Journal of
SWINE HEALTH & PRODUCTION
March and April 2024 • Volume 32, Number 2

Gross anatomical measurements and epidermal laminar density of the porcine hoof capsule
Fick ME, Weber W, Karriker LA, et al

Survival of ten PRRSV strains at three temperatures
Quinonez-Munoz A, Sobhy NM, Goyal SM

The Journal of the American Association of Swine Veterinarians

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

The *Journal of Swine Health and Production* is a refereed publication and is a benefit of membership in the American Association of Swine Veterinarians. For inquiries regarding membership or subscriptions, please contact:

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

Editorial questions, comments, and inquiries should be addressed to Rhea Schirm, Publications Manager: 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 CAB Abstracts, Google Scholar, Web of Science SCIE, and CrossRef

JOURNAL OF SWINE HEALTH AND PRODUCTION

(ISSN 1537-209X) Volume 32, Number 2; March and April

AASV STAFF

AASV OFFICERS

JSHAP STAFF

EDITORIAL BOARD

TABLE OF CONTENTS

Cover photo is courtesy of Tina Smith
(taken at University of Missouri).

Download this issue at **www.aasv.org/shap/issues/v32n2/v32n2jshap.pdf**

JSHAP SPOTLIGHT

Jack Korenyi-Both

2023 Top Student Seminar Winner
Ohio State University

Jack Korenyi-Both earned a BS ('20) in Animal Science and is currently a fourth-year veterinary student at The Ohio State University. After graduation, Jack plans to work in small- or mixed-animal medicine while he finishes his Master's of Public Health degree. Upon completion, he is interested in pursuing a career with the government or military in regulatory medicine where he hopes to contribute to food-animal medicine in some capacity. "I have made many connections and friendships through AASV where students are always welcomed and supported. I am grateful to be supported by the AASV and this industry in my pursuit of veterinary medicine and the swine industry." Jack was the Top Student Seminar award winner at the 2023 AASV Annual Meeting.

uniferon®
Iron(III) Dextran

us.uniferon.com

IT ISN'T HOW MUCH A SECOND DOSE OF UNIFERON® COSTS.

IT'S HOW MUCH IT RETURNS.

Research proves that investing in a second dose of Uniferon® for your baby pigs provides ROI that can't be denied.

6.56 LBS
IMPROVEMENT AT WEAN TO MARKET

4%
INCREASE IN AVERAGE DAILY GAIN

2.5%
IMPROVEMENT IN HOT AND COLD CARCASS WEIGHTS

1.5 LBS
ADDITIONAL TRIMMED LOIN

To learn more about what two doses of Uniferon® can do for your baby pigs and your operation, call 908-769-7045 or email us at uniferon.us@pharmacosmos.com.

54th Annual Meeting of the American Association of Swine Veterinarians http://amp.aasv.org/p/225_Chevalier.pdf

PHARMACOSMOS

PM-070-00

Continue to Be There!

Over a year ago we put together the Annual Meeting program centered around the theme "Be There" with the collective message to support the pigs in our care, the clients we serve, and the members of our association. Little did we know that 2023 would end up to be one of the worst economic climates for pig farmers ever. All hog farm clients experienced financial stress as weaned piglets became nearly worthless during the summer months due to peaking input costs. Fortunately, the productivity of the national herd in general was able to break through some significant challenges and march forward with greater piglets weaned per sow and greater overall herd productivity. Herd health appears to be stable as well, with reduced porcine reproductive and respiratory syndrome prevalence as referenced in the Morrison Swine Health Monitoring Program database.

My challenge to the AASV membership is to continue to be there as the advocate for the pig. We need to tackle tough challenges within reach, such as porcine epidemic diarrhea virus (PEDV) elimination. We need to further understand why we see pockets of new diseases like sapovirus, Senecavirus, and others. We have the tools to quickly identify these challenges. We also can work with our clients on control and elimination programs using breeding projects and biosecurity to rid the industry of these headaches and improve the herds in our care.

The history of my appreciation for the "Be There" theme comes from a relationship with one of my favorite clients. Bill Gray used to tell me "Some of the most important decisions on the planet will be made by those who choose to show up." We would travel together to public hearings on the Livestock Facilities Act proposed in the Illinois government. The message to show up and volunteer to be there was critical to support intelligent structure in the manner that livestock facilities would be governed. The same philosophy applies to client service for a serious health break or even the decision to be there for a friend in need.

This will be my last article as president of the AASV. I am excited to share the responsibilities of the executive committee with newly elected leaders. There is unfinished business I am asking all of us to continue to support and see it through. Support the development of the US Swine Health Improvement Plan for a national herd health debate and framework. Support the herd traceability efforts of the US Department of Agriculture to maintain industry function should a foreign disease be identified. Support the PEDV Elimination Task Force as they begin to work on strategy for a national effort to rid the country of this disease. Support the ongoing committees and educational programs critical to service our herds and our membership. Be there for the early career veterinarians as mentors and career development coaches. Be there for clients who are hopeful to see financial recovery and industry reinvestment.

"My challenge to the AASV membership is to continue to be there as the advocate for the pig."

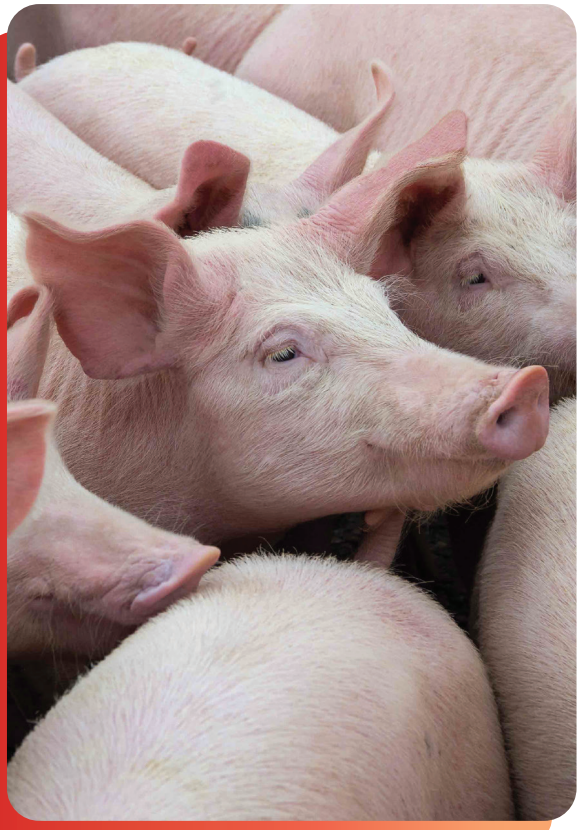
Thank you for the opportunity to serve as AASV president, it has been an honor.

William L Hollis, DVM
AASV President

CAMBRIDGE TECHNOLOGIES

PRECISION VACCINOLOGY

YOUR HEALTHY PIG PARTNER



Cambridge Technologies combines innovative diagnostics and surveillance with proven autogenous vaccines to bring Precision Vaccinology® to today's leading veterinarians.

- Complete diagnostic menu
- Total vaccine customization
- Innovative manufacturing techniques
- Legendary customer support

Visit our website today to learn more about putting our tradition of innovation to work for you.

877-298-1321

INFO@CAMBRIDGETECHNOLOGIES.COM
WWW.CAMBRIDGETECHNOLOGIES.COM
1525 BIOSCIENCE DRIVE,
WORTHINGTON, MN 56187

SCAN QR

AASV challenges and opportunities and ChatGPT

I humbly thank you for the opportunity to serve the AASV membership. As I sit composing this message on New Year's Day, my thoughts on a New Year's resolution are different this year. The resolution that I commit to for my messages to you in the journal is to provide information and questions that are timely and thought provoking, and to open discussions within our membership, all for the betterment of the swine industry and the AASV membership.

So, as I noodled over this first message, I asked myself "What are the top challenges for the swine industry and the AASV membership in 2024?" This is also a similar question posed to the AASV Program Planning Committee for our Annual Meeting, but that question was "With the challenges in front of the swine industry and AASV, how do we lead AASV into the future?" Not being averse to the use of technology, I decided to pose my question to ChatGPT. These are the top six challenges that the AI chatbot provided:

1. Disease management: The ongoing challenge of swine diseases and the need for effective biosecurity, vaccination strategies, and diagnostics.
2. Sustainability: Addressing environmental concerns and promoting sustainable practices, such as efficient resource utilization, waste management, and maintenance of healthy animals that consume the resources.
3. Antibiotic stewardship: Continuing efforts to ensure responsible use of antibiotics in swine production to prevent the development of antimicrobial resistance.
4. Consumer demands: Addressing changing consumer preferences and demands for animal welfare, transparency, and food safety.
5. Economic factors: Navigating market volatility, trade policies, and other economic factors that may affect the profitability and sustainability of the swine industry.
6. Workforce development: Encouraging education, training, and attracting young professionals to the field of swine veterinary medicine.

You may receive this issue of the journal before the 2024 Annual Meeting, so I hope to entice you to attend sessions that address the challenges identified above – and there are many! However, if you are reading this message after the Annual Meeting, please take the time to review the proceedings papers and start a conversation with the presenters.

Looking at the preconference seminars, you will see that they cover all the challenges identified by the AI chatbot. Specifically, the seminars cover Big Diagnostic Data, Disease Preparedness, Mastering the Art of Swine Business, Pig Livability, Biosecurity, Influenza, Health through Nutrition, and Swine Medicine for Students.

The highlight for me is the Monday morning general session; I will declare my bias as the program chair. The Howard Dunne Memorial Lecture and the Alex Hogg Memorial Lecture, given by Dr Joel Nerem and Dr Chris Rademacher, respectively, highlight the opportunities AASV and swine veterinarians face.

"The resolution that I commit to for my messages to you in the journal is to provide information and questions that are timely and thought provoking, and to open discussions within our membership, all for the betterment of the swine industry and the AASV membership."

Dr Nerem outlines the challenges with the statement "When in doubt, do what is right for 1) the pig, 2) the farmer, and 3) the consumer." He challenges us to be a next generation veterinarian and to practice next generation veterinary medicine. Dr Rademacher honors Dr Alex Hogg with his evaluation of the future of veterinary students and swine education. Further, he shines a light on the tools of the future for veterinary practitioners. The challenge presented by Dr Rademacher is to be open to taking a different mindset and way of thinking to propel swine veterinary practice into the future.

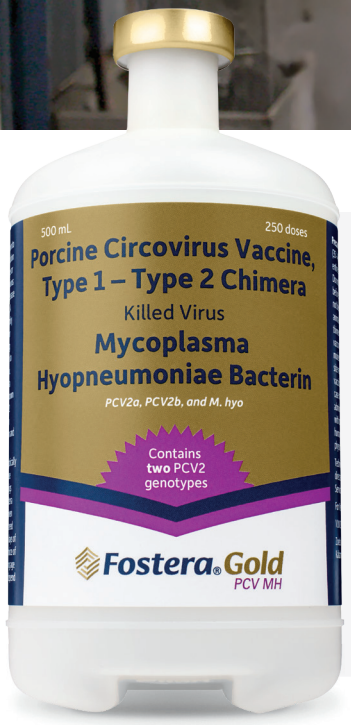
The remainder of Monday morning focuses on disease management and elimination. Taglines from each of the speaker's presentations include:

> "Generals always prepare to fight the last war – especially if they won." - Dr Jeff Zimmerman
>
> "The only thing that is holding us back from moving forward (with *Mycoplasma* elimination) on a regional and even a national program is the political will to make it happen." - Dr Paul Yeske
>
> "How does the industry structure, sustainability, and mindset about the future play out regarding PRRSV? Is the industry in automatic response mode or will it take on the challenge of eliminating this pathogen from our US herds?" - Dr Amy Maschhoff

President-elect message continued on page 53

Fostera Gold PCV MH

Strong Protection. Proven Safety. Take control of PCV2.



- **Broadest antigenic coverage.**[1–4] The first and only porcine circovirus Type 2 (PCV2) bivalent vaccine containing two PCV2 genotypes – PCV2a and PCV2b.
- **Longest-lasting PCV protection.**[5–9] The longest duration of immunity (DOI) of 23 weeks helps protect against PCV2 and respiratory disease due to *Mycoplasma hyopneumoniae* (Mhp).
- **Breeding herd immunity.**[10] First and only PCV2 vaccine with a USDA safety approval for use in pregnant sows and gilts.

Talk to your Zoetis representative about whole herd protection with Fostera Gold PCV MH

[1]Data on file, Study Report No. B822R-US-14-325, Zoetis Inc.
[2]Data on file, Study Report No. B822R-US-16-582, Zoetis Inc.
[3]Data on file, Study Report No. B825R-US-16-667, Zoetis Inc.
[4]Data on file, Study Report No. B822R-US-15-557, Zoetis Inc.
[5]Data on file, Study Report No. B824R-US-15-451, Zoetis Inc.
[6]Data on file, Study Report No. B824R-US-13-118, Zoetis Inc.
[7]Data on file, Study Report No. B822R-US-15-544, Zoetis Inc.
[8]Data on file, Study Report No. B822R-US-16-622, Zoetis Inc.
[9]Data on file, Study Report No. B824R-US-15-505, Zoetis Inc.
[10]Data on file, Study Report No. B921R-US-20-992, Zoetis Inc.

zoetis

President-elect message continued from page 51

> "What can we do to not become another zombie apocalypse cliché? We need to 1) know the threats, 2) know our strengths, 3) know our weaknesses and have the fortitude to address them, 4) don't be complacent, and 5) be prepared." - Dr Luc Defresne

The entirety of the concurrent sessions encompasses and expands on the challenges and opportunities we have as swine veterinarians and AASV members. From poster sessions, student seminars, industrial partners sessions, the Disease Elimination session, the Sustaining the Farm session, to the Immunology Toolbox, there is a wealth of information to be gained. Each of the 6 ChatGPT challenges are addressed throughout the AASV Annual Meeting. This holds true for the Tuesday general session that you should not miss. The session will focus on driving demand and protecting the product; what role you play and how you should be involved.

Did I need to use ChatGPT to identify the challenges for AASV and the swine industry? No. With the circle of friends and colleagues that are the AASV, I could have just as easily surveyed a small number to come up with a list of challenges. This brings up the best part of being a member of AASV – the friends, mentors, and supporters that you gain throughout the years. The networking that occurs during hallway talk, the student reception event, and the awards reception is the best value of a lifetime. I am excited to see you there to expand our friendships, gain valuable knowledge, and "Lead AASV into the Future."

Angela Baysinger, DVM, MSc
AASV President-elect

Kills deadly pathogens*

African Swine Fever Virus (ASFv),
Porcine Reproductive and Respiratory Syndrome virus (PRRSv),
Porcine Epidemic Diarrhea virus (PEDv)

All-in-one cleaner and disinfectant

Excellent foaming ability allows you to easily see surface coverage

Tackle the toughest pathogens

There are few diseases that have the devastating impact to the swine industry compared to African Swine Fever. Intervention™ Disinfectants, powered by Accelerated Hydrogen Peroxide®, is formulated to kill deadly pathogens that threaten your animals. Its powerful formulation is designed to clean, disinfect and protect, while delivering the confidence and peace of mind you deserve.

InterventionDisinfectants.com

VIROX® TECHNOLOGIES INC. | Creators of ACCELERATED HYDROGEN PEROXIDE® Patented | INTERvention®

Intervention® is a member of the Virox family of brands.

*Refer to product label and reference sheet for full list of claims, contact times and use-directions.

