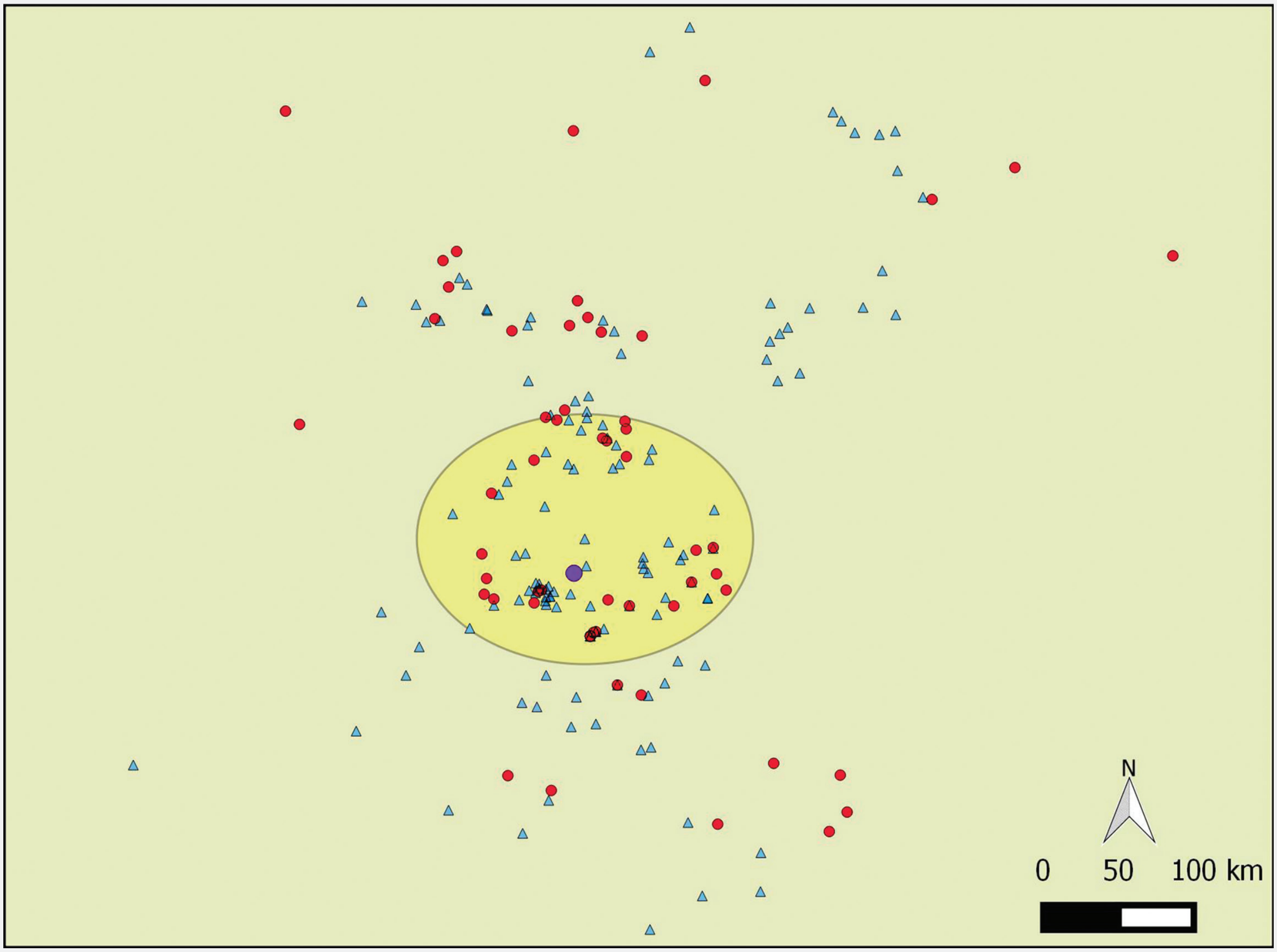
* Only lots of pigs showing clinical signs of vesicular disease were tested.
† Odds ratio of a lot testing positive for SVA by RT-PCR if the supplier had (yes) the factor evaluated.
‡ Presence of lots testing positive (yes or no) were compared using logistic regression with a model that included the risk factor (pigs raised outdoors, buying station and supplier location type) as the main effect.
SVA = Senecavirus A; RT-PCR = reverse transcription-polymerase chain reaction; OR = odds ratio.

Table 2: Weekly weather data compared to the 30-year mean over the investigation period for humidity, temperature, and rainfall precipitation.

			Humidity high, %		Temperature high, °C		Rainfall precipitation, mm	
Week	Investigation period*	No. of cases	2017	% of historical mean†	2017	% of historical mean†	2017	% of historical mean†
1	4/24–4/30	0	86.6	**111**	10.0	76	8.3	**327**
2	5/1–5/7	0	84.4	**106**	21.7	**103**	1.2	42
3	5/8–5/14	0	82.6	**104**	25.0	**109**	2.1	69
4	5/15-5/21	0	93.0	**117**	17.9	88	12.3	**367**
5	5/22-5/28	0	86.0	**108**	21.7	95	0.1	3
6	5/29-6/4	0	88.7	**110**	27.9	**106**	0.0	0
7	6/5-6/11	17	75.3	93	31.5	**111**	0.0	0
8	6/12-6/18	27	88.3	**109**	30.3	**106**	5.7	**161**
9	6/19-6/25	25	79.4	98	28.3	99	0.0	0
10	6/26-7/2	5	87.9	**108**	28.5	97	3.3	99
11	7/3-7/9	0	86.9	**105**	32.1	**104**	0.0	0
12	7/10-7/16	1	91.6	**111**	31.9	**103**	3.1	**113**
13	7/17-7/23	0	90.1	**109**	33.5	**106**	0.1	3
14	7/24-7/30	0	91.6	**111**	29.8	100	4.5	**171**
15	7/31-8/6	0	92.6	**109**	25.1	90	3.3	**121**
16	8/7-8/9	0	98.5	**116**	25.8	92	0.0	0

* The investigation period occurred from April 24 to August 8, 2017 and consisted of 3 periods: pre-outbreak (week 1-6); outbreak when Senecavirus A-positive cases were reported (week 7-12); and post outbreak after the last positive case was reported (week 13-16).
† Values in bold are above the 30-year mean for that week.

Figure 2: Cluster map showing the location of suppliers during an SVA outbreak between June 8 and June 28, 2017. Red dots represent supplier addresses that had at least one lot of pigs that tested positive for SVA by RT-PCR at the packing plant, blue triangles represent supplier addresses with lots of pigs that tested negative for SVA by RT-PCR at the plant, and the purple dot is the packing plant. The yellow circle is the geographic cluster containing 81 supplier locations, 32 of which had at least one SVA-positive lot of pigs delivered to the packing plant. SVA = Senecavirus A; RT-PCR = reverse transcription-polymerase chain reaction.



One significant cluster in time and space ($P < .001$; Figure 2) was detected with the spatial-temporal analyses. The time frame of the cluster was from June 8 to 28, which was nearly the entire outbreak period, and the cluster covered a region with a radius of 83 km. The packing plant was located about 23 km south of the cluster center (Figure 2). Thirty-two of the 81 sites (39.5%) in this cluster had at least one lot of pigs that tested positive for SVA by RT-PCR. The cluster results confirmed that the number of observed cases in this cluster were over 3 times higher than the number of expected cases, suggesting that the proximity to the packing plant may be associated with a higher than expected incidence of lots testing positive for SVA. Thus, the presence of the packing plant inside the cluster highlight that it may serve as an indirect contact between the sites since packing plants can act as a potential reservoir of bacterial, viral, prion, and parasitic pathogens capable of infecting animals and fomites.[17,18]

However, a comprehensive investigation of all possible routes of transmission of the virus was not conducted. Therefore, the role the packing plant played in the spread of the virus can only be speculated. There were other limitations in this outbreak investigation as well. Due to the large number of suppliers involved (n = 193), suppliers were not contacted and site visits were not carried out. Only information provided by the packing plant was used. To validate the geographic location of suppliers provided by the plant, Google Earth images were used to verify the supplier address and subjectively assess the presence and type (indoor or outdoor) of swine facilities. Although the most recent images were used, the possibility of outdated images or errors in characterizing the facilities may have led to some classification bias.

Implications

Under the conditions of this study:

- A cluster of SVA cases occurred at a plant between June 8 and June 28, 2017.
- Pigs with SVA were less likely from single site suppliers or kept outdoors.
- Weather conditions pre-outbreak may have favored insect multiplication.

Acknowledgments

The investigation was funded by the Swine Health Information Center (Project No. 18-196 SHIC) with in-kind support from the National Pork Board.

Conflict of interest

None reported.

Disclaimer

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

References

1. Montiel N, Buckley A, Guo B, Kulshreshtha V, VanGeelen A, Hoang H, Rademacher C, Yoon KJ, Lager K. Vesicular disease in 9-week-old pigs experimentally infected with Senecavirus A. *Emerg Infect Dis*. 2016;22:1246-1248. doi:10.3201/eid2207.151863

2. Hales LM, Knowles NJ, Reddy PS, Xu L, Hay C, Hallenbeck PL. Complete genome sequence analysis of Seneca Valley virus-001, a novel oncolytic Picornavirus. *J Gen Virol*. 2008;89:1265-1275. doi:10.1099/vir.0.83570-0

3. Venkataraman S, Reddy SP, Loo J, Idamakanti N, Hallenbeck PL, Reddy VS. Structure of Seneca Valley Virus-001: an oncolytic Picornavirus representing a new genus. *Structure*. 2008;16(10):1555-1561. doi:10.1016/j.str.2008.07.013

4. Canning P, Canon A, Bates JL, Gerardy K, Linhares DCL, Piñeyro PE, Schwartz KJ, Yoon KJ, Rademacher CJ, Holtkamp D, Karriker L. Neonatal mortality, vesicular lesions and lameness associated with Senecavirus A in a U.S. sow farm. *Transbound Emerg Dis*. 2016;63:373-378. doi:10.1111/tbed.12516

5. Guo B, Piñeyro PE, Rademacher CJ, Zheng Y, Li G, Yuan J, Hoang H, Gauger PC, Madson DM, Schwartz KJ, Canning PE, Arruda BL, Cooper VL, Baum DH, Linhares DC, Main RG, Yoon KJ. Novel Senecavirus A in swine with vesicular disease, United States, July 2015. *Emerg Infec Dis.* 2016;22:1325-1327. doi:10.3201/eid2207.151758