Perrydise

It is the week of January 22. I am sitting in the AASV office in Perry, Iowa. Most of Iowa is just starting to thaw from a brutal week of winter weather that saw blizzard conditions, high temperatures below zero, frigid winds, and blowing snow. An old-time Midwest winter. The ground is snow-covered with drifts and piles higher than my head. The sky is cloudy, it is misting, and there has been dense fog most of the day. A very somber type of day that matches my general mood.

This is the first time I have been back to Perry since the tragic school shooting on January 4, 2024, that left 6 people wounded and claimed the lives of a sixth-grade student and the high school principal, Dan Marburger. Numerous acts of bravery, including that of Principal Marburger who confronted the 17-year-old shooter, have been credited with saving lives. Obviously, this was not the first school shooting (there have reportedly been at least 3 prior to January 18 of this year) and, regrettably, will likely not be the last.

Even though I am not from Perry, this tragedy hit close to home for me. This town has long been the home of AASV. I have been coming here frequently for the last 18 years. I have gotten to know some of the locals, and I feel I have a better than passing sense for the community. So, I felt the sorrow emanating from the residents. Sue Schulteis, AASV associate director, and Tom Burkgren, retired AASV executive director, have lived in Perry for decades. They raised their families here and are active in the community. Their kids went to school in Perry under the watchful eye of Principal Marburger and with his kids. I am sure they feel the loss way more acutely than I do.

I noticed the blue ribbons and "Perry Strong" signs scattered around town symbolizing the unity and resilience that arises from these types of events. While I was waiting at the local bank, I noticed a group of big furry yellow dogs wearing blue vests and their handlers walking down the street not far from the school. I mentioned it to the bank teller, and she said they were probably in town to provide some support for folks as the school children began returning to the classroom this week. That human-animal bond is innate and real. I did, however, think that pack needed a beagle.

On the news last night, they showed the kids as they walked past the piles of snow near the school. Despite the sadness, and likely some trepidation, I am sure they were feeling, it was heartening to see that most of the kids were smiling and leading their parents along the way. It appeared at least that they were anxious to see their friends and get back to a "normal" routine.

I know that this tragedy will be a couple of months old by the time you read this article, but I wanted to take an opportunity to share with you some of my thoughts about our little place in the world. I also wanted you to know that the AASV Board of Directors approved a contribution to a fund established to assist the community and support those affected by the shooting. Perry residents are hurting and stunned right now, as any tight-knit community would be, but I am confident it will rebound. Perry is strong. It has been, as Sue would say, Perrydise, and it will be again.

Harry Snelson, DVM
Executive Director


SEQUIVITY®
IAV-S NA
YOUR NEW WEAPON
AGAINST
FLU
NEW SEQUIVITY IAV-S NA vaccine works differently than past influenza A vaccines. Because it was built differently.
This one-of-a-kind influenza A vaccine for growing pigs utilizes revolutionary RNA particle technology to cut down flu with serious power. It's safe and effective – and the proven Microsol Diluvac Forte® adjuvant provides optimal immune response to help keep pigs on track.
Scan the QR code to learn more, or visit SEQUIVITY.COM/IAVS-NA.
TALK TO YOUR VETERINARIAN TODAY.
DrivenByPrevention.com • 800-521-5767 • ©2023 Merck & Co., Inc., Rahway, NJ, USA and its affiliates. All rights reserved. US-SEI-230800002
DRIVEN BY PREVENTION®
MERCK Animal Health

JSHAP Spotlight on student membership

In one of my recent messages, I dropped a hint about the JSHAP Spotlight series for 2024.[1] By now I hope you have seen some of these JSHAP Spotlights featuring our student members. For those of you not familiar with the JSHAP Spotlight you can find the piece directly below the table of contents and one page-turn from the front cover. We started this piece to highlight the contributions from our editorial board members and reviewers. Our student membership is healthy and active in the association, so we also wanted to highlight the meaningful contributions that our veterinary students are making.

My message this issue also comes at a time when veterinary students at my university are looking for mentorship and summer employment opportunities. I am pleased to say that many new local and national veterinary mentorship opportunities, with strong funding support, have become available for swine-focused students. Not only are these opportunities for students who have an interest in swine medicine, but also for those who wish to explore if it is a potential career path.

This also reminded me of the call to action put forward by Patterson et al[2] at the 2020 AASV Annual Meeting in Atlanta.[2] The call for action put forward important considerations that have made progress as highlighted by the opportunities in my region. But there are still issues that remain relevant today. These career-building opportunities, mentor-student relationships, and funding opportunities are important to continue fostering as the shortage of veterinarians continues to be a worldwide issue.

I hope you are enjoying the JSHAP Spotlight featuring some of our student members.

Terri O'Sullivan, DVM, PhD
Executive Editor

"Our student membership is healthy and active in the association, so we also wanted to highlight the meaningful contributions that our veterinary students are making."

References

*1. O'Sullivan T. Terri's favorites [editorial]. *J Swine Health Prod*. 2023;31:277.

*2. Patterson G, Karriker L, Almond G, Althouse G, Bowman A, Pieters M, Ramirez A, Zhitnitskiy P. Challenges and opportunities in modern swine veterinary education. In: *Proc of the 51st AASV Annual Meeting*. American Association of Swine Veterinarians; 2020:344-346.

* Non-refereed references.

Peer reviewed **Original Research**

Gross anatomical measurements and microscopic quantification of epidermal laminar density of the porcine hoof capsule

Meghan E. Fick, DVM; Wolfgang Weber; Locke A. Karriker, DVM; Kenneth J. Stalder, PhD; Julie A. Nelson, MS; Eric W. Rowe, DVM, PhD

Summary

Objective: To compare measurements of the medial and lateral hooves of the forelimbs and rear limbs and to quantify epidermal laminae density in the hoof capsules of sows.

Materials and methods: Hoof measurements were obtained from 40 thoracic and 40 pelvic limbs of clinically sound sows. Holes were drilled into each digit to determine the depth of the dorsal wall, abaxial wall, and sole. Dorsal wall length, abaxial wall height, sole width, sole + wall length, and ground surface of each hoof were measured. All measurements of depth and length were made using an electronic digital caliper. Epidermal laminar density was analyzed in 69 thoracic and 74 pelvic limbs. The laminar junction was divided into zones consisting of 25 laminae each. Zone width was measured using an electronic digital caliper.

Results: Lateral digits from rear limbs were longer than medial digits on the dorsal and volar surfaces. Both digits on the forelimbs had wider soles than those of the rear limbs. Abaxial wall depth was significantly less than dorsal wall depth. The laminar zones at the axial and abaxial extremities of the wall were significantly less dense than the zones at the dorsal aspect of the toe.

Implications: Differences in hoof wall measurements in swine have previously been under reported in scientific literature. The results of this study indicate that the thinnest portions of the hoof wall may be related to the most common sites of lesions as reported in prior studies.

Keywords: swine, hoof capsule, lesions, lameness, laminae density

Received: June 22, 2023
Accepted: December 5, 2023

Resumen - Mediciones anatómicas generales y cuantificación microscópica de la densidad laminar epidérmica de la cápsula de la pezuña porcina

Objetivo: Comparar las medidas de las pezuñas medial y lateral de las extremidades anteriores y traseras y cuantificar la densidad de las láminas epidérmicas en las cápsulas de las pezuñas de cerdas.

Materiales y métodos: Se obtuvieron medidas de las pezuñas de 40 extremidades torácicas y 40 pélvicas de cerdas clínicamente sanas. Se perforaron agujeros en cada dedo para determinar la profundidad de la pared dorsal, la pared abaxial y la planta del pie. Se midieron la longitud de la pared dorsal, la altura de la pared abaxial, el ancho de la planta, la longitud de la planta + la pared, y la superficie del suelo de cada pezuña. Todas las mediciones de profundidad y longitud se realizaron utilizando un calibrador digital electrónico. Se analizó la densidad laminar epidérmica en 69 miembros torácicos y 74 pélvicos. La unión laminar se dividió en zonas de 25 láminas cada una. El ancho de la zona se midió utilizando un calibrador digital electrónico.

Resultados: Los dedos laterales de las extremidades posteriores eran más largos que los dedos mediales en las superficies dorsal y volar. Ambos dedos de las extremidades anteriores tenían las plantas más anchas que las de las extremidades traseras. La profundidad de la pared abaxial fue significativamente menor que la de la dorsal. Las zonas laminares en los extremos axial y abaxial de la pared eran significativamente menos densas que las zonas en la cara dorsal del dedo.

Implicaciones: Las diferencias en las medidas de la pared de las pezuñas en cerdos han sido poco reportadas previamente en la literatura científica. Los resultados de este estudio indican que las porciones más delgadas de la pared de la pezuña pueden estar relacionadas con los sitios más comunes de lesiones como se ha reportado en estudios anteriores.

MEF: Veterinary Teaching Hospital, College of Veterinary Medicine, University of Georgia, Athens, Georgia.

WW, JAN, EWR: Department of Biomedical Sciences, College of Veterinary Medicine, Iowa State University, Ames, Iowa.

LAK: Department of Veterinary Diagnostic and Production Animal Medicine, College of Veterinary Medicine, Iowa State University, Ames, Iowa.

KJS: Department of Animal Science, College of Agriculture and Life Sciences, Iowa State University, Ames, Iowa.

Corresponding author: Dr Eric W. Rowe, 1800 Christensen Dr, Ames, IA 50011; Tel: 515-294-7729; Email: **erowe@iastate.edu**

This article was derived from Meghan Fick's MS thesis, Iowa State University, Ames, Iowa.

Fick ME, Weber W, Karriker LA, Stalder KJ, Nelson JA, Rowe EW. Gross anatomical measurements and microscopic quantification of epidermal laminar density of the porcine hoof capsule. *J Swine Health Prod.* 2024;32(2):58-65. **https://doi.org/10.54846/jshap/1377**

Résumé – Dimensions anatomiques macroscopiques et quantification microscopique de la densité laminaire épidermique des onglons du sabot porcin

Objectif: Comparer les dimensions des onglons médial et latéral des membres antérieurs et postérieurs, et quantifier la densité laminaire épidermique des onglons du sabot de truies.

Matériels et méthodes: Les dimensions des sabots ont été obtenues de 40 membres thoraciques et 40 membres pelviens de truies cliniquement en santé. Des trous ont été percés dans chaque onglon afin de déterminer la profondeur de la muraille dorsale, de la muraille abaxiale, et de la sole. La longueur de la muraille dorsale, la longueur de la muraille abaxiale, la largeur de la sole, la longueur de la sole + la longueur de la muraille, ainsi que la surface au sol de chaque sabot ont été mesurées. Toutes les mesures de profondeur et de longueur ont été réalisées en utilisant un pied à coulisse digital électronique. La densité laminaire épidermique a été analysée de 69 membres thoraciques et 74 membres pelviens. La jonction laminaire a été divisée en zones constituées de 25 lamelles chaque. La largeur des zones était mesurée avec un pied à coulisse digital électronique.

Résultats: Les onglons latéraux des membres postérieurs étaient plus longs que les onglons médiaux sur les surfaces dorsales et palmaires. Les deux onglons des membres antérieurs avaient des soles plus larges que ceux des membres postérieurs. La profondeur des murailles abaxiales était significativement plus petite que la profondeur des murailles dorsales. Les zones laminaires aux extrémités axiale et abaxiale de la muraille étaient significativement moins denses que les zones à l'aspect dorsal de l'onglon.

Implications: Des différences dans les dimensions de la muraille des sabots ont été sous-rapportées dans la littérature scientifique. Les résultats de la présente étude indiquent que les portions les plus minces de la muraille du sabot pourraient être reliés aux sites les plus fréquents de lésions, tel que rapporté dans des études antérieures.

Lameness in swine is a frequent cause for compromised animal welfare and reduced efficiency. Lameness results in behavioral changes such as reduced activity, social behavior, and feeding behavior due to reduced locomotion ability and pain, thereby decreasing welfare.[1] Furthermore, retaining healthy sows and gilts is vital to avoiding unnecessary losses and incurring unwanted costs. Involuntary culling, or removal of animals from the herd due to poor health, injury, or incurable disease before the end of their productive lifespan, is generally less profitable than voluntary culling because the producer is not prepared for it.[2] Lame sows are frequently unable to attain their ideal breeding efficiency and are often culled before they reach their peak production.[3] Production costs can exist even if the animal is not culled, as feed intake may decrease in the days prior to the presentation of lameness, potentially impairing productivity.[4] Using sow lameness models, attempts have been made to determine objective measurements for detecting lameness earlier in order to treat these sows while they still have value.[5] Because multiple factors such as parity, gestation stage, and housing characteristics can influence detection of lameness, it is important to use a reliable indicator of sow lameness for treatment or voluntary culling.[6]

In breeding sows, the most common causes of lameness include hoof lesions, trauma, musculoskeletal disease, fractures, skin lesions, and arthritis.[1] Studies have shown that regardless of housing type, lameness severity, and other lesions (body or limb), a majority of sows will have at least one hoof lesion.[7] The cause of lameness may not be apparently evident since physical examinations are difficult to perform, and oftentimes there is more than one lesion causing the lameness. The most common hoof lesions seen are overgrown hooves, torn dewclaws, hoof cracks, white line cracks, cracks at the heel-sole junction, and sole ulcers.[7-9]

The basic anatomy of the porcine hoof has been described in various anatomy texts, but detailed descriptions have yet to be reported. Most of the assumed information has been extrapolated from studies on equine and bovine hooves, which bear many similarities to those of swine. Regardless of the species, an important function of the hoof is protecting the terminal limb structures. The hard epidermal hoof wall lies just over the supportive tissue layer, the corium. The corium, or the dermal part of the hoof, contains blood vessels and nerves, making it sensitive to pain once exposed to the external environment. When the integrity of the hoof capsule becomes compromised and the sensitive dermis has been exposed, the sow may develop lameness.

Areas of the hoof where hard horn meets soft horn (where wall meets sole) are also prone to injury. Interaction of the epidermis and the corium occurs at the laminar junction, where primary epidermal laminae project from the innermost layer of the hoof wall, the stratum internum. These primary epidermal laminae interact with the similarly-structured primary dermal laminae in order to maintain the attachment of the hoof wall to the distal phalanx enclosed within the hoof.[10] One previous study showed that there was a significant difference in lesion severity on the abaxial wall as well as the white line in lame sows and sound sows,[11] suggesting that further study into these areas may be warranted.

A better understanding of the porcine hoof capsule depth at different locations, as well as determining the density and laminar structure in sows, may provide an anatomical correlation to previously documented hoof lesions and aid producers and swine veterinarians in formulating preventative measures or treatment plans for lame sows. The purpose of this study was to create a basic reference for normal porcine hoof measurements as well as quantify the density of epidermal laminae.

Animal care and use

All samples were obtained post mortem from a fedrally inspected abattoir subject to the US Humane Methods of Slaughter Act.

Materials and methods

Measurement of hoof wall dimensions

For this study, 40 forelimbs and 40 rear limbs were obtained from mixed-breed sows participating in an Agriculture and Food Research Initiative lameness trial. The sows were not clinically lame when they were sent to the abattoir and the distal limb was disarticulated in the carpal or metacarpal region. Most of the limbs were labeled right vs left and front vs rear at the time of death. If they were not differentiated right from left, the carpal or tarsal bones were used to identify the left from right limb. In cases where the disarticulation was distal to

the carpus or tarsus, the tendons of the long or common digital extensor and lateral digital extensor muscles were used. Feet with severe lesions, as defined by the Zinpro Feet First hoof lesion scoring system,[12] were discarded from the study. The weight, age, and parity of these sows were unknown.

The limbs were frozen until they were ready for use. They were thawed either at room temperature for approximately 12 hours or in a cooler for 24 to 36 hours prior to obtaining measurements. Measurements of length, width, and sole depth were taken in a manner similar to a study evaluating cows post mortem.[13] All holes were drilled with a Hollymatic HY16 electric drill and all depth and length measurements were taken with a ProGrade electronic digital caliper.