6. Leme RA, Zotti E, Alcântara BK, Oliveira MV, Freitas LA, Alfieri AF, Alfieri AA. Senecavirus A: An emerging vesicular infection in Brazilian pig herds. *Transbound Emerg Dis*. 2015;62:603-611. doi:10.1111/tbed.12430

7. Vannucci FA, Linhares DCL, Barcellos DESN, Lam HC, Collins J, Marthaler D. Identification and complete genome of Seneca Valley Virus in vesicular fluid and sera of pigs affected with idiopathic vesicular disease, Brazil. *Transbound Emerg Dis*. 2015;62:589-593. doi:10.1111/tbed.12410

*8. US Department of Agriculture. Animal and Plant Health Inspection Services. VS Guidance 7406.3. Recommendations for swine with potential vesicular disease. 2016. `https://www.vdl.umn.edu/sites/vdl.umn.edu/files/vsg_7406.3_recommendations_for_swine_with_potential_vesicular_disease.pdf`. Published April 28, 2017. Accessed March 2018.

*9. Iowa Environmental Mesonet. Iowa State University web site. `https://mesonet.agron.iastate.edu/`. Accessed March 2018.

*10. Historical Weather. Weather Underground web site. `https://www.wunderground.com/history/`. Accessed March 2018.

*11. Humidity Levels in Nebraska During April. Current Results web site. `https://www.currentresults.com/Weather/Nebraska/humidity-april.php`. Accessed March 2018.

*12. Morrison Swine Health Monitoring Project. *Senecavirus A: Case updates.* St. Paul, MN: College of Veterinary Medicine, University of Minnesota; October 1, 2019. Weekly Report.

*13. Romagosa A. Applied review on evidence-based biosecurity. *Proc AASV*. Denver, Colorado. 2017:5-11.

14. Sternberg Lewerin S, Österberg J, Alenius S, Elvander M, Fellström C, Tråvén M, Wallgren P, Waller KP, Jacobson M. Risk assessment as a tool for improving external biosecurity at farm level. *BMC Vet Res.* 2015;11:171. doi:10.1186/s12917-015-0477-7

15. Joshi LR, Mohr KA, Clement T, Hain KS, Myers B, Yaros J, Nelson EA, Christopher-Hennings J, Gava D, Schaefer R, Caron L, Dee S, Diel DG. Detection of the emerging Picornavirus Senecavirus A in pigs, mice, and houseflies. *J Clin Microbiol*. 2016;54:1536-1545. doi:10.1128/JCM.03390-15

16. Shaman J, Day JF. Reproductive phase locking of mosquito populations in response to rainfall frequency. *PLoS One.* 2007;2:e331. doi:10.1371/journal.pone.0000331

17. Franke-Whittle IH, Insam H. Treatment alternatives of slaughterhouse wastes, and their effect on the inactivation of different pathogens: a review. *Crit Rev Microbiol*. 2013;39:139-151. doi:10.3109/1040841X.2012.694410

18. Urlings HAP, van Logtestijn JG, Bijker PGH. Slaughter by-products: Problems, preliminary research and possible solutions. *Vet Q.* 1992;14:34-38. doi:10.1080/01652176.1992.9694323

*Non-refereed references.

Conversion tables

Weights and measures conversions

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

Temperature equivalents (approx)

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

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

Conversion chart, kg to lb (approx)

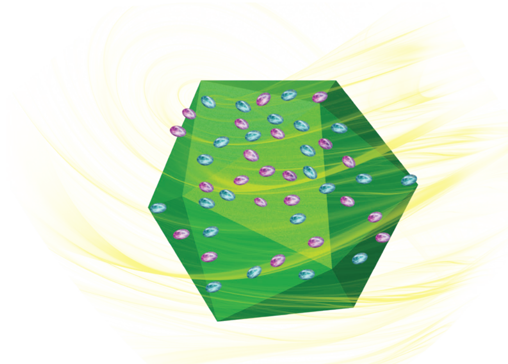
Pig size	Lb	Kg
Birth	3.3-4.4	1.5-2.0
Weaning	7.7	3.5
	11	5
	22	10
Nursery	33	15
	44	20
	55	25
	66	30
Grower	99	45
	110	50
	132	60
Finisher	198	90
	220	100
	231	105
	242	110
	253	115
Sow	300	135
	661	300
Boar	794	360
	800	363

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

Ingelvac CircoFLEX® is now non-virucidal[1] thanks to a brilliant idea.

PARTNER PROTECT PERFORM

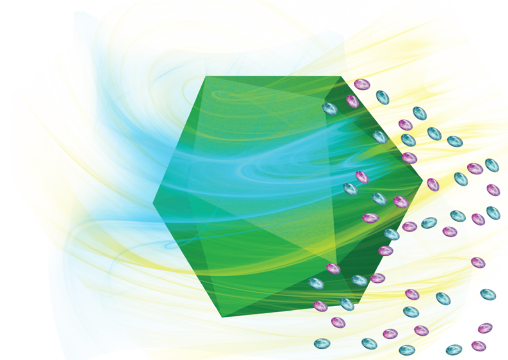
The new DiaTEC purification process:



1.