Three, approximately 6-mm holes were drilled into each digit using a 0.25-inch drill bit. The holes were used to measure the dorsal wall depth, the abaxial wall depth, and the sole depth. The dorsal wall depth was measured at the most proximal aspect, while the abaxial wall depth was measured at the most palmar or plantar aspect of their respective holes. The sole was measured in 4 sites: cranial, caudal, axial, and abaxial.

The dorsal wall length was measured from the most proximal aspect of the perioplic segment to the most distal aspect of the toe. The same location on the distal aspect of the toe to the caudalmost aspect of the bulb was used to determine the ground surface. The palmar or plantar aspect of the ground surface was used as the initial measurement for the abaxial wall height. The calipers were placed approximately perpendicularly to the ground surface and measured from there to the haired skin (Figure 1).

Sole width was measured at the caudalmost aspect of the axial sole in the interdigital space across to the abaxial surface at an approximate 90° angle to the ground surface measurement. The sole + wall length was measured in the same manner as the ground surface, from the center of the distal toe, but only extending the length of the sole, where hard and soft horn meet (Figure 2). This measurement includes the sole, the white line, and the wall. For each sample, 3 measurements were taken at each location and the mean of the 3 measurements was used for statistical analysis.

Figure 1: Schematization of hoof wall measurements as seen from the lateral aspect of the digit. Red arrows indicate the locations of measurements.

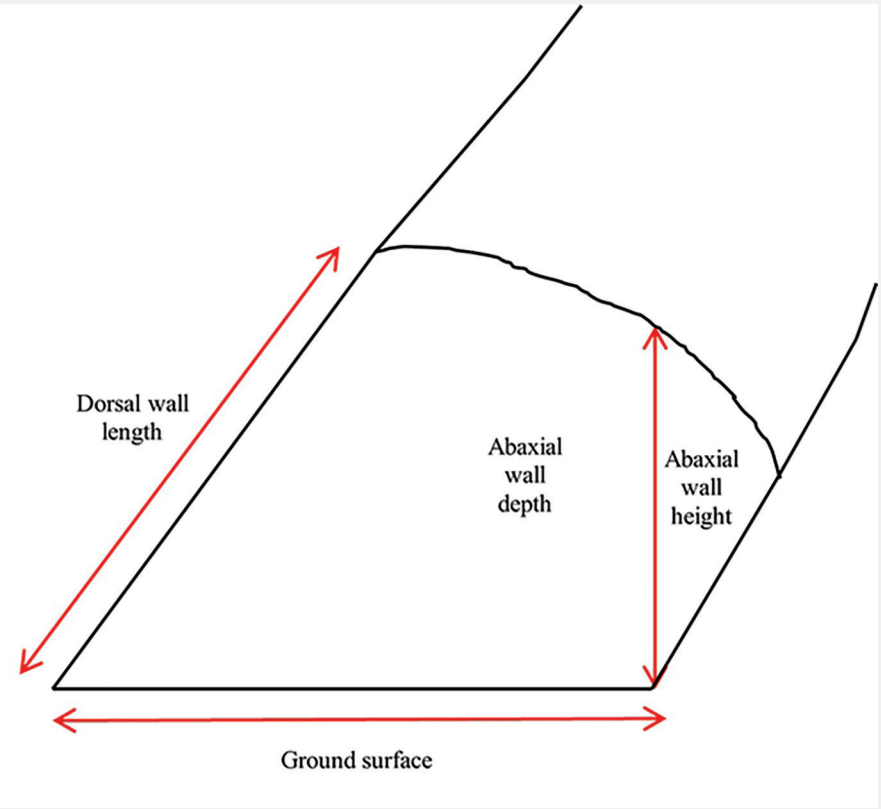
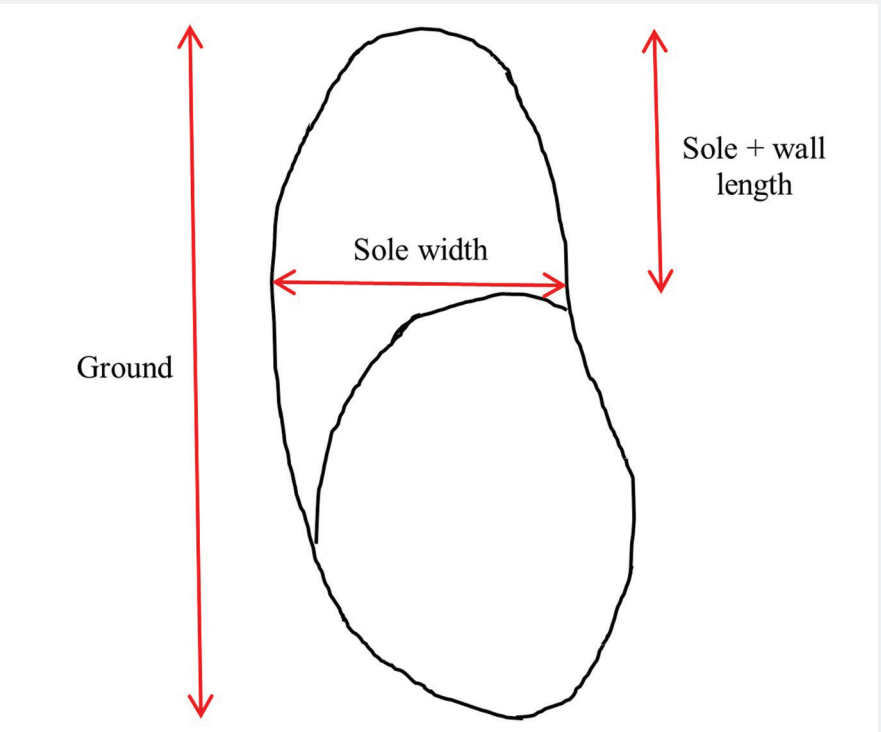


Figure 2: Schematization of hoof wall measurements as seen from the ground surface (volar) aspect of the digit. Red arrows indicate the locations of measurements.



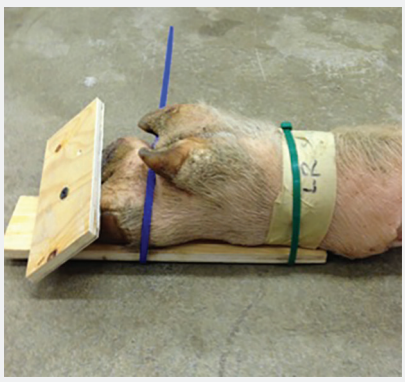
Quantification of epidermal laminae

For the second part of the study, 69 forelimbs and 74 rear limbs from sows were obtained from a federally inspected abattoir. These limbs were all counted individually, and no grouping was made per sow or per digit. The limbs were disarticulated at the distal metacarpus or the proximal phalanges. These limbs were not differentiated right from left, and both digits from each limb were regarded in the same manner. The purpose of this study was to create a basic reference for normal porcine hoof measurements as well as quantify the epidermal laminar density. Limbs were initially frozen, keeping the forelimbs separate from the rear limbs, and then thawed for approximately 12 hours at room temperature until the digits could be manipulated separately.

Commercially-obtained cable ties were used to secure them to pieces of plywood in a weight-bearing position. To accomplish this, the dorsal aspect of the distal limb was laid on a rectangular 15- to 20-cm wide and 30- to 40-cm long piece of plywood and 1 to 2 cable ties were used to secure it. A second piece of plywood, approximately 10 × 20 cm, was placed on the ground surface of the hoof and secured to the first piece of plywood with a screw in the interdigital space. After the feet were once again frozen, the cable ties and wood were removed (Figure 3).

The feet were sliced with a band saw at an approximate 30° to 35° angle from the ground surface. Each slice was approximately 5-mm thick. The slices were labeled 1 to 4, with 1 being the most distal slice and 4 being the most proximal slice (Figure 4). The distal and proximal aspects of each slice were inspected to determine the best sample to visualize the epidermal laminae.

Figure 3: Example of plywood and cable ties used to manipulate the distal limb into an assumed weight bearing position as seen from the plantar-lateral aspect.



The laminar junction was stained with a 5% methylene blue stain solution and immediately placed in 70% alcohol for 5 minutes, rinsed with distilled water, and placed back in the 70% alcohol for another 5 minutes. The slice was blotted dry with a paper towel and then allowed to air dry.

Under a dissecting microscope, the epidermal laminar density was analyzed in a manner similar to that reported by Barreto-Vianna et al.[14] The most dorsal aspect of the chosen slice, or the location where the epidermal laminae turned away from each other, was selected as point 1. From this point, the laminar junction was divided into zones of 25 laminae each. The zones started at the dorsal aspect of the toe, and moved axially and abaxially with A, C, E, and J on the axial surface and B, D, F, G, H, and I on the abaxial surface (Figure 5). Zones I and J were not observed on toes from pelvic limbs. Pins were used as markers to differentiate between each zone. The same ProGrade electronic digital caliper was used to make all the measurements from the shaft of the adjacent pins. This "zone width" was used to determine epidermal laminar density, with smaller widths being more dense and larger widths being less dense. For each sample, 3 measurements were taken at each location and the mean of the 3 measurements was used.

Statistical analysis

Variances in hoof wall measurements and density of epidermal laminae were quantified and analyzed with JMP Pro 11 using a one-way analysis of variance followed by Student's *t*-test with the significance level set at $P < .05$ to determine if significant differences in measurements existed between digits 3 and 4 of right and left thoracic and pelvic limbs.

Results

Hoof wall measurements

Overall, the limbs from 48 sows were evaluated. Only normal limbs were evaluated and those with severe hoof wall lesions or abnormalities according to the Zinpro Feet First scoring system[12] were excluded. These sows were all obtained from the same source and 1 person made all the measurements. All data appeared roughly normally distributed.

Figure 4: Schematization of hoof slices used to quantify epidermal laminae.

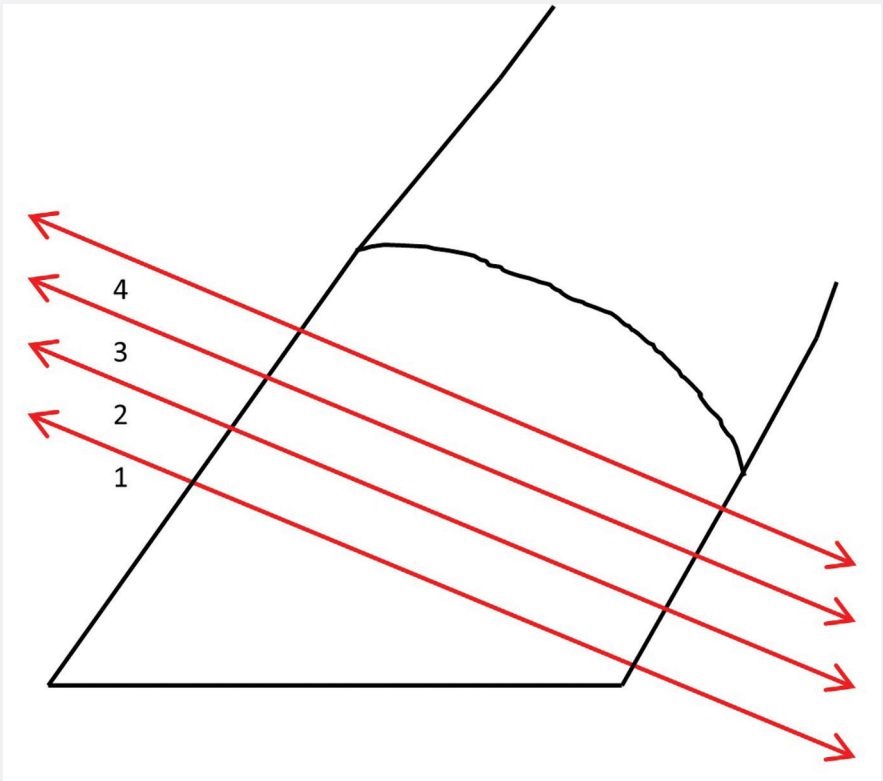
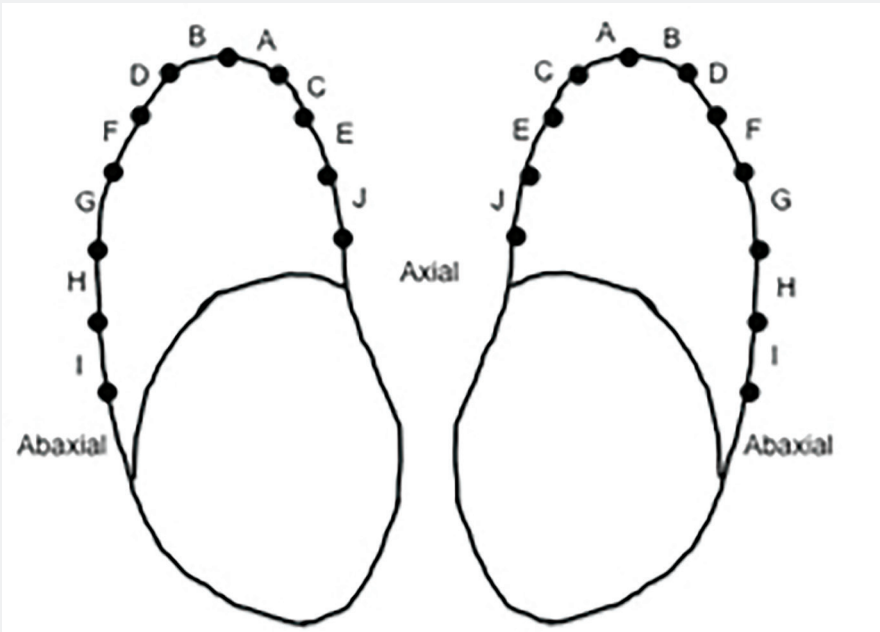


Figure 5: Schematic diagram of a hoof slice divided into zones of 25 laminae each. Zones I and J were not present on pelvic limbs.



The dorsal wall length of the lateral digit (digit 4) on both right and left rear limbs was significantly longer than that of the medial digit (digit 3) on the right and left rear limbs, as well as all 4 digits on the forelimbs. In addition, the sole + wall length of the lateral digit of both rear limbs was significantly longer than those of all 4 digits on the forelimbs, which were significantly longer than that of the medial digit on the rear limbs (Table 1). The ground surface (sole + wall and volar surface of the bulb) was significantly longer for both lateral digits of the rear limb than the remaining 6 digits (the medial rear limb digit and all 4 forelimb digits, Table 1). Furthermore, the width of the sole when measured among the 4 digits of the forelimbs was very similar. These measurements were all significantly greater than all 4 digits on the rear limbs, showing that the digits of the forelimb are wider than those of the rear limbs (Table 1).

The left and right rear digit 4 had a thicker dorsal wall than any digit on the forelimb. There was no significant difference when comparing any of the 4 digits of the forelimb (Table 2). Multiple measurements were made when comparing depths of the sole (cranial, caudal, axial, and abaxial sole depth), but overall, digit 4 of the rear limb had the deepest sole measurements with forelimb digit 3 being the thinnest (Table 2).

The most significant differences in hoof capsule depth came when comparing the dorsal wall and the sole to the abaxial wall depth. The dorsal wall depth of all digits (digits 3 and 4 of the forelimbs and rear limbs) was significantly thicker than the abaxial wall depth on all 8 digits. The same was true when comparing the abaxial wall depth of each digit to all 4 sole measurements (cranial, caudal, axial, and abaxial): the abaxial wall is significantly thinner than that of the sole (Table 2).

Quantification of epidermal laminae

On the thoracic limb, zones A and B were significantly narrower than all of the remaining zones. Zones C and D were narrower than E, F, G, H, and I. Zones E and F were narrower than G, H, and I (Table 3). This demonstrates that zones located at the most dorsal aspect of the toe are the narrowest and the zones become wider moving axially and abaxially toward the heel. Since the narrowest zones represent the most densely packed epidermal laminae, the dorsal aspect of the hoof capsule has the most dense epidermal laminae and the least densely packed areas are located at the axial and abaxial hoof walls.

In the pelvic limb, zones A and B were significantly narrower than the remaining zones, and zones C and D were significantly narrower than E, F, G, and H. The widest zones were G and H (Table 3). Like the thoracic limb, the pelvic limb epidermal laminae are most dense in the dorsal region of the hoof and least dense at the far plantar region. When the thoracic and pelvic limbs are compared to one another, the zones maintain the same pattern of highest density (narrowest zones) at the dorsal part of the hoof, and lowest density (widest zones) at the abaxial wall. The pelvic limb is significantly less dense in the abaxial wall region than the thoracic limb (Table 3).

Discussion

The main objective of this study was to further investigate the anatomy of the porcine hoof wall and draw conclusions about predispositions to foot lesions based on this inherent anatomy. A second goal was to establish known values of various measurements (lengths and depths) of swine hooves for future studies to build on. Some of the most significant findings in this study reaffirmed research that has been done previously, such as the size disparity between the lateral and medial digits on the rear limb and the equal ground surface of the forelimbs.[15] An important finding from the present work showed that the thinnest portion of the hoof capsule was located at the abaxial wall, which had not been reported in the scientific literature previously. This corresponded with the least dense region found in the epidermal laminae.

Isolating the differences in thickness of the hoof capsule can point to areas that may be predisposed to cause lameness if foot lesions occur there. A majority of the sow's weight is born by the heel, one of the most frequent places to see cracks and erosions. One of the subsequent highest weight-bearing regions is where the heel meets the abaxial hoof wall of the lateral digit.[15-17] Data from the present work shows that the junction of heel and hoof wall is where the hoof capsule's thinnest region is located when compared to the sole and the dorsal wall, making it easier for minor cracks to reach the corium, the sensitive layer of the hoof.

The current findings are in agreement with previously reported data concluding that the lateral digits of the rear limbs were longer, both dorsally and on the ground surface, than both the medial digits of the rear limb and the digits of the forelimb. Severe overgrowth of the

Table 1: Mean (SD) hoof wall and sole measurements

Digit	Dorsal wall length, mm	Abaxial wall length, mm	Sole width, mm	Sole + wall length, mm	Ground surface, mm
LF digit 3	43.04 (2.82)[c]	30.82 (3.90)[a]	31.91 (3.75)[a]	23.89 (3.21)[b]	57.62 (4.54)[c,d]
LF digit 4	44.21 (3.60)[b,c]	30.08 (4.48)[a,b]	32.43 (3.08)[a]	24.70 (2.82)[b]	60.82 (7.61)[b]
RF digit 3	43.04 (3.15)[c]	28.57 (4.29)[b,c]	31.53 (3.48)[a]	23.45 (2.94)[b]	58.65 (5.37)[b,c]
RF digit 4	44.45 (3.82)[b,c]	31.63 (4.71)[a]	32.24 (2.62)[a]	23.99 (3.03)[b]	60.80 (7.38)[b]
LR digit 3	45.87 (3.80)[b]	28.01 (4.93)[b,c]	24.06 (2.45)[c]	21.55 (2.31)[c]	55.00 (5.49)[d,e]
LR digit 4	48.92 (5.66)[a]	27.44 (5.51)[c,d]	29.90 (2.69)[c]	27.06 (4.18)[a]	64.75 (7.97)[a]
RR digit 3	45.35 (3.81)[b]	25.48 (5.15)[d]	24.43 (3.06)[b]	22.44 (2.96)[c]	54.54 (6.64)[e]
RR digit 4	49.67 (5.95)[a]	29.76 (5.48)[a,b]	30.03 (3.55)[b]	27.48 (4.28)[a]	66.67 (8.75)[a]

[a-e] Superscript letters denote a connecting letters report of the Student's *t*-test. Values within columns with differing letters are statistically different.

LF = left front; RF = right front; LR = left rear; RR = right rear.

Table 2: Mean (SD) hoof wall and sole depths

Digit	Dorsal wall depth, mm	Abaxial wall depth, mm	Sole cranial depth, mm	Sole caudal depth, mm	Sole axial depth, mm	Sole abaxial depth, mm
LF digit 3	3.24 (0.54)[c]	2.77 (0.95)[a]	3.71 (0.94)[c]	3.80 (1.01)[b,c]	3.69 (0.97)[c]	3.94 (0.90)[c,d]
LF digit 4	3.21 (0.51)[c]	2.64 (0.59)[a,b]	4.02 (1.04)[b,c]	4.07 (1.16)[b,c]	4.07 (1.08)[b,c]	4.10 (0.98)[c,d]
RF digit 3	3.14 (0.58)[c]	2.56 (0.80)[a,b]	3.71 (0.94)[c]	3.80 (0.99)[c]	3.92 (1.01)[b,c]	3.80 (0.97)[d]
RF digit 4	3.34 (0.60)[b,c]	2.77 (0.72)[a]	4.10 (1.15)[a,b,c]	4.30 (1.07)[b]	4.05 (1.03)[b,c]	4.39 (1.05)[b,c]
LR digit 3	3.30 (0.62)[c]	2.38 (0.82)[b]	3.91 (1.17)[b,c]	4.15 (1.18)[b,c]	3.84 (1.26)[c]	4.15 (1.19)[c,d]
LR digit 4	3.62 (0.79)[a]	2.52 (0.89)[a,b]	4.37 (1.10)[a,b]	4.83 (1.19)[a]	4.36 (1.29)[a,b]	4.71 (1.18)[a,b]
RR digit 3	3.28 (0.56)[c]	2.50 (0.81)[a,b]	3.89 (1.18)[b,c]	4.04 (1.02)[b,c]	3.92 (1.06)[b,c]	4.04 (1.07)[c,d]
RR digit 4	3.61 (0.71)[a,b]	2.74 (0.92)[a]	4.51 (1.32)[a]	5.11 (1.46)[a]	4.60 (1.26)[a]	5.04 (1.33)[a]

[a-d] Superscript letters denote a connecting letters report of the Student's *t*-test. Values within columns with differing letters are statistically different.

LF = left front; RF = right front; LR = left rear; RR = right rear.

hooves is associated with lameness, particularly when sows are housed on slatted floors where claws may be trapped between slats and suffer cracks when the sow attempts to free itself.[18] The dorsal wall length, ground surface length, and sole width of the forelimbs were more comparable between lateral and medial digits than the greater disparity in size seen in the rear limbs. It has also been reported that hoof wall lesions are more frequently seen on the lateral hooves of the rear limb than on the medial hooves. Previous findings have reported that the lateral digits on the rear limbs carry more weight than the medial digits, and are therefore possibly more prone to developing lesions.[19] Additionally, in pigs raised with access to concrete flooring, the rate of claw horn growth and wear are greater on the rear feet. The more rapid growth rate may result in the exposure of less mature horn to the walking surface, potentially predisposing the rear feet to the development of lesions.[20] Further studies into the anatomy of these regions in particular may be warranted.

The present results show that the abaxial region has the least dense epidermal laminae when compared to the dorsal toe region. Because laminae function to increase the surface area for attachment, the paucity of laminae means there is less epidermal-dermal interaction, perhaps making this region more susceptible to white line disease. Separation of the corium and epidermis commonly occurs on the abaxial border, frequently at the heel-sole junction.[17] Due to the low density of laminae in this area and the thin abaxial wall, it is easier for minor damage to affect the sensitive corium and, due to the location of the lesion, the damage may lead to infections as well.

In the present study, sows were obtained from different sources, and the premortem lameness status was unknown for each individual animal. It would have been ideal to have a truly random sample of clinically sound sows with differentiation between the left and right limb in order to determine the lateral and medial digit when quantifying epidermal laminae. Furthermore, information about the breed, age, parity, weight, and housing of the individual sows used in this study was unavailable. Without knowing these potentially confounding factors, it is not

Table 3: Mean (SD) measurements of epidermal laminae zone width

Zone*	Thoracic limb width, mm	Pelvic limb width, mm	Thoracic limb branching, mm	Pelvic limb branching, mm
Zone A	5.28 (0.86)[d]	4.75 (0.71)[e]	1.08 (1.20)[c]	1.03 (1.18)[d]
Zone B	5.17 (0.84)[d]	4.88 (0.77)[e]	1.28 (1.28)[b,c]	1.09 (1.22)[c,d]
Zone C	5.82 (0.90)[c]	5.49 (0.88)[e]	1.47 (1.43)[b]	1.37 (1.47)[b,c]
Zone D	5.87 (0.83)[c]	5.90 (0.77)[d]	1.47 (1.30)[b]	1.68 (1.36)[a,b]
Zone E	6.80 (1.05)[b]	6.30 (0.95)[c]	2.08 (1.52)[a]	1.58 (1.49)[a,b]
Zone F	6.84 (0.98)[b]	6.75 (0.93)[b]	1.38 (1.21)[b,c]	1.71 (1.30)[a]
Zone G	7.70 (1.12)[a]	7.11 (1.14)[a]	2.10 (1.48)[a]	1.72 (1.16)[a]
Zone H	7.48 (1.10)[a]	7.19 (1.36)[a]	2.20 (1.75)[a]	1.41 (1.42)[a,b,c,d]
Zone I	7.89 (0.88)[a]	NA†	1.45 (1.51)[a,b,c]	NA†
Zone J	7.11 (0.78)[a,b]	NA†	0.43 (0.79)[b,c]	NA†

* Zones comprised 25 laminae each.

† Zones I and J were not present on the pelvic limbs.

[a-e] Superscript letters denote a connecting letters report of the Student's *t*-test. Values within columns with differing letters are statistically different.

LF = left front; RF = right front; LR = left rear; RR = right rear; NA = not applicable.

possible to suggest a causal relationship between hoof wall thickness and either lesion prevalence or lameness.

A second limitation in this present study is the lack of comparison sows. This study would have been more complete if the measurements of clinically sound sows were compared to those of lame animals.

Despite these limitations, it is hoped that this manuscript will serve as a descriptive baseline to guide further research into the anatomy of the porcine hoof capsule that will lead to better animal welfare management and decreased cull rates for lameness in breeding sows.

Implications

Under the conditions of this study:

- The thinnest portion of the hoof capsule was located at the abaxial wall.
- The abaxial hoof wall had the lowest density of epidermal laminae.
- Hoof anatomy is related to the most common previously reported lesion sites.

Acknowledgments

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. Heinonen M, Peltoniemi O, Valros A. Impact of lameness and claw lesions in sows on welfare, health and production. *Livest Sci.* 2013;156(1-3):2-9. **https://doi.org/10.1016/j.livsci.2013.06.002**

2. Dagorn J, Aumaitre A. Sow culling: Reasons for and effect on productivity. *Livest Prod Sci.* 1979;6(2):167-177. **https://doi.org/10.1016/0301-6226(79)90018-6**

3. D'Allaire S, Stein TE, Leman AD. Culling patterns in selected Minnesota swine breeding herds. *Can J Vet Res.* 1987;51(4):506-512.

4. Munsterhjelm M, Heinonen M, Valros A. Effects of clinical lameness and tail biting lesions on voluntary feed intake in growing pigs. *Livest Sci.* 2015;181:210-219. **https://doi.org/10.1016/j.livsci.2015.09.003**

5. Abell CE, Johnson AK, Karriker LA, Rothschild MF, Hoff SJ, Sun G, Fitzgerald RF, Stalder KJ. Using classification trees to detect induced sow lameness with a transient model. *Animal.* 2014;8(6):1000-1009. **https://doi.org/10.1017/S1751731114000871**

6. Conte S, Bergeron R, Grégoire J, Gete M, D'Allaire S, Meunier-Salaun MC, Devillers N. On-farm evaluation of methods to assess welfare of gestating sows. *Animal.* 2014;8(7):1153-1161. **https://doi.org/10.1017/S1751731114000949**

7. Calderón Díaz JA, Fahey AG, Boyle LA. Effects of gestation housing system and floor type during lactation on locomotory ability; body, limb, and claw lesions; and lying-down behavior of lactating sows. *J Anim Sci.* 2014;92(4):1675-1685. **https://doi.org/10.2527/jas.2013-6279**

8. Dewey CE, Friendship RM, Wilson MR. Clinical and postmortem examination of sows culled for lameness. *Can Vet J.* 1993;34(9):555-556.

9. Nalon E, Conte S, Maes D, Tuyttens FAM, Devillers N. Assessment of lameness and claw lesions in sows. *Livest Sci.* 2013;156:10-23. **https://doi.org/10.1016/j.livsci.2013.06.003**

10. Pollitt CC. Anatomy and physiology of the inner hoof wall. *Clin Tech Equine Pract.* 2004;3(1):3-21. **https://doi.org/10.1053/j.ctep.2004.07.001**

*11. Anil L, Anil SS, Deen J. Claw lesions predict lameness in breeding sows. Paper presented at: Allen D. Leman Swine Conference. September 15, 2007; St Paul, MN. **https://hdl.handle.net/11299/156239**

*12. Zinpro Feet First Swine Locomotion Scoring System. Zinpro. 2021. Accessed September 3, 2023. **www.zinpro.com/performance-solutions/production-optimization-tools/feet-first/.**

13. Nuss K, Paulus N. Measurements of claw dimensions in cows before and after functional trimming: A post-mortem study. *Vet J.* 2006;172(2):284-292. **https://doi.org/10.1016/j.tvjl.2005.04.031**

14. Barreto-Vianna ARC, Oliveira LS, Leonardo AS, Santana MI, Godoy RF, de Lima EMM. Density of primary and secondary epidermal laminae of equine hoof. *Pesq Vet Bras.* 2013;33(4):543-548. **https://doi.org/10.1590/S0100-736X2013000400020**

15. Cameron R. Integumentary System. In: Zimmerman JJ, Karriker LA, Ramierez A, Schwartz KJ, Stevenson GW, eds. *Diseases of Swine*. 10th ed. Wiley-Blackwell; 2012:251-269.

*16. Anil SS, Anil L, Deen J. Association of parity, body condition and lactation feed intake with claw integrity in sows. Paper presented at: Allen D. Leman Swine Conference. September 15, 2007; St Paul, MN. **https://hdl.handle.net/11299/157064**

17. König HE, Liebich HG, Bragulla H. Common Integument. In: König HE, Liebich HG. *Veterinary Anatomy of Domestic Mammals: Textbook and Colour Atlas*. 3rd ed. Schattauer; 2007:585-635.

18. Lisgara M, Skampardonis V, Kouroupides S, Leontides L. Hoof lesions and lameness in sows in three Greek swine herds. *J Swine Health Prod*. 2015;23(5):244-251.

19. Mouttotou N, Hatchell FM, Lundervold M, Green LE. Prevalence and distribution of foot lesions in finishing pigs in south-west England. *Vet Rec*. 1997;141(5):115-120. **https://doi.org/10.1136/vr.141.5.115**

20. Van Amstel S, Doherty T. Claw horn growth and wear rates, toe length, and claw size in commercial pigs: A pilot study. *J Swine Health Prod.* 2010;18(5):239-243.

* Non-refereed references.