EXPRESSION

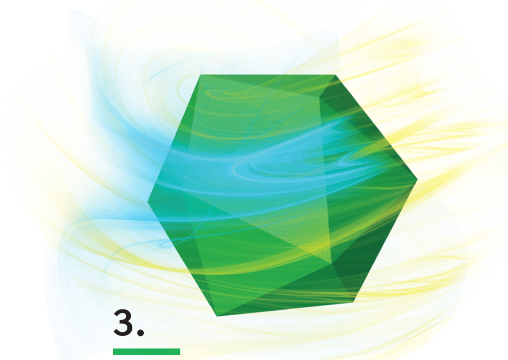
Antigenic virus-like particles (VLPs), identical to the live PCV2 virus, are produced.



2.

PURIFICATION

Non-specific proteins and cell debris are extracted, leaving the VLPs.



3.

THE DIATEC PROCESS

The new purification process removes residual cell components from the VLPs.

4.

A NON-VIRUCIDAL VACCINE

The result is a non-virucidal vaccine.

Ingelvac CircoFLEX® antigen | Cell debris | Cell media components | Ingelvac CircoFLEX® antigen with Boehringer Ingelheim's DiaTEC process

FLEX DiaTEC

To learn more about Ingelvac CircoFLEX® and the new DiaTEC purification process, contact your Boehringer Ingelheim representative.

[1] Bautista E, Schlesinger K, Gassel M. Boehringer Ingelheim Animal Health USA Inc. Data on file, Study No. 2017044.

Boehringer Ingelheim

Zaabel joins NPB Swine Health and Production Team

Dr Pam Zaabel, Director of Swine Health.

In late January, the National Pork Board announced Dr Pam Zaabel, DVM, as Director of Swine Health to work on the Pork Checkoff's Swine Health and Production objectives and priorities. Zaabel previously worked at the National Pork Board as Director of Swine Information and Research (2006-2008) and most recently as a Veterinary Specialist at the Iowa State University Center for Food Security and Public Health, where she was responsible for projects focusing on swine diseases and swine health. Zaabel has worked extensively on African swine fever and the Secure Pork Supply Plan. She lives in Kellogg, Iowa with her husband, Roger, and five children.

For more information, contact Dr Pam Zaabel at **pzaabel@pork.org** or 515-223-2600.

Checkoff announces key task forces for 2020

In its bid to become more nimble and outcome-focused, the National Pork Board has gone from a committee-based structure for its research planning to one of task forces on specific objectives. In the science area, these include the Swine Disease (National Swine Disease Council), Euthanasia, Public Health Implications of Live Production, Water Quality and Soil Health, and Air Quality task forces. The first two in the list will have a heavy focus on African swine fever in 2020. According to the board of directors, this change is designed to move on priority areas of the industry more quickly. This change will still be led by pork producers but will have greater involvement from staff and outside subject matter experts. To help expedite potential solutions to the key objectives of each task force, the board has approved much larger budgets than most previous science-based committees have had in the past.

For more information, contact Dr Dave Pyburn at **dpyburn@pork.org** or 515-223-2634.

Pork's sustainability continues upward trek

The Checkoff recently released its new sustainability report, *Commit and Improve: Pig Farmers' Approach to Sustainability*, and updated **porkcares.org** website. The report and website share firsthand accounts and data supporting pig farmers' progress toward sustainability through the We Care ethical principles.

"As pig farmers, we are committed to producing safe food, protecting the environment and caring for our pigs by following the six We Care ethical principles," said David Newman, president of the National Pork Board and a pig farmer representing Arkansas. "These new resources were developed to share relevant information and metrics and to lay a foundation for continuous improvement in the area of sustainability."

The new report demonstrates the progress pig farmers have made toward the We Care ethical principles of food safety, animal well-being, the environment, public health, our people, and communities. Data for the report was gathered from governmental agencies, the pork industry's life cycle assessment, and pig farmers from across the country. Highlights that demonstrate the pork industry's commitment to the We Care principles include:

- According to the Environmental Protection Agency, pork production contributes just 0.46% of US greenhouse gas emissions to the atmosphere.
- More than 71,000 individuals are Pork Quality Assurance Plus certified, representing roughly 85% of US pork production.
- The pork value chain has come together to develop and use the Common Swine Industry Audit, which is certified by the Professional Animal Auditor Certification Organization.
- The most recent life-cycle assessment, *A Retrospective of US Pork Production*, shows a significant reduction in the use of natural resources during the past 55 years. Per pound of pork produced, US pork producers have reduced land use by 76%, water use by 25%, energy use by 7%, and their carbon footprint by more than 7%.
- More than 94% of pig farms keep detailed medical and treatment records, which shows pig farmers' commitment to responsible antibiotic use.
- In 2018, pig farmers donated 3.2 million servings of food, volunteered more than 54,000 hours, and donated more than $5.5 million to local charities.

For more information, contact Dr Brett Kaysen at **bkaysen@pork.org** or 515-223-2600.

Alternate Student Delegate selected for AASV Board

The AASV Student Recruitment Committee is pleased to announce the selection of Amanda Anderson, a second-year veterinary student at Iowa State University (ISU), as the incoming Alternate Student Delegate to the AASV Board of Directors.

Growing up in Iowa, Anderson was involved in 4-H, FFA, family farming activities, and spent time at local veterinary clinics. Through those activities, she became interested in food-animal veterinary medicine at an early age. "I gained an appreciation for livestock production and found my passion for health and medicine," Anderson recalls.

As an undergraduate majoring in animal science at ISU, Anderson strived to gain a well-rounded perspective of the swine veterinary profession. Beginning as a research intern under Dr Derald Holtkamp, she not only learned about disease transmission and biosecurity, but she also made numerous contacts in the industry, exciting her about swine veterinary medicine.