Comparative survival of ten porcine reproductive and respiratory syndrome virus strains at three temperatures

Angie Quinonez-Munoz, DVM; Nader M. Sobhy, DVM, PhD; Sagar M. Goyal, DVM, PhD

Summary

Objective: Comparative survival of 10 strains of porcine reproductive and respiratory syndrome virus (PRRSV) at 3 temperatures.

Materials and methods: Strains of PRRSV were propagated in MARC-145 cell line. Aliquots of virus were placed in the bottom of wells on 24-well plates at 100 µL per well. After the virus inoculum was dry, the plates were stored at one of 3 temperatures (4°C, room temperature [22°C-25°C], or 37°C). The surviving virus was eluted at different time points and then titrated.

Results: All 10 strains survived for at least 35 days at 4°C but showed variability in percent survival. For example, the percent survival of strains 1-7-4, Lelystad, 1-8-4, VR-2332, 1-4-2, and 1-4-4 MN was greater (0.29%-2.19%) than that of the other 5 strains (0.01%-0.03%). At room temperature, 5 strains (VR-2332, Lelystad, 1-4-4 SD, 1-4-4 MN, and 1-8-4) survived between 3 and 7 days while the other 5 survived for 1 day only. Four of the ten strains (Lelystad, 1-4-4 MN, 1-4-4 SD, and 1-8-4) survived for up to 3 days at 37°C and the remaining 6 strains for 1 day only. The recently emerged variant 1-4-4 L1C was one of the more resistant strains surviving for 7 days at room temperature and 3 days at 37°C.

Implications: There were differences in the survival of different PRRSV strains at different temperatures, which should be taken into consideration for designing effective biosecurity practices including disinfection regimens.

Keywords: swine, porcine reproductive and respiratory syndrome virus variants, survivability, temperature, inactivation

Received: April 23, 2023
Accepted: December 12, 2023

Resumen - Supervivencia comparativa de diez cepas del virus del síndrome reproductivo y respiratorio porcino a tres temperaturas

Objetivo: Supervivencia comparativa de 10 cepas del virus del síndrome reproductivo y respiratorio porcino (VPRRS) a 3 temperaturas.

Materiales y métodos: Se propagaron diferentes cepas del VPRRS en la línea celular MARC-145. Se colocaron alícuotas de 100 µL del virus en el fondo de los pocillos de placas de 24 pocillos. Después de que el inoculo del virus se secó, las placas se conservaron a una de tres temperaturas (4°C, temperatura ambiente [22°C-25°C], o 37°C). El virus superviviente se eluyó en diferentes momentos y se tituló.

Resultados: Las 10 cepas sobrevivieron durante por lo menos 35 días a 4°C, sin embargo, hubo variabilidad en el porcentaje de supervivencia. Por ejemplo, el porcentaje de supervivencia de las cepas 1-7-4, Lelystad, 1-8-4, VR-2332, 1-4-2, y 1-4-4 MN fue mayor (0.29%-2.19%) que el de las otras 5 cepas (0.01%-0.03%). A temperatura ambiente, 5 cepas (VR-2332, Lelystad, 1-4-4 SD, 1-4-4 MN, y 1-8-4) sobrevivieron entre 3 y 7 días, mientras que las otras 5 sobrevivieron solo 1 día. Cuatro de las diez cepas (Lelystad, 1-4-4 MN, 1-4-4 SD, y 1-8-4) sobrevivieron hasta 3 días a 37°C y las 6 cepas restantes solo durante 1 día. Cuatro de las diez cepas (Lelystad, 1-4-4 MN, 1-4-4 SD, y 1-8-4) sobrevivieron hasta 3 días a 37°C, y las 6 cepas restantes solo durante 1 día. La variante 1-4-4 L1C que surgió recientemente fue una de las cepas más resistentes y sobrevivió durante 7 días a temperatura ambiente, y 3 días a 37°C.

Implicaciones: Hubo diferencias en la supervivencia de las diferentes cepas del VPRRS a diferentes temperaturas, esto debe tomarse en cuenta para diseñar prácticas de bioseguridad efectivas, incluidos los regímenes de desinfección.

Résumé – Comparaison de la survie de dix souches du virus du syndrome reproducteur et respiratoire porcin à trois températures

Objectif: Comparer la survie de 10 souches du virus du syndrome reproducteur et respiratoire porcin (VSRRP) à 3 températures.

Matériels et méthodes: Les souches de VSRRP ont été cultivées sur la lignée cellulaire MARC-145. Des aliquotes du virus ont été déposés au fond des puits d'une plaque à 24 puits à raison de 100 µL par puit. Après que l'inoculum du virus a eu séché, les plaques ont été entreposées à l'une des 3 températures (4°C, température ambiante [22°C - 25°C], ou 37°C). Les virus ayant survécu ont été élués à différents temps et titrés.

Résultats: Les 10 souches ont survécu pour au moins 35 jours à 4°C mais il y avait de la variabilité dans les pourcentages de survie. Par exemple, les

AQ-M, NMS, SMG: Department of Veterinary Population Medicine, University of Minnesota, St. Paul, Minnesota.

NMS: Department of Animal Medicine, Faculty of Veterinary Medicine, Zagazig University, Zagazig, Sharkia, Egypt.

Corresponding author: Dr Sagar M. Goyal, 1333 Gortner Ave, St. Paul, MN 55108-1098; Tel: 612-625-2714; Email: **goyal001@umn.edu**

Quinonez-Munoz A, Sobhy NM, Goyal SM. Comparative survival of ten porcine reproductive and respiratory syndrome virus strains at three temperatures. *J Swine Health Prod.* 2024;32(2):66-73. **https://doi.org/10.54846/jshap/1369**

pourcentages de survie des souches 1-7-4, Lelystad, 1-8-4, VR-2332, 1-4-2, et 1-4-4 MN étaient supérieurs (0.29%-2.19%) à ceux des 5 autres souches (0.01%-0.03%). À température ambiante, 5 souches (VR-2332, Lelystad, 1-4-4 SD, 1-4-4 MN, et 1-8-4) ont survécu entre 3 et 7 jours alors que les 5 autres souches n'ont survécu que pour 1 journée seulement. Quatre des dix souches (Lelystad, 1-4-4 MN, 1-4-4 SD, et 1-8-4) ont survécu jusqu'à 3 jours à 37°C et les 6 autres souches n'ont survécu qu'une seule journée. Le nouveau variant émergent 1-4-4 L1C était l'une des souches les plus résistantes ayant survécu 7 jours à la température ambiante et 3 jours à 37°C.

Implications: Il y avait des différences dans la survie des différentes souches de VSRRP à différentes températures, ce qui devrait être pris en considération lors de l'élaboration de mesures de biosécurité incluant des protocoles de désinfection.

Porcine reproductive and respiratory syndrome (PRRS) is an endemic disease that causes significant economic losses in the North American swine industry with an estimated loss of $664 million annually.[1] Clinical signs include reproductive failure in sows and gilts and respiratory problems in young growing pigs leading to growth reduction, decreased performance, and increased mortality.[2] The etiologic agent of this syndrome is PRRS virus (PRRSV), which is an enveloped, single-stranded, positive-sense RNA virus, classified in the order Nidovirales, family Arteriviridae, genus *Betaarterivirus*.[3] Two different species have been identified, eg, *Beta arterivirus suid 1* (PRRSV1) and *Beta arterivirus suid 2* (PRRSV2).[4] Although each species was initially predominant in Europe and North America, respectively, both serotypes now occur globally.[5] The term strain is used to distinguish PRRSVs that are a genetically distinct lineage because of one or more mutations.

Due to a high mutation rate, several PRRSV2 variants have emerged over the last decade. The classification of PRRSV2 variants is based on the open reading frame (ORF) 5 of the viral genome, which includes restriction fragment length polymorphism (RFLP) patterns, and more recently on the phylogenetic lineages and sublineages. Recently, an emerging PRRSV2 variant classified as 1-4-4 RFLP pattern, lineage 1C has been the cause of a regional outbreak in the midwestern United States since 2020 leading to significant losses for the swine industry.[6]

Transmission of PRRSV in naive herds can occur via direct and indirect routes. Direct transmission occurs through secretions and excretions from infected pigs including blood, saliva, semen, feces, aerosol, milk, and colostrum.[7] For an indirect route to be successful, the virus needs to survive in the environment, which depends on several factors including matrix, temperature, moisture, and pH. Fomites such as boots, coveralls, equipment, and needles are the main vehicles implicated in indirect PRRSV transmission.[8-11] The virus is stable between pH 6.5 and 7.5 and remains infectious for months to years at -70°C to -20°C.[12] A previous study did not detect infectious virus on dry materials (eg, plastic, stainless steel, rubber, alfalfa, wood shavings, straw, corn, swine starter feed, or denim cloth) beyond the day of inoculation at 25°C to 27°C.[13] Other studies found a similar half-life ($t_{1/2}$) for four PRRSV2 isolates at 4°C, 10°C, 20°C, and 30°C in cell culture media.[14,15]

The evolutionary dynamics of PRRSV over the last 3 decades have been characterized by the cyclical emergence of new genetic variants of the virus.[16] The high mutation rate of PRRSV is well known, possibly caused by RNA polymerase errors and lack of proofreading, which contribute to its genetic diversity.[17] Dissemination of these variants on farms by routine animal movements has contributed to persistence of PRRSV in the US pig population.[16] The severity of disease outbreaks associated with new viral variants raises concerns about their stability in the environment, which may affect their dissemination. Survival data on recently circulating variants is critically needed to understand viral dynamics that may lead to developing or strengthening prevention and control measures to limit pathogen dispersal. The aim of this study was to determine the comparative survival of 10 strains of PRRSV (one PRRSV1 and nine PRRSV2) at three temperatures.

Materials and methods

Viruses

Seven PRRSV strains (1-8-4, 1-4-4 MN, Lelystad, VR-2332, 1-4-2, 1-26-2, and 1-7-4) were taken from the University of Minnesota Veterinary Diagnostic Laboratory virus repository. The 1-4-4 SD strain was kindly supplied by Dr Eric Nelson from South Dakota State University. The 2-5-2 and ATP vaccine strains were from Ingelvac PRRS MLV and Ingelvac PRRS ATP commercial vaccines, respectively (Boehringer Ingelheim Animal Health). All strains were propagated in MARC-145 cell line using maintenance medium consisting of Eagle's minimum essential medium supplemented with 4% fetal bovine serum, neomycin at 50 µg/mL, fungizone at 1 µg/mL, penicillin at 150 IU/mL, and streptomycin at 150 µg/mL. Virus titration was also done in monolayers of these cells.

Procedure

For each strain, three Costar 24-well plates (Corning No. 3526) were labelled appropriately (4°C, room temperature, and 37°C). Aliquots of virus were placed in the bottom of all wells at 100 µL per well. The plates were air-dried for 4 hours and stored at their respective temperatures. A calibrated refrigerator with a thermometer was used for the 4°C temperature. Room temperature was monitored with an indoor thermometer; the temperature readings were between 22°C and 25°C during the duration of experiment. A non-CO_2 incubator was used for the 37°C temperature. The surviving virus was eluted from 3 wells each after 4 hours and 1, 3, 7, 14, 21, 28, and 35 days using 200 µL of elution buffer (3% beef extract in 0.05 M glycine solution) per well.

Virus titration

Serial 10-fold dilutions of all samples were prepared in maintenance medium. All dilutions were then inoculated in monolayers of MARC-145 cells in 96-well plates using 3 wells per dilution. The inoculated plates were incubated at 37°C under 5% CO_2 and were examined daily under an inverted microscope for the appearance of cytopathic effects (CPE). After 7 days of incubation, virus titers were calculated using the Karber method and were expressed as $\log_{10}$ median tissue culture infectious dose ($TCID_{50}$) per 100µL.[18] Percent virus inactivation at different time and temperature was then calculated by using (A-B/A) × 100, where A is the initial virus titer and B is the remaining virus titer at a certain time point. The $t_{1/2}$ was calculated by an online method available at **https://www.calculator.net/half-life-calculator.html**.

Statistical analysis

An unpaired one-way analysis of variance (ANOVA) was used to determine significant differences ($P < .05$) in virus titer reduction at different temperatures. To delineate the effect of temperature and time separately, we conducted two *post hoc* tests: the Bonferroni method and Tukey's Honest Significance Difference tests. Significance of $t_{1/2}$ among isolates and between temperatures was tested at $P < .05$.

Results

The initial titers of all viral strains and the titers of surviving virus strains after storage at different times and temperatures are shown in Table 1. Percent inactivation of viral strains at different temperatures is shown in Table 2. All 10 strains of PRRSV survived for at least 35 days at 4°C although there were differences among the amounts of inactivated virus. The viability of strains 1-7-4, Lelystad, 1-8-4, VR-2332, 1-4-2, and 1-4-4 MN at 4°C was relatively higher than that of the other strains.

At room temperature, 5 strains survived for 1 day while the other 5 strains (VR-2332, Lelystad, 1-4-4 SD, 1-4-4 MN, and 1-8-4) survived for 3 to 7 days; strains 1-8-4 and 1-4-4 MN were viable for up to 7 days. Slight variation was observed in percent reduction among different strains with maximum reduction for Lelystad, VR-2332, 1-26-2, ATP Vaccine, and 2-5-2 and minimum reduction for 1-4-4 SD.

Four of the ten strains survived for up to 3 days at 37°C (Lelystad, 1-4-4 MN, 1-4-4 SD, and 1-8-4). The remaining strains survived for only 1 day (Table 2). Most strains showed high percent reduction (99.53%-99.99%) at 37°C except 1-4-4 MN, which showed 98.87% reduction. The recently emerged variant 1-4-4 L1C was one of the more resistant strains surviving for 7 days at room temperature and 3 days at 37°C.

Using one-way ANOVA, significant titer reduction was detected among groups at 4°C and at room temperature. Using *post hoc* tests, we found that titer reduction was significant on days 21, 28, and 35 at 4°C. Additionally, the titer reduction was significant at 1 day and all other successive time points for room temperature and 37°C. The $t_{1/2}$ for strain 1-8-4 was higher than the other strains indicating its stability at different temperatures. Strains 1-7-4 and Lelystad were more stable at 4°C and room temperature, while strains 1-4-4 MN and 1-4-4 SD were more stable at 37°C than other strains. Two vaccine strains and strain 1-26-2 were the least stable at all temperatures (Table 3). Statistically, no differences in $t_{1/2}$ were observed among isolates ($P < .05$) although $t_{1/2}$ between temperatures was significantly different.

Discussion

Since the initial detection of PRRSV among US swine herds, it has been difficult to control the disease, which periodically causes outbreaks leading to substantial economic losses. Continuous circulation of the virus increases the chances for virus mutation, which could possibly explain the emergence of new variants that are currently affecting the pig industry.[6,16,17] It is known that temperature is one of the important factors that can directly affect virus viability/stability in the environment. The survivability of 8 PRRSV strains along with 2 vaccine strains at 3 temperatures was investigated in this study to determine their role in disease progression.

Strain 1-4-4 was identified during fall 2020 in midwestern US swine herds. This strain is highly virulent causing high production losses among growing pigs.[6] The two 1-4-4 strains (1-4-4 MN and 1-4-4 SD) have different survival rates, which raises a question about the effect of genome structure on this phenotypic feature of the virus although both strains belong to sublineage L1C. Whole genome sequencing, which was beyond the scope of this study, may answer this question. The authors are not aware of any published studies analyzing the complete genome of 1-4-4 viruses from different localities. However, other strains from unrelated localities and different production systems have shown > 99% nucleotide identities in the ORF 5 region.[6]

Changes in the frequency of RFLP through time have been observed within a sublineage.[19] For example, strain 1-8-4 was found to have the most frequent polymorphism according to RFLP analysis in the ORF 5 region of the viral genome; 73% of sequences in 1-8-4 strains belonged to sublineage 1F, while newer 1-8-4 strains belonged to sublineage 1H. This indicates the possibility of obtaining different survival patterns if the experiment is repeated with the same strain from a different outbreak. Our results suggest that additional control measures should be taken in swine farms experiencing PRRSV outbreaks due to new divergent strains 1-8-4 and 1-4-4 since they appear to be the most stable in the environment regarding time and temperature.

Lelystad virus is a Dutch strain discovered in 1991. The main clinical signs include abortion in late gestation, stillborn, or the birth of mummified piglets. The piglets experience respiratory problems and even death. The virus was originally isolated on porcine alveolar macrophages and was serologically identified.[20] During the same period, the VR-2332 strain appeared in North America. This strain was identified in a Minnesota swine herd suffering from interstitial pneumonitis and lymphomononuclear encephalitis. Koch's postulates were fulfilled, and the virus was isolated on CL2621 cells.[21] The first study characterizing VR-2332 described that virus infectivity was reduced 50% after incubation at 37°C for 12 hours and completely inactivated after 48 hours.[12] The VR-2332 strain used in this study was able to survive up to 24 hours at this temperature with a $t_{1/2}$ of 0.54 days. It is not possible to know if the same isolate belonging to this RFLP was used in both studies, however it is interesting that similar results were obtained in this study while using the MARC-145 cell line.

Both Lelystad and VR-2332 strains have significant sequence differences that may clarify the difference in clinical features and the ability to survive at 37°C. The amino acid identity between Lelystad and VR-2332 ranges from 55% to 79% in ORF 5 and ORF 6 structural proteins.[22] Longer survival of VR-2332 at room temperature indicates that the virus may survive longer in the barn environment and may cause problems for the herd if proper biosecurity measures are not fulfilled.

Strains 2-5-2 and 1-4-2 are Ingelvac vaccine strains with consistent RFLP types.[23] Ingelvac PRRS ATP vaccine is an attenuated live strain derived from the JA142 parent strain and is used to control PRRSV infection.[24] Vaccine viruses differ phenotypically as they replicate better in MARC-145 cells than their parental strains with two amino acid mutations in the ORF 3 region.[25] These two strains showed the lowest $t_{1/2}$ values which corresponds with both strains being clinically mild in nature. However, our results showed that the 1-7-4 strain did not survive for more than 1 day at room temperature and 37°C, and was the most frequently detected strain during the last

Table 1: Titers of PRRSV strains at different temperatures and times

Strain	Initial titer*	T, °C	Mean titer post exposure, $TCID_{50}$/0.1 mL*†							
			4 hr	Day 1	Day 3	Day 7	Day 14	Day 21	Day 28	Day 35
1-8-4	3.83	4	3.72	3.05	2.28	2.28	2.72	2.39	2.17	2.17
		RT‡	3.39	3.50	2.17	0.28	0.00	0.00	0.00	0.00
		37	3.17	2.94	1.50	0.00	0.00	0.00	0.00	0.00
1-4-4 MN	3.17	4	3.17	3.17	1.50	1.17	1.11	0.67	0.67	0.67
		RT‡	3.17	3.17	2.05	0.28	0.00	0.00	0.00	0.00
		37	2.83	2.83	1.22	0.00	0.00	0.00	0.00	0.00
1-4-4 SD	4.17	4	3.83	3.61	1.39	1.39	1.50	1.00	0.55	0.28
		RT‡	3.28	3.17	1.22	0.00	0.00	0.00	0.00	0.00
		37	3.72	3.17	0.89	0.00	0.00	0.00	0.00	0.00
Lelystad	5.50	4	4.83	4.17	3. 94	3. 72	3. 61	3.50	3.06	3.06
		RT‡	4.17	2.94	0.78	0.00	0.00	0.00	0.00	0.00
		37	3.72	2.83	0.28	0.00	0.00	0.00	0.00	0.00
VR-2332	5.83	4	4.72	4.50	4.28	4.05	3. 61	3. 50	3.50	3.28
		RT‡	4.72	2.39	0.67	0.00	0.00	0.00	0.00	0.00
		37	5.17	1.61	0.00	0.00	0.00	0.00	0.00	0.00
1-4-2	5.50	4	4.28	3.94	3.83	3.83	3.28	2.94	2.39	2.39
		RT‡	4.39	2.06	0.00	0.00	0.00	0.00	0.00	0.00
		37	4.16	1.50	0.00	0.00	0.00	0.00	0.00	0.00
1-26-2	6.50	4	4.39	3.61	3.28	2.94	2.83	2.50	1.83	1.72
		RT‡	3.95	2.39	0.00	0.00	0.00	0.00	0.00	0.00
		37	3.72	1.84	0.00	0.00	0.00	0.00	0.00	0.00
ATP vaccine§	5.83	4	2.83	2.61	2.39	1.72	1.72	1.61	1.28	1.22
		RT‡	2.83	0.67	0.00	0.00	0.00	0.00	0.00	0.00
		37	2.94	0.28	0.00	0.00	0.00	0.00	0.00	0.00
2-5-2 vaccine¶	5.83	4	3.17	3.06	2.50	2.17	2.39	1.94	1.94	1.61
		RT‡	3.61	1.72	0.00	0.00	0.00	0.00	0.00	0.00
		37	2.94	1.50	0.00	0.00	0.00	0.00	0.00	0.00
1-7-4	5.50	4	5.17	4.94	4.28	4.17	3.94	3.72	3. 72	3.61
		RT‡	4.72	2.83	0.00	0.00	0.00	0.00	0.00	0.00
		37	4.39	1.61	0.00	0.00	0.00	0.00	0.00	0.00

* Titers are expressed as $\log_{10}$ $TCID_{50}$/0.1 mL.

† Limit of detection is 1 $TCID_{50}$/0.1 mL.

‡ Room temperature was between 22°C and 25°C.

§ Strain sourced from Ingelvac PRRS ATP vaccine.

¶ Strain sourced from Ingelvac PRRS MLV vaccine.

PRRSV = porcine reproductive and respiratory syndrome virus; T = temperature; $TCID_{50}$ = mean tissue culture infectious dose, RT = room temperature.

Table 2: Survival of various PRRSV strains at three temperatures

	Storage temperature					
	4°C		RT[†]		37°C	
PRRSV strain[*]	Days of survival	Reduction in virus titer[‡], %	Days of survival	Reduction in virus titer[‡], %	Days of survival	Reduction in virus titer[‡], %
1-8-4	35	97.81	7	99.97	3	99.53
1-4-4 MN	35	99.12	7	99.87	3	98.87
1-4-4 SD	35	99.98	3	99.88	3	99.94
Lelystad+	35	98.71	3	99.99	3	99.99
VR-2332	35	99.71	3	99.99	1	99.99
1-4-2	35	99.39	1	99.96	1	99.99
1-26-2	35	99.99	1	99.99	1	99.99
ATP vaccine	35	99.99	1	99.99	1	99.99
2-5-2 vaccine	35	99.97	1	99.99	1	99.99
1-7-4	35	98.71	1	99.78	1	99.98

[*] All strains belong to PRRSV2 except the Lelystad strain, which belongs to PRRSV1.

[†] Room temperature was between 22°C and 25°C.

[‡] Percent virus reduction was calculated by the formula (A-B/A) × 100 where A is the initial virus titer and B is the remaining virus titer.

PRRSV = porcine reproductive and respiratory syndrome virus; RT = room temperature

Table 3: Half-life of PRRSV strains at different temperatures

	Half-life, d		
PRRSV strain	4°C	RT[*]	37°C
1-8-4	42.70	1.85	2.21
1-4-4 MN	15.60	1.99	2.17
1-4-4 SD	8.98	1.69	1.34
Lelystad	41.37	1.06	0.69
VR-2332	42.17	0.96	0.53
1-4-2	29.10	0.70	0.53
1-26-2	18.24	0.69	0.54
ATP vaccine	15.50	0.32	0.22
2-5-2 vaccine	18.85	0.56	0.51
1-7-4	57.61	1.04	0.56

[*] Room temperature was between 22°C and 25°C.

PRRSV = porcine reproductive and respiratory syndrome virus; RT = room temperature

decade with high virulence and severe clinical cases.[26,27] The increased frequency of occurrence may or may not be related to virus stability but is related to the shedding rate and carrier state in the host.[28,29] A study comparing the whole genome sequence of different isolates all belonging to RFLP 1-7-4 found that clinical signs differed between isolates that were 81.4% to 99.8% identical.[30] The pathogenicity and genome of the 1-7-4 strain used in this study is unknown, therefore, a direct correlation between virus survival, frequency of occurrence, and clinical presentation cannot be fully established. The role of these factors in virus epidemiology requires more investigation.

The PRRSV 1-4-2 strain is a virulent strain that was first isolated in Iowa in late 1996 from an atypical PRRS case. The virus causes unusually severe reproductive failure in previously vaccinated pigs due to sudden mutation leading to extensive antigenic drift.[31] Moreover, 1-4-2, 1-26-2, 2-5-2, and 1-7-4 PRRSV strains show lower survivability at both room temperature and 37°C.

The presence of PRRSV in a pig population is enhanced not only by infected animals shedding the virus during acute infection, but also by persistent infection in these animals. The duration of this persistence has been documented in a few studies, but results are highly variable.[3] Therefore, pig flow management strategies such as the Management Changes to Reduce Exposure to Bacteria to Eliminate Losses (McREBEL) system in the farrowing house, all-in/all-out animal flow, or partial herd repopulation should be carried out promptly to prevent PRRSV circulation post weaning. In addition, a strict sanitation and disinfection protocol is critical to decrease the viral load for the healthy pigs that will be introduced to the farm.[32]

This study had some limitations. For example, the sample size was inadequate to statistically determine differences in survival among strains at each temperature. In addition, no complementary assays with higher sensitivity such as indirect immunofluorescence assay (IFA) or quantitative polymerase chain reaction were used. However, it is unknown if IFA results would be consistent for all strains. Hence, we used a $TCID_{50}$ assay for the evaluation of infectious PRRSV as these strains exhibit detectable CPE. Each strain was evaluated individually; therefore, the chances of confusion during plate reading or titer calculation were minimized. Despite these limitations, the study provides insightful information that contributes to the knowledge of temperature effect on PRRSV survival.

It is known that the PRRSV survives better at lower temperatures in the environment and in animal tissues.[33] Survival of virus at 4°C for ≥ 35 days may explain the endemic nature and increased infections during winter months in the United States.[34-36]

A previous study demonstrated the mechanical transmission of PRRSV (strain MN 30-100) during periods of cold weather (-2°C and -9°C).[10] Though this strain was not evaluated in this study, the results of the previous study support our findings at 4°C highlighting the risk of PRRSV survival at cold temperatures with a wide survival range.

A critical point is the efficacy of disinfectants for sanitation of transport vehicles at cold temperatures. In an earlier study, negative samples were collected from PRRSV-contaminated trailers that were washed with water at 21°C delivered at a pressure of 20,500 kPa, followed by disinfection with a hurricane fogger, and 8-hour (overnight) period of drying in a separate nursery room heated at 20°C. These results were obtained at 4°C for PRRSV strain MN 30-100 while comparing 7 disinfectants.[37] Although meeting all these specifications could be challenging under field conditions, it is important to emphasize that any opportunity to increase water temperature for washing, drying temperature, and the drying period length may increase virus inactivation and should be considered in disinfection and sanitation protocols for transport vehicles.

An alternative to increasing the length of the drying period is the use of a thermo-assisted drying and decontamination (TADD) system, which raises the interior temperature of trailers to 71°C for 30 minutes. The TADD system was found to be equal to the overnight drying treatment for PRRSV MN 30-100.[38] The benefits of a shorter drying period should be taken into consideration while establishing sanitation protocols. Since PRRSV MN 30-100 was the only strain evaluated in this previous study, further experiments evaluating new emergent strains should be considered in the future.

Other critical points that require attention are quarantine and housing facilities. Proper washing by removing any organic material followed by disinfection and drying protocols must be performed to inactivate the virus. Based on our findings, increasing the temperature of facilities during the drying period may enhance the sanitation process. Temperatures near 37°C are suggested for most of the PRRSV strains evaluated in this study. Consider using temperatures > 37°C for strains 1-8-4 and 1-4-4 since they were able to survive for up to 7 days at room temperature and up to 3 days at 37°C.

It is debatable if the suggested measures will completely eliminate PRRSV from the farm premises. However, the data obtained in this study should help producers and veterinarians in understanding the dynamics of PRRSV survival in the environment and its relationship with temperature. Further studies evaluating not only temperature, but also the nature of materials (fomites) contaminated by different strains, are necessary to develop better disinfection and sanitation protocols to decrease the risk of transmission and dissemination of PRRSV among farms. Studies are also needed to evaluate correlation, if any, between phenotypic and genotypic characterization of the divergent PRRSV strains and their survival at different temperatures. In conclusion, our results indicate that there are differences in the survival of PRRSV strains at different temperatures; the virus survives longer at cold temperature (4°C) as compared to room temperature and 37°C.

Implications

Under the conditions of this study:

- Definitive strain diagnosis is important to overcome between-strain variability.
- An appropriate biosecurity plan requires strain identification during outbreaks.
- Contaminated surfaces at low temperatures are a risk for virus transmission.

Acknowledgments

We thank Dr Eric Nelson of South Dakota State University for providing the 1-4-4 SD strain.

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

2. Goyal SM. Porcine reproductive and respiratory syndrome. *J Vet Diagn Invest*. 1993;5:656-664. **https://doi.org/10.1177/104063879300500435**

3. Cho JG, Dee SA. Porcine reproductive and respiratory syndrome virus. *Theriogenology*. 2006;66:655-662. **https://doi.org/10.1016/j.theriogenology.2006.04.024**

4. Walker PJ, Siddell SG, Lefkowitz EJ, Mushegian AR, Adriaenssens EM, Dempsey DM, Dutilh BE, Harrach B, Harrison RL, Hendrickson RC, Junglen S, Knowles NJ, Kropinski AM, Krupovic M, Kuhn JH, Nibert M, Orton RJ, Rubino L, Sabanadzovic S, Simmonds P, Smith DB, Varsani A, Zerbini FM, Davison AJ. Changes to virus taxonomy and the statutes ratified by the international committee on taxonomy of viruses. *Arch Virol*. 2020;165:2737-2748. **https://doi.org/10.1007/s00705-020-04752-x**

5. Cortey M, Díaz I, Martín-Valls GE, Mateu E. Next-generation sequencing as a tool for the study of porcine reproductive and respiratory syndrome virus (PRRSV) macro- and micromolecular epidemiology. *Vet Microbiol*. 2017;209:5-12. **https://doi.org/10.1016/j.vetmic.2017.02.002**

6. Kikuti M, Paploski IAD, Pamornchainavakul N, Picasso-Risso C, Schwartz M, Yeske P, Leuwerke B, Bruner L, Murray D, Roggow BD, Thomas P, Feldmann L, Allerson M, Hensch M, Bauman T, Sexton B, Rovira A, VanderWaal K, Corzo CA. Emergence of a new lineage 1C variant of porcine reproductive and respiratory syndrome virus 2 in the United States. *Front Vet Sci*. 2021;8:1-10. **https://doi.org/10.3389/fvets.2021.752938**

7. Wills RW, Zimmerman JJ, Yoon K-J, Swenson SL, Hoffman LJ, McGinley MJ, Hill HT, Platt KB. Porcine reproductive and respiratory syndrome virus: Routes of excretion. *Vet Microbiol*. 1997;57:69-81. **https://doi.org/10.1016/s0378-1135(97)00079-5**

8. Otake S, Dee SA, Rossow KD, Deen J, Joo HS, Molitor TW, Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by fomites (boots and coveralls). *J Swine Health Prod*. 2002;10:59-65.