Anderson also spent part of her undergraduate time conducting research and site visits as a Veterinary Project Manager for Smithfield Hog Production. There, she managed rotavirus research under Dr Jeremy Pittman, collected samples, analyzed diagnostic data, and provided recommendations. Her enthusiasm for her research projects in this role motivated her to pursue a Master of Science in Veterinary Preventive Medicine concurrently with her DVM.

Anderson has held multiple positions of service in her academic career. Anderson's excellent communication, organizational, and leadership skills she learned as an Iowa officer for the National FFA Association will help her serve AASV as the Alternate Student Delegate. She has also held the office of president for the ISU Pre-veterinary Club, serves as a student representative for curriculum and hospital recommendations for the ISU College of Veterinary Medicine Food Animal Advisory Board, and represented the first year class and volunteered as a wet lab committee member for the ISU Student AASV Chapter. She is currently the vice president of the ISU Student AASV Chapter.

Anderson has participated in the AASV Annual Meeting in the past, both as a student poster presenter and as a Research Topics participant. Selected for the 2020 Veterinary Student Poster Competition, Anderson will present research from her 2019 summer internship at Pipestone Veterinary Services at the AASV Annual Meeting in Atlanta.

Inspired by participation, mentorship, and connections she has made through AASV, Anderson hopes to become more involved as a leader in the progress of the organization. "Each year it becomes more apparent that the association is made up of many diverse, motivated individuals who are quickly moving the industry forward through innovation and collaboration," she states.

In her role as the Alternate Student Delegate, Anderson is excited to connect with more food animal interested veterinary students. "I hope to get more students involved, assist in making them aware of the opportunities available through AASV, and drive the organization forward as the next generation."

As the daughter of AASV Past President Dr Matt Anderson, Amanda carries on a legacy within AASV. After graduation, she plans to join a swine-specific practice with health, management, and production responsibilities. She hopes to participate in research, product development, and eventual ownership.

Amanda Anderson, Alternate Student Delegate to the AASV Board of Directors

Anderson will assume her duties as Alternate Student Delegate during the 2020 AASV Annual Meeting in Atlanta, Georgia. The current alternate delegate, Jamie Madigan (NCSU, 2021), will assume the delegate position currently held by Jonathan Tubbs (Auburn, 2020), who will rotate off the board. Jamie and Amanda will represent student interests within AASV as non-voting members of the Board of Directors and the Student Recruitment Committee. Please join us in welcoming Amanda to the AASV Board of Directors and thanking Jonathan for his service!

Start your AASV leadership path: join an AASV committee

The AASV Board of Directors establishes committees to address specific issues associated with swine veterinary medicine and provide recommendations for actions to the AASV leadership. The AASV committees are an integral part of the leadership structure within AASV. They also serve as a great way for members to participate in developing positions for the association, learn about particular issues, and meet other members.

Each AASV committee typically conducts a face-to-face meeting during the AASV Annual Meeting. The majority of AASV's 15 issue-based committees will meet on Saturday morning during the 2020 AASV Annual Meeting. Committees generally handle additional business by email or conference call during the remainder of the year. All committee meetings are open to any AASV member, including student members. Only committee members are eligible to vote.

The committees are a critical part of the AASV leadership, and we appreciate the efforts of the volunteer members. Visit the committee web pages on the AASV website (`aasv.org/members/only/committee.php`) to learn more about the committee activities and view the meeting agendas.

If you are interested in joining a committee, please contact the committee chair or AASV Director of Communications, Dr Abbey Canon at `canon@aasv.org`. We hope to see you at a committee meeting!

Visit the AASV Well-Being Center at the 2020 Annual Meeting; pick up an AVMA Wheel of Well-being

Well-being – the state of being comfortable, healthy, or happy – is something you can practice every day, whether you have 3 minutes or 3 hours. Right now, take 30 seconds and smile. Smiling is a powerful tool that can fend off sadness, anxiety, and nervousness.

The American Association of Swine Veterinarians is committed to providing members resources to promote well-being.

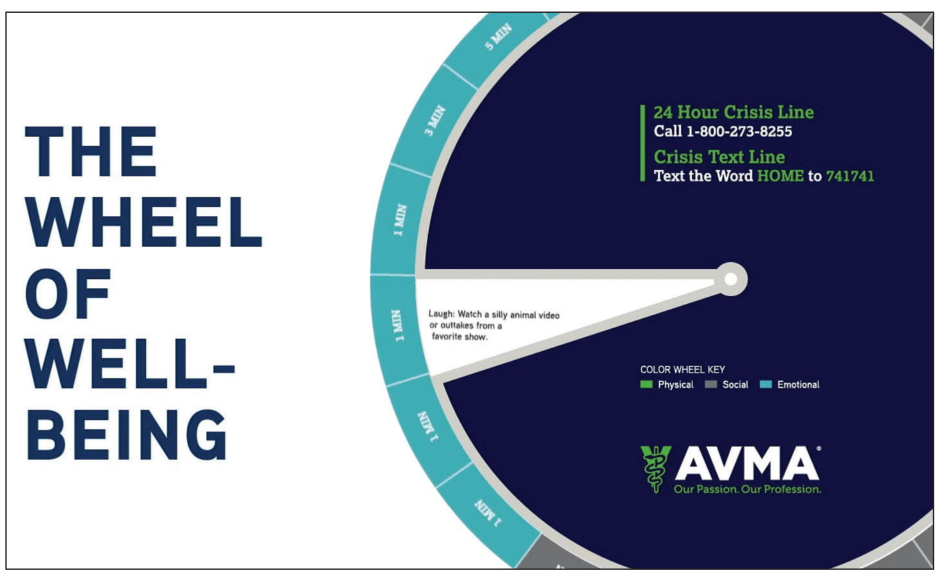
The American Veterinary Medical Association's (AVMA) Wheel of Well-being highlights three dimensions of wellness – physical, social, and emotional – with tips for activities you can do at home, at work, and on-the-go, like the smiling tip previously mentioned. It also includes a clear pocket to insert a reminder of what you are passionate about, such as a photo, a word, a quote, or anything else that motivates you to be at your best. Learn more about the Wheel of Well-being at `youtube.com/watch?v=5FmDQZ_p0UU`.