9. Otake S, Dee SA, Rossow KD, Moon RD, Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus by mosquitoes, *Aedes vexans* (Meigen). *Can J Vet Res*. 2002;66:191-195.

10. Dee S, Deen J, Rossow K, Weise C, Otake S, Joo HS, Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus throughout a coordinated sequence of events during cold weather. *Can J Vet Res*. 2002;66:232-239.

11. Dee S, Deen J, Rossow K, Weise C, Eliason R, Otake S, Joo HS, Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus throughout a coordinated sequence of events during warm weather. *Can J Vet Res*. 2003;67:12-19.

12. Benfield DA, Nelson E, Collins JE, Harris L, Goyal SM, Robison D, Christianson WT, Morrison RB, Gorcyca D, Chladek D. Characterization of swine infertility and respiratory syndrome (SIRS) virus (isolate ATCC VR-2332). *J Vet Diagn Invest*. 1992;4:127-133. **https://doi.org/10.1177/104063879200400202**

13. Pirtle EC, Beran GW. Stability of porcine reproductive and respiratory syndrome virus in the presence of fomites commonly used in farms. *JAVMA*. 1996;208:390-392. **https://doi.org/10.2460/javma.1996.208.03.390**

14. Jacobs AC, Hermann JR, Muñoz-Zanzi C, Prickett JR, Roof MB, Yoon K-J, Zimmerman JJ. Stability of porcine reproductive and respiratory syndrome virus at ambient temperatures. *J Vet Diagn Invest*. 2010;260:257-260. **https://doi.org/10.1177/104063871002200216**

15. Linhares DCL, Torremorell M, Joo HS, Morrison RB. Infectivity of PRRS virus in pig manure at different temperatures. *Vet Microbiol*. 2012;160:23-28. **https://doi.org/10.1016/j.vetmic.2012.05.009**

16. Pamornchainavakul N, Paploski IAD, Makau DN, Kikuti M, Rovira A, Lycett S, Corzo CA, VanderWaal K. Mapping the dynamics of contemporary PRRSV-2 evolution and its emergence and spreading hotspots in the US using phylogeography. *Pathogens*. 2023;12:740. **https://doi.org/10.3390/pathogens12050740**

17. Paploski IAD, Corzo C, Rovira A, Murtaugh MP, Sanhueza JM, Vilalta C, Schroeder DC, VanderWaal K. Temporal dynamics of co-circulating lineages of porcine reproductive and respiratory syndrome virus. *Front Microbiol*. 2019;10:1-13. **https://doi.org/10.3389/fmicb.2019.02486**

18. Karber G. Contribution to the collective treatment of pharmacological series experiments. Article in German. *Naunyn Schmiedebergs Arch Exp Pathol Pharmakol*. 1931;162:480-484. **https://doi.org/10.1007/BF01863914**

19. Paploski IA, Pamornchainavakul N, Makau DN, Rovira A, Corzo CA, Schroeder DC, Cheeran MC-J, Doeschl-Wilson A, Kao RR, Lycett S, VanderWaal K. Phylogenetic structure and sequential dominance of sub-lineages of PRRSV type-2 lineage 1 in the United States. *Vaccines (Basel)*. 2021;9:608. **https://doi.org/10.3390/vaccines9060608**

20. Wensvoort G, Terpstra C, Pol JM, ter Laak EA, Bloemraad M, De Kluyver EP, Kragten C, van Buiten L, den Besten A, Wagenaar F, Broekhuijsen JM. Mystery swine disease in the Netherlands: the isolation of Lelystad virus. *Vet Q*. 1991;13:121-130. **https://doi.org/10.1080/01652176.1991.9694296**

21. Collins JE, Benfield DA, Christianson WT, Harris L, Henings JC, Shaw DP, Goyal SM, McCullough S, Morrison RB, Joo HS, Gorcyca D, Chladek D. Isolation of swine infertility and respiratory syndrome virus (isolate ATCC VR-2332) in North America and experimental reproduction of the disease in gnotobiotic pigs. *J Vet Diagn Invest*. 1992;4:117-126. **https://doi.org/10.1177/104063879200400201**

22. Murtaugh MP, Elam MR, Kakach LT. Comparison of the structural protein coding sequences of the VR-2332 and Lelystad virus strains of the PRRS virus. *Arch Virol*. 1995;140:1451-1460. **https://doi.org/10.1007/BF01322671**

23. Rosendal T, Dewey C, Friendship R, Wootton S, Young B, Poljak Z. Spatial and temporal patterns of porcine reproductive and respiratory syndrome virus (PRRSV) genotypes in Ontario, Canada, 2004-2007. *BMC Vet Res*. 2014;10:1-13. **https://doi.org/10.1186/1746-6148-10-83**

24. Key KF, Guenette DK, Yoon K-J, Halbur PG, Toth TE, Meng XJ. Development of a heteroduplex mobility assay to identify field isolates of porcine reproductive and respiratory syndrome virus with nucleotide sequences closely related to those of modified live-attenuated vaccines. *J Clin Microbiol*. 2003;41:2433-2439. **https://doi.org/10.1128/JCM.41.6.2433-2439.2003**

25. Kim W-I, Kim J-J, Cha S-H, Yoon K-J. Different biological characteristics of wild-type porcine reproductive and respiratory syndrome viruses and vaccine viruses and identification of the corresponding genetic determinants. *J Clin Microbiol*. 2008;46:1758-1768. **https://doi.org/10.1128/JCM.01927-07**

26. Alkhamis MA, Perez AM, Murtaugh MP, Wang X, Morrison RB. Applications of Bayesian phylodynamic methods in a recent US porcine reproductive and respiratory syndrome virus outbreak. *Front Microbiol*. 2016;7:67. **https://doi.org/10.3389/fmicb.2016.00067**

*27. Kikuti M, Sanhueza J, Geary E, Vilalta C, Fioravante P, Corzo C. Detection of PRRSV RFLP type 1-7-4 over time. Morrison Swine Health Monitoring Program. Published June 2019. Accessed March 13, 2023. **https://mnshmp.dl9.umn.edu/sites/mnshmp.umn.edu/files/2023-06/shmp_2018l19.49_detection_of_prrsv_1-7-4_over_time.pdf**

28. Horter DC, Pogranichniy RM, Chang C-C, Evans RB, Yoon K-J, Zimmerman JJ. Characterization of the carrier state in porcine reproductive and respiratory syndrome virus infection. *Vet Microbiol*. 2002;86:213-228. **https://doi.org/10.1016/s0378-1135(02)00013-5**

29. Bonilauri P, Merialdi G, Dottori M, Barbieri I. Presence of PRRSV in wild boar in Italy. *Vet Rec*. 2006;158:107-108. **https://doi.org/10.1136/vr.158.3.107-a**

30. van Geelen AGM, Anderson TK, Lager KM, Das PB, Otis NJ, Montiel NA, Miller LC, Kulshreshtha V, Buckley AC, Brockmeier SL, Zhang J, Gauger PC, Harmon KM, Faaberg KS. Porcine reproductive and respiratory disease virus: Evolution and recombination yields distinct ORF5 RFLP 1-7-4 viruses with individual pathogenicity. *Virology*. 2018;513:168-179. **https://doi.org/10.1016/j.virol.2017.10.002**

*31. Osorio FA, Zuckermann F, Wills R, Meier W, Christian S, Galeota J, Doster A. PRRSV: comparison of commercial vaccines in their ability to induce protection against current PRRSV strains of high virulence. In: *Proc of the Allen D. Leman Swine Conference*. University of Minnesota; 1998:176-182.

32. Corzo CA, Mondaca E, Wayne S, Torremorell M, Dee S, Davies P, Morrison RB. Control and elimination of porcine reproductive and respiratory syndrome virus. *Virus Res*. 2010;154:185-192. **https://doi.org/10.1016/j.virusres.2010.08.016**

33. Van Alstine WG, Kanitz CL, Stevenson GW. Time and temperature survivability of PRRS virus in serum and tissues. *J Vet Diagn Invest*. 1993;5:621-622. **https://doi.org/10.1177/104063879300500421**

34. Alkhamis MA, Arruda AG, Morrison RB, Perez AM. Novel approaches for spatial and molecular surveillance of porcine reproductive and respiratory syndrome virus (PRRSV) in the United States. *Sci Rep*. 2017;7:1-14. **https://doi.org/10.1038/s41598-017-04628-2**

35. Valdes-Donoso P, Alvarez J, Jarvis LS, Morrison RB, Perez AM. Production losses from an endemic animal disease: Porcine reproductive and respiratory syndrome (PRRS) in selected midwest US sow farms. *Front Vet Sci*. 2018;5:102. **https://doi.org/10.3389/fvets.2018.00102**

36. Sanhueza JM, Stevenson MA, Vilalta C, Kikuti M, Corzo CA. Spatial relative risk and factors associated with porcine reproductive and respiratory syndrome outbreaks in United States breeding herds. *Prev Vet Med*. 2020;183:105-128. **https://doi.org/10.1016/j.prevetmed.2020.105128**

37. Dee S, Deen J, Burns D, Douthit G, Pijoan C. An evaluation of disinfectants for the sanitation of porcine reproductive and respiratory syndrome virus-contaminated transport vehicles at cold temperatures. *Can J Vet Res*. 2005;69:64-70.

38. Dee S, Torremorell M, Thompson B, Deen J, Pijoan C. An evaluation of thermo-assisted drying and decontamination for the elimination of porcine reproductive and respiratory syndrome virus from contaminated livestock transport vehicles. *Can J Vet Res*. 2005;69:58-63.

* Non-refereed references.

Conversion tables

Weights and measures conversions

Common (US)	Metric	To convert	Multiply by
1 oz	28.35 g	oz to g	28.35
1 lb (16 oz)	0.45 kg	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)	0.3 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	35.3
1 gal (128 fl oz)	3.8 L	gal to L	3.8
0.26 gal	1 L	L to gal	0.26
1 qt (32 fl oz)	0.95 L	qt to L	0.95
1.06 qt	1 L	L to qt	1.06

Temperature equivalents (approx)

°F	°C
32	0
50	10.0
60	15.5
61	16.1
65	18.3
70	21.1
75	23.8
80	26.6
82	27.7
85	29.4
90	32.2
102	38.8
103	39.4
104	40.0
105	40.5
106	41.1
212	100.0

°F = (°C × 9/5) + 32

°C = (°F - 32) × 5/9

Conversion calculator available at: amamanualofstyle.com/page/si-conversion-calculator

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	136
	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

Biosecurity is grounded in practicality and research

Research funded by the Swine Health Information Center (SHIC) found significant biosecurity gaps in wean-to-finish facilities after placement, specifically regarding potential porcine reproductive and respiratory syndrome (PRRS) virus, porcine epidemic diarrhea (PED) virus, and *Actinobacillus pleuropneumoniae* transmission.[1] Additionally, aggregated data from the SHIC-funded Swine Disease Monitoring Report shows breeding herd outbreaks of PRRS virus tend to follow outbreaks in wean-to-finish sites. These breaks escalate up the supply chain with losses estimated to be $664 million[2] for PRRS virus coupled with supply and demand implications for PED virus.[3] The onset of emerging and endemic animal health concerns is being proactively addressed with the producer- and veterinarian-led Wean-to-Harvest Biosecurity Program initiated by SHIC.

"By leveraging funds together with Pork Checkoff and the Foundation for Food & Agriculture Research for this program, SHIC has funded a wide range of diverse research projects that will enable the pork industry to consider biosecurity in novel and unconventional ways," remarked Dr Megan Niederwerder, SHIC executive director. "These projects are trying to solve the biosecurity gap that results in higher prevalence of endemic diseases such as PED and PRRS in the wean-to-harvest phases of pork production. Addressing this gap lessens disease pressure across all phases of production and provides value to the whole industry."

Research outcomes from the inaugural 2-year program are beginning to be shared. In all, the 16 projects funded in 2023 have laid a solid foundation for future advancements in swine health management.

Five additional projects (listed in sidebar) prioritize on-site and transportation biosecurity in five targeted areas in the second round of funding.[4] The priority areas include:

1. personnel biocontainment and bio-exclusion;
2. mortality management;
3. truck wash efficiency;
4. alternatives to a fixed truck wash; and
5. packing plant biocontainment.

The collaborative proposals define practices and investigate technologies and protocols to improve biosecurity. Herd health status monitoring can demonstrate success while evaluating the solution's affordability, efficiency, and practicality. Specific details about each priority can be found at **swinehealth.org**.

In essence, biosecurity is not merely about filling gaps; it is about constructing robust bridges in animal care, grounded in practicality and research. "Biosecurity is one of the most important lines of defense against disease for producers and veterinarians," says Dr Marisa Rotolo, director of swine health at the National Pork Board. "As an industry, it is vitally important we continue to evaluate and improve our biosecurity protocols across all phases of production, especially wean-to-harvest. Veterinarians can reduce the risk of disease and improve herd health by staying up to date on this program and the research it invests in to advance our understanding of effective biosecurity."

While industry-wide initiatives are instrumental, Rotolo says veterinarians can make an immediate impact by assisting farmers in implementing a Secure Pork Supply plan, which includes an enhanced site-specific biosecurity plan. Resources to help develop these plans can be found at **securepork.org**.

Titles of round two Wean-to-Harvest Biosecurity Program projects awarded are:

- Self-vaccinating pigs to save labor, improve efficacy and enhance biosecurity: Mycoplasma hyopneumoniae, influenza A virus, ileitis, and erysipelas evaluations
- Determining the economical and epidemiological benefit of cleaning and disinfecting market-haul trailers within the US swine industry
- Comparison of a rail-mounted automated power washer to a commercial manual power washing crew in terms of cleanliness, manpower, and water usage efficiency
- Development of an effective and practical biosecurity entrance system
- Using sensors and psychological profile to increase compliance of wean-to-market barn biosecurity

NPB news continued on page 77

UNITED ANIMAL HEALTH

WE ♡ MOMS

Systemwide performance starts with the sow.

Strong sow research can change your system.

UnitedAnH.com/Mother

NPB news continued from page 75

Other practical examples of biosecurity include requiring sign-in sheets; identifying perimeters and lines of separation; and providing proper footwear, shoe covers and clothing. More extensive changes could include using ultraviolet boxes, implementing a Danish entry, and installing showers. A self-assessment checklist for enhanced biosecurity for animals raised indoors is available at **securepork.org**, in addition to training videos and signs to hang near barns.

As results from the second round of the program are in progress, the industry anticipates a future where comprehensive biosecurity practices significantly enhance the resilience of swine production systems.

Other practical examples of biosecurity include requiring sign-in visitor logs.

References

*1. SHIC-funded project examines growing pig site biosecurity gaps. Swine Health Information Center. June 16, 2022. Accessed January 18, 2024. **https://www.swinehealth.org/shic-funded-project-examines-growing-pig-site-biosecurity-gaps/**

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

3. Schulz LL, Tonsor GT. Assessment of the economic impacts of porcine epidemic diarrhea virus in the United States. *J Anim Sci*. 2015;93(11):5111-5118. **https://doi.org/10.2527/jas.2015-9136**

*4. Swine Health Information Center 2024 plan of work strategic priorities. Accessed January 18, 2024. **https://www.swinehealth.org/wp-content/uploads/2023/12/2024-SHIC-Plan-of-Work-FINAL.pdf**

* Non-refereed references.

There's only one Hy•D®
for lifetime productivity

When it comes to purity, performance and immunity, Hy•D® has been helping pigs and producers stand strong for years. As the proven source of pure 25-OH D3 for diet fortification, Hy•D is the fastest and most efficient way to provide pigs with essential vitamin D.

1

Pure 25-OH D3, which is the single safest and most effective metabolite for improving vitamin D status in pigs

7+

Years on the market for swine in North America, with demonstrated safety and research for increasing vitamin D status

100+

Research trials demonstrating the safety and benefits of Hy•D in diets for poultry, swine, and ruminants globally

2.6 Million

Pigs fed Hy•D per year in North America, based on dsm-firmenich actual sales, recommended feeding rates and survey data

There's only one Hy•D

Follow us on:

dsm-firmenich

Alternate student delegate selected for AASV Board

The AASV Student Engagement Committee is pleased to announce the selection of Mallory Wilhelm, a second-year veterinary student at Iowa State University (ISU), as the incoming alternate student delegate to the AASV Board of Directors.

Mallory has embraced many opportunities available to veterinary students interested in swine, and she brings a variety of experiences to her new role. After a production internship during college, she shared her knowledge as a teaching assistant for an undergraduate swine science course. During two summers in the Swine Veterinary Internship Program, she completed research projects in immunology and biosecurity. She presented her research at the 2023 AASV Annual Meeting, and she will present again during the 2024 AASV Annual Meeting. Mallory is active in the ISU Student AASV chapter, where she is the current wet lab coordinator.

When thinking about her upcoming role with AASV, Mallory said, "I am committed to improving the AASV organization for both veterinarians as well as veterinary students." When Mallory graduates in 2026, she plans to be a part of the swine industry and remain active within AASV.

Mallory will assume her duties as alternate student delegate during the 2024 AASV Annual Meeting. The current alternate delegate, Alexis Berte (ISU, 2025), will assume the delegate position currently held by Hunter Everett (NCSU, 2024), who will rotate off the board. Alexis and Mallory will represent student interests within AASV as nonvoting members of the Board of Directors and the Student Engagement Committee. Please join us in welcoming Mallory to the AASV Board of Directors and thanking Hunter for his service!

AASV conference proceedings online

More than 230 papers representing the presentations at the 2024 AASV Annual Meeting are now available for AASV members to access at **aasv.org/library/proceedings/**.

Current 2024 dues-paid membership is required to access the files.

As in the past, the papers are available as follows:

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

You will be prompted for your AASV website username and password to access the files. If you have forgotten your password, use the "Reset Password" link in the upper right of the AASV website (**aasv.org**) or contact the AASV office for assistance.

AASV news continued on page 81

FULL VALUE PORK™

"LIFE IS HARD"

Reduce oxidative stress and boost the diversity of beneficial bacteria in the gut microbiota to support a strengthened intestinal wall and the reduction of diarrhea incidence and severity.

Inhibit the production of *E. coli* pili, to reduce their ability to attach to the gut wall and induce diarrhea.[2,3,4]

Benefit piglet immunity through passed maternal antibodies that prevent attachment of *E. coli* to gut walls.

E. coli doesn't have to be a barrier to success for your operation. Contact your Elanco representative to discover the right solutions for your operation.

[1]Elanco Animal Health. Data on File.
[2]Rostagno M., Pelger. G. Exposure to the antibiotic avilamycin inhibits E. coli fimbriae and attachment. IPVS 2014, Pg. 246.
[3]Elanco Animal Health. Data on File.
[4]Elanco Animal Health. Data on File.

The labels contain complete use information, including cautions and warnings. Always read, understand and follow the label and use directions.

PM-US-24-0015 | 1263191067

Elanco

AASV news continued from page 79

Animal Depopulation Resiliency Check-in Tool now available in French, Spanish, and English; training video created

The Animal Depopulation Resiliency Check-in Tool (ADRCT), a 5-question-public health protocol for stakeholders who are preparing for, participating in, and recovering from animal depopulation, created by AASV and Dr Elizabeth Strand, is now available in French, Spanish, and English. A short video describing how to use the tool is also available. All ADRCT resources are available at **aasv.org/resources/depop-resiliency.php**.

Animal depopulation is associated with distressing psychological impacts on people. These impacts affect many stakeholders including veterinarians, producers, public health officials, and others who make decisions about and carry out depopulation.

The goals of the ADRCT are to:

- Identify any psychological distress that may result from depopulation,
- Promote social support and coping among those engaged in the depopulation process, and
- Help individuals who may need mental health intervention by providing referral information for additional support.

The American Association of Swine Veterinarians received funding from the US Department of Agriculture Animal and Plant Health Inspection Service through their National Animal Disease Preparedness and Response Program in 2021 to develop resources, including the ADRCT, to build and improve capabilities and capacities for responding to emergency events that require animal depopulation. Those resources are available at **aasv.org/Resources/welfare**.

The ADRCT is now available in English, Spanish, and French.

A short video describing how to use the ADRCT is available in English and Spanish.

American Association of
Swine Veterinarians Foundation

It's not too late, donate to the AASV Foundation today!

Multiple ways to contribute:

- Make a one-time, monthly, or annual donation of any amount
- Become a Leman Fellow: $1,000 donation
- Become a Heritage Fellow: $5,000 donation
- Establish a Legacy Fund: $50,000 or more

Payment:

- Send a check to the AASV Foundation: 830 26th Street Perry, Iowa 50220-2328
- Credit Card - (Pay now using the QR code to the right)
- Email **foundation@aasv.org** to inquire about donating stock, being invoiced, or requesting company matching funds

AASV Foundation
830 26th Street,
Perry, IA 50220-2328
ecom.aasv.org

AASV Foundation

The AASV Foundation, a 501 (c) (3) corporation, was founded in 1989 as the charitable arm of the AASV. Funding for foundation programs is provided by corporate donations, the Leman, Heritage, and Legacy giving programs, individual donations and bequests, and fundraising efforts.

As a result of generous support by member and corporate donors, the AASV Foundation administers a number of ongoing programs to carry out its mission.

What do your contributions support?

- Howard Dunne Memorial Lectures
- Alex Hogg Memorial Lectures
- Veterinary Student Scholarships
- Hogg Scholarships
- ABVP Swine Health Management Scholarships
- American College of Animal Welfare Scholarships
- Swine Research Grants
- Student Debt Relief Grants
- Swine Externship Grants
- Annual Meeting Travel Stipends
- Heritage "Member Recollection" Videos

Your generous support of the AASV Foundation helps ensure the future of these and other foundation programs. For more information about the AASV Foundation, visit aasv.org/foundation.

Auction Item Donors

Abilene Animal Hospital
Aurora Pharmaceutical
Joaquín Becerril
Bill Beckman
Lisa Becton
Melissa Billling
Boehringer Ingelheim Animal Health
Cambridge Technologies
Abbey and Chris Canon Family
Dyneah Classen
Alejandrina Da Silva
Susan Detmer
DNA Genetics
Fairmont Veterinary Clinic
Four Star Veterinary Service
Bri Fredrich
Christa Goodell
Jeff Harker and Family
Perry Harms
Hank and Isabel Harris
Jennifer Hasty
Phil Hayes
Megan Hood
Grace Houston
Jeff Husa
Huvepharma
IDEXX
Indiana Packers Corporation
Iowa State University CVM
Iowa State University VDL
Micah Jansen
Clayton Johnson
Kemin Animal Nutrition and Health
Andrew Kleis
K-State Applied Swine Nutrition Team
Kuster Research and Consulting
Longhorn Vaccines and Diagnostics
Aaron Lower
MAI Animal Health
National Pork Producers Council
Norbrook
Chris Olsen
Pharmacosmos
Pharmgate Animal Health
Phibro Animal Health
Reid Philips
Dale Polson
Preferred Capital Management
Karen Richardson
Larry Rueff
Lee Schulteis
Smithfield Foods
Suidae Health and Production
Swine Vet Center
TechMix
Matthew Turner
University of Pennsylvania School of Veterinary Medicine
John Waddell
Brandon Whitt
Warren and Marilyn Wilson

Cash Donations

$5000 and above

AMVC
Paul J. Armbrecht
Dyneah M. Classen
PIC USA

$2000 - $4999

Innovative Veterinary Solutions
Zoetis

$1000 - $1999

Anonymous (2)
Butch and Emma Baker
Mary Lou Chapek-Hogg
Jack and Carla Coleman
Larry Coleman
Joe and Callie Connor
Wayne and Karen Freese
Peggy Anne Hawkins

$1000 - $1999 cont.

Steve Henry
Tyler Holck and Gayle Brown
Kerry and Betsy Keffaber
Keith P. Kinsley
Jim and Erin Lowe
Alejandro Ramirez
Cameron and Cassie Schmitt
Dennis Villani
The Waddell Family
Nate Winkelman
Teddi Wolff

$500 - $999

Brian Boyle
Keith Kinsley
Tim and Ruth Loula

$500 - $999 cont.

Alan Scheidt
Struve Labs International
Chris Uglum
Mac and Pam Wilt

$50 - $499

Pat Anderson
John Baker and Family
Phil Gauger
Tom and Denise Gillespie
Hans Rotto
Harold Tilstra

THANK YOU for your generous donations!

When SRD-complex has less impact on your cost of gain

THAT'S THE SOY EFFECT

Higher levels of soybean meal can help reduce swine respiratory disease (SRD) losses

Soybean meal (SBM) contains essential amino acids and functional bioactive molecules — not found in alternative least-cost ingredients. By strategically feeding higher levels of soybean meal in health-challenged pig flows, you can help reduce mortality, increase gain and improve feed efficiency.[1] Optimize performance and profitability by formulating for the full value of SBM in your swine diets.

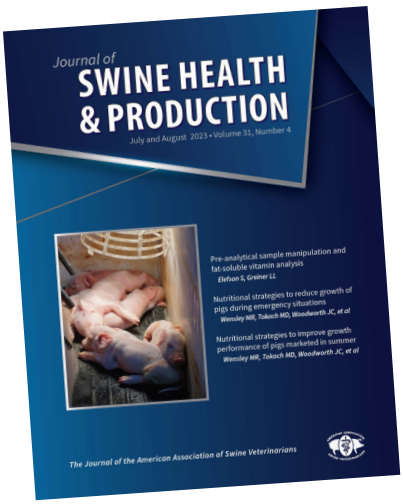
LEARN MORE AT SOYEFFECT.USSOY.ORG

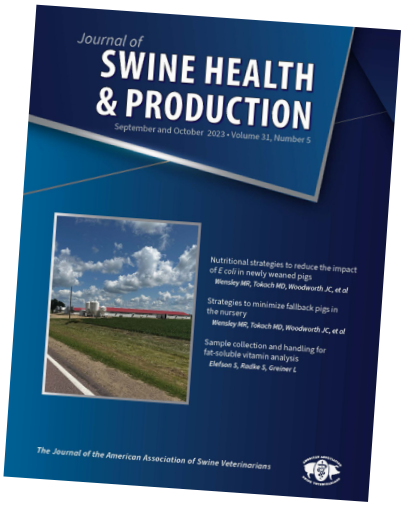
[1]Boyd, R. D. Soybean Meal: Growth and Health Promoting Effects Under High Health and Immune Stress. 2021 International Conference on Swine Nutrition. https://www.youtube.com/watch?v=Z13ssHwUb2s

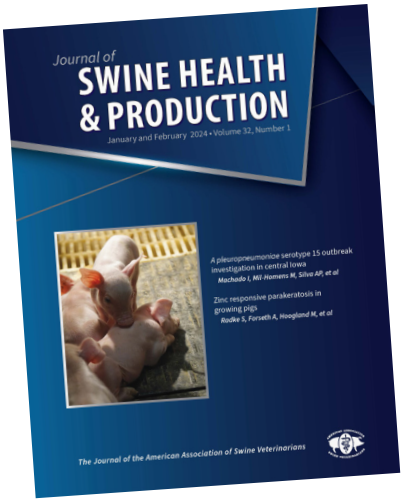
ussoy.org

US SOY

Pigs of #instaham







Share your pig photos for the JSHAP cover

Submissions by readers are welcome!

- Photos must represent healthy pigs and modern production facilities and not include people.
- Photos must be taken using the camera's largest file size and highest resolution.
- Please send the original image(s); do not resize, crop, rotate, or color-correct the image prior to submission.
- Submit photos with your name and affiliation to **tina@aasv.org**.

WATER-SOLUBLE MEDICATIONS ARE CREATING A

RIPPLE EFFECT

ACROSS THE SWINE INDUSTRY

How? Efficiency.

Low cost per dose. Herd-wide administration in minutes. Fast uptake. Control over multiple pathogens.

Water is essential to life. Pharmgate makes it work more efficiently.

Talk with our team.
Visit pharmgate.com/efficiency.

Pharmgate
ANIMAL HEALTH

UPCOMING MEETINGS

International Symposium on One Health Research: Improving Food Security and Resilience

April 21 - 23, 2024 (Sun-Tue)
Moody Gardens Resort and Convention Center
One Hope Boulevard
Galveston, Texas

For more information:
Email: **UTMBOneHealth@utmb.edu**
Web: **utmb.edu/one-health/events/international-one-health-symposium/welcome-symposium**

Animal Agriculture Alliance 2024 Stakeholders Summit

May 8 - 9, 2024 (Wed-Thu)
InterContinental at the Plaza
Kansas City, Missouri

For more information:
Abby Kornegay
Email: **akornegay@animalagalliance.org**
Web: **animalagalliance.org/initiatives/stakeholders-summit**

27th International Pig Veterinary Society Congress & 15th European Symposium of Porcine Health Management

June 4 - 7, 2024 (Tue-Fri)
Congress Centre Leipzig
Leipzig, Germany

For more information:
Web: **ipvs2024.com**

World Pork Expo

June 5 - 6, 2024 (Wed-Thu)
Iowa State Fairgrounds
Des Moines, Iowa

For more information:
Web: **worldpork.org**

9th International Conference on Emerging Zoonoses

June 9 - 12, 2024 (Sun-Wed)
Grand Hotel Piazza Borsa
Palermo, Italy

For more information:
Email: **zoo@target-conferences.com**
Web: **zoonoses-conferences.com**

12th International Conference on Antimicrobial Agents in Veterinary Medicine

June 16 - 19, 2024 (Sun-Wed)
Athens, Greece

For more information:
Email: **aavm@target-conferences.com**
Web: **aavmconference.com**

AVMA Convention 2024

June 21 - 25, 2024 (Fri-Tue)
Austin, Texas

For more information:
Web: **avma.org/events/avma-convention**

ISU James D. McKean Swine Conference

July 23 - 24, 2024 (Tue-Wed)
Scheman Building
Iowa State University
Ames, Iowa

For more information:
Tel: 515-294-6222
Email: **registrations@iastate.edu**
Web: **regcytes.extension.iastate.edu/swinedisease**

International Conference on Boar Semen Preservation

August 19 - 22, 2024 (Mon-Thu)
Vic, Barcelona, Spain

For more information:
Email: **info@boarsemen2024.com**
Web: **boarsemen2024.com**

Carthage Veterinary Service 34th Annual Swine Conference

August 27, 2024 (Tue)
Oakley-Lindsay Center
Quincy, Illinois

For more information:
Web: **hogvet.com**

Allen D. Leman Swine Conference

September 21 - 24, 2024 (Sat-Tue)
St Paul River Center
Saint Paul, Minnesota

For more information:
Web: **lemanconference.umn.edu**

US Animal Health Association 128th Annual Meeting

October 10 - 16, 2024 (Thu-Wed)
Gaylord Opryland Hotel
Nashville, Tennessee

For more information:
Web: **usaha.org/meetings**

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:**

JSHAP Resources

AASV resources	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
Industry Support Council member info	aasv.org/shap/advertising.php