The AVMA strives to be a nationally recognized leader in promoting health, well-being, and diversity for the veterinary profession. The AASV is excited to partner with AVMA and CareCredit in their efforts to advance wellness and help promote a healthy physical and emotional environment in veterinary medicine. By sharing the AVMA Wheel of Well-being, we hope to help inspire swine veterinarians, team members, and their clients to incorporate these and other wellness practices into their daily lives.

For more resources on well-being and other related topics, please visit `aasv.org/Resources/Wellbeing` and `avma.org/wellbeing`.

Be sure to pick up a free AVMA Wheel of Well-Being, participate in interactive activities, gather and share healthy tips to support a culture of well-being, and find other wellness resources at the AASV Well-being Center in the Centennial Foyer at the Hyatt Regency in Atlanta during the 2020 Annual Meeting.

Visit early, supplies are limited!



Salary Survey 2020

The AASV is conducting its seventh survey of swine-veterinarian income and benefits. Active members of AASV (non-retired veterinarians) in the United States and Canada are asked to watch for information regarding the 2020 survey in the AASV e-Letter, and to participate by using the electronic survey form on the AASV website.

Similar surveys have been conducted every 3 years since 2002. Members have found the resulting salary and benefit summary useful when seeking employment or preparing to hire veterinary professionals in the swine industry. The survey results have also been used to inform veterinary students about the career opportunities available in swine medicine.

Members of AASV are divided into two survey groups according to their employment type. The *practitioner* survey should be completed by members engaged in private practice, as well as those who oversee pig health for a production or genetics company. Members who work for a university, corporation, or government and are engaged in education, research, technical services, public health, or regulatory work should complete the survey for *public/corporate* veterinarians.

In addition to 2019 income and benefits, the survey requests information about education and training, employment type, and hours worked. Responses are confidential and the results are reported in a manner to assure participant anonymity.

The overall results of the salary and compensation review will be published and distributed for use by AASV members and students. Previous survey results are available for members to access on the AASV website under the Member Center menu tab.

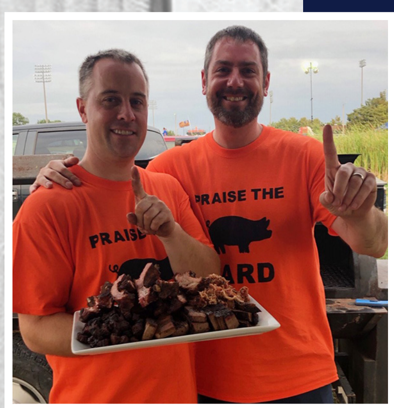
AASV Annual Meeting proceedings online

The proceedings of the 2020 AASV Annual Meeting are available at **aasv.org/annmtg/proceedings** for members to download.

The proceedings are available in the following formats:

- The "big book" of all the regular session papers in a single PDF file with a linked table of contents
- Seminar booklets: a PDF file for each seminar
- Individual papers in the Swine Information Library: **aasv.org/library/swineinfo/**

To access the files, make sure your AASV membership has been renewed for 2020. You'll need your AASV website username and password to log in. If they are not handy, contact the AASV office or use the "Reset Password" link in the upper right of the AASV website (**aasv.org**) to have them emailed to you.



AASV Foundation Fundraising

AUCTION

Held in conjunction with the
AASV ANNUAL MEETING
March 9, 2020 – Atlanta

THANK YOU to the many individuals, veterinary practices, and companies who made generous contributions to the auction!

AUCTION DONORS

Abilene Animal Hospital
AgCreate Solutions
AMVC
Pat Anderson
Animal Biotech
Anonymous
APC
Paul Armbrecht
Asociación Mexicana de Veterinarios Especialistas en Cerdos
AVMA PLIT
Butch and Emma Baker
John and Andrea Baker
Melissa Billing
Bimeda
Boehringer Ingelheim
Brian Boyle
Cambridge Technologies
Mary Lou Chapek-Hogg
Jack and Carla Coleman
Susan Detmer
Diamond V
East Fork Swine Veterinary Services
Energy Panel Structures
Fairmont Veterinary Clinic
Fast Genetics
Four Star Veterinary Service
Pete Franz
Wayne Freese
Tom Gillespie
Norma Gonzalez
Christa Goodell
Jeff Harker and Family
Perry Harms
Peggy Anne Hawkins
Phil Hayes
Steve Henry
Jeff and Jennifer Husa
Huvepharma
Indiana Packers Corporation
Innovative Veterinary Solutions
Iowa Select Farms
Iowa State University College of Veterinary Medicine

For information about the AASV Foundation,

2020: *A Vision for the Future*

Help ensure the future and create a legacy for swine veterinarians by participating in the 2020 fundraising auction!

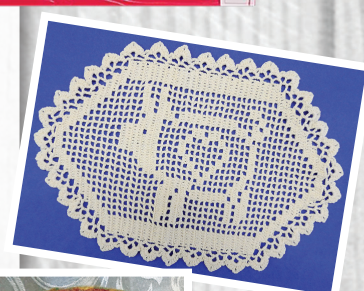
Start bidding today:
aasvf.cbo.io

Silent auction bidding closes at 7:00 PM Eastern Daylight Time on Monday, March 9.

Everybody bid-a-now!

AUCTION DONORS

Iowa State University Veterinary Diagnostic Laboratory
Clayton Johnson
Kerry and Betsy Keffaber
Andrew Kleis
Paul and Markeeta Knoernschild
Kuster Research and Consulting
Claire LeFevre
Livestock Veterinary Services
Aaron Lower
Paul Mleziva
National Pork Producers Council
Norbrook
Pharmacosmos
Pharmgate Animal Health
Phibro Animal Health
Reid Philips
PIC
Dale Polson
Cristina Quijano Alvarez
Karen Richardson
Max and Carol Rodibaugh
Gail Rueff
Larry Rueff
Lee Schulteis
Skylar Nutrition
Smithfield Foods
Steve Sornsen
Struve Labs International
Suidae Health & Production
Swine Medicine Education Center
Swine Vet Center
Harold Tilstra
Mike and Lisa Tokach
Tonisity
Matthew Turner
Dennis and Elizabeth Villani
Virox Animal Health
John Waddell
Warren Wilson
Nathan Winkelman
Boguslaw Zakrzewski
Zoetis



The fellowship of One Health

Every December for nearly two decades, especially as a student amidst finals, I have binge watched the Lord of the Rings when the winter holidays near. This year was no exception, particularly because this article was due near Christmas. The movie-based-on-book trilogy spends 9 hours in Middle Earth assembling good to defeat evil and the one ring to control all.

Off screen, a great opponent gathers strength as it multiplies in many countries outside of the United States. Foreign animal disease preparedness and prevention are part of our everyday lives now. We talk, think, and worry about African swine fever (ASF) every single day.

Spoiler alert – good triumphs against evil in the Lord of the Rings story. But where it all started was with a fellowship of the ring, a fellowship of diverse beings – hobbits, dwarves, elves, and men – who came together with a shared common goal as darkness approached.

The swine industry has united in fellowship to focus their prevention efforts on African swine fever. The American Association of Swine Veterinarians (AASV) continues to have strong allied forces with the National Pork Board (NPB), National Pork Producers Council (NPPC), the Swine Health Information Center, and others to prevent ASF and other foreign animal diseases.

Justifiably, we have put a great deal of attention toward ASF prevention and preparedness. Those efforts have likely led to improved biosecurity and disease prevention of all diseases. While attention is on foreign animal disease prevention, we still battle porcine reproductive and respiratory syndrome, and goblins, and influenza, and trolls, and *Salmonella*, and orcs daily. At least some of those.

Regardless of the pathogen, having strong partnerships in place is important for disease control and prevention. Even in the face of ASF, we continue to build fellowships to strengthen our forces beyond the swine industry. The AASV continues to regularly meet with the Centers for Disease Control and Prevention (CDC), the US Department of Agriculture (USDA) Agriculture Research Service, the Food and Drug Administration (FDA), and others to identify common goals.

For example, AASV, NPB, and NPPC recently attended a preharvest workshop in Washington DC. With representatives from beef and dairy, poultry and eggs, CDC, USDA, state public health, and state animal health, we met to discuss a shared goal – safe food.

About a year ago, Dr Harry Snelson wrote an advocacy article, "Pigs are not broccoli."[1] In that article, he described a 2015 *Salmonella* outbreak associated with pork consumption. During that outbreak, there was a strong desire from a public health department to perform an on-farm investigation and collect samples from the farm environment and pigs. The primary public health response in any outbreak investigation is to identify the source, stop the outbreak, and prevent future cases. There were several reasons why the proposed on-farm sampling would not have helped achieve those goals in that outbreak.

Following that outbreak and investigation, stakeholders recognized the need to come together via a collaborative One Health approach to understand how we as public health, animal health, and industry achieve

"The primary public health response in any outbreak investigation is to identify the source, stop the outbreak, and prevent future cases."

the shared goal of producing and providing safe food. The objective of the recent preharvest workshop was to enhance communication and collaboration networks between industry, animal, and public health surrounding foodborne illness.

As expected, achieving common goals must start with early, open communication. The best way to ensure that occurs is by having working relationships – a fellowship – in place before an outbreak.

Early communication between these three entities provides an opportunity for all stakeholders to learn what we do not know, learn what others do know, and learn what else we might do to mitigate foodborne illness immediately.

As suggested during the workshop, one of the most important pieces of a preharvest foodborne illness investigation is an industry assessment. Industry and animal health representatives can and should be relied on as subject matter experts, helping public health epidemiologists understand how pig farming works, where and how a pig spends its life, and if their hypotheses might be possible. Industry assessment should be at the top of an inverted pyramid, and often sample collection at the bottom.

I often retell the story of a cluster of *Campylobacter jejuni* cases in sheep ranchers to demonstrate the value of veterinarians in public health. A public health and food animal veterinarian who was very familiar with livestock, sheep and wool, and "how things work" was involved in the investigation. Again, the investigation goals were to identify the source, stop the outbreak, and prevent future cases. Because of this public health veterinarian's background, she knew the questions to ask. This cluster, associated with patients castrating lambs with their teeth, was solved because of an industry understanding.

Advocacy in Action continued on page 105

Advocacy in Action continued from page 103

Early communication also helps tell the true One Health story. If a new or emerging foodborne pathogen is causing human illness, veterinarians might have seen its presence, either with or without clinical significance, as part of routine animal health surveillance. We can help describe the organism, identify trends, and share what research has been conducted.

Information about organisms in animal health can be important to human health, and information about organisms in human health can be important to animal health. Bidirectional early communication can open discussion to prevent disease in both humans and animals. We may see problems in animals but may not understand or appreciate applications or consequences of that organism until we are aware of events or trends in human health.

Finally, early and open communication provides an opportunity to work together on collaborative messaging. Providing safe, wholesome pork is a top priority for swine veterinarians and pork producers. During an outbreak, a united message recognizing that everyone shares that goal and collaborates to prevent illness improves response coordination, collaboration, and consumer confidence.

The AASV will continue to meet regularly with swine and other food-animal representatives, animal and public health stakeholders, and others who may be important members of our fellowship. As we look to always improve animal health, human health, and food safety, we know that fellowship is valuable, even *precious*.

Abbey Canon, DVM, MPH, DACVPM
Director of Communications

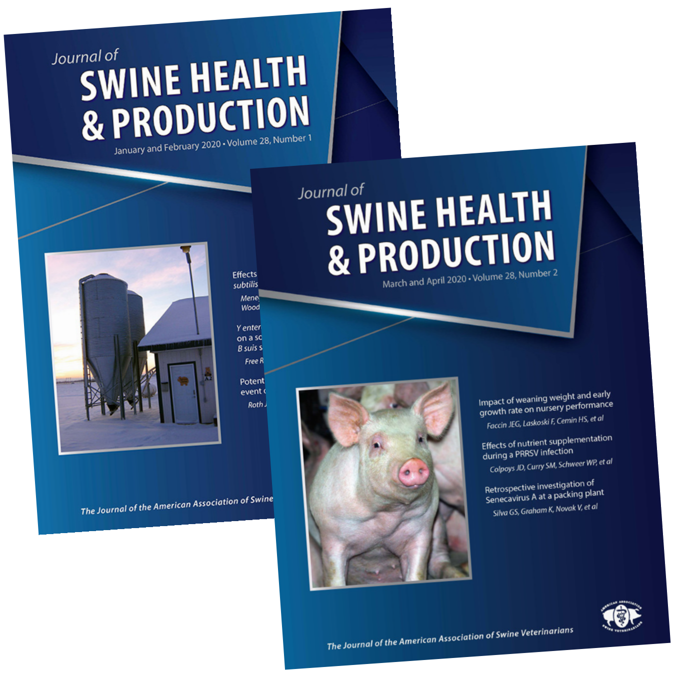
Reference

*1. Snelson H. Pigs are not Broccoli [editorial]. *J Swine Health Prod*. 2019;27(1):46-47.

* Non-refereed reference.

Pigs of #instaham

Share your best pig photos for JSHAP publication.



The front and back covers of the *Journal of Swine Health and Production* feature images submitted by readers. Images must represent healthy pigs and modern production facilities and must not include people.

Images must be the largest size and highest resolution available on your camera when taking the photo. Do not resize, crop, rotate, or color-correct the image prior to submission.

Submit your .jpg photo to **tina@aasv.org** along with your name and affiliation. You will receive notification if your photo is selected for publication and receive photo credit.

American Association of Swine Veterinarians 51st Annual Meeting

March 7-10, 2020 (Sat-Tue)
Hyatt Regency Atlanta
Atlanta, Georgia

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

Emerging Animal Infectious Disease Conference

March 23-25, 2020 (Mon-Wed)
State College, Pennsylvania

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

26th International Pig Veterinary Society Congress

June 2-5, 2020 (Tue-Fri)
Florianopolis, Brazil

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

World Pork Expo

June 3-5, 2020 (Wed-Fri)
Hosted by the National Pork Producers Council (NPPC)
Iowa State Fairgrounds
Des Moines, Iowa

For more information:
National Pork Producers Council
Tel: 515-278-8012
Fax: 515-278-8014
Web: worldpork.org

Allen D. Leman Swine Conference

September 19-22, 2020 (Sat-Tue)
Saint Paul River Centre
Saint Paul, Minnesota

Hosted by the University of Minnesota

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

United States Animal Health Association 124th Annual Meeting

October 15-21, 2020 (Thu-Wed)
Gaylord Opryland Hotel
Nashville, Tennessee

For more information:
Web: usaha.org/meetings

International Conference on Pig Survivability

October 28-29, 2020 (Wed-Thu)
Omaha, Nebraska
Hosted by Iowa State University, Kansas State University, and Purdue University

For more information:
Email: jderouch@ksu.edu
Web: piglivability.org/conference

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

AASV Industry Support Council

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

Photo Corner

Photo courtesy of Sue Schulteis