

JOURNAL OF SWINE HEALTH & PRODUCTION

Summary of growing pig lameness associated with joint and leg submissions to a VDL

Canning P, Costello N, Mahan-Riggs E, et al

Pulmonary *Paragonimus* infection and other pathologic findings in feral swine from Alabama

Gilbreath ET, Gorham SL, Anderson DL, et al

Systematic review of injectable antibiotic treatment options for swine respiratory disease

O'Connor AM, Totton SC, Shane D



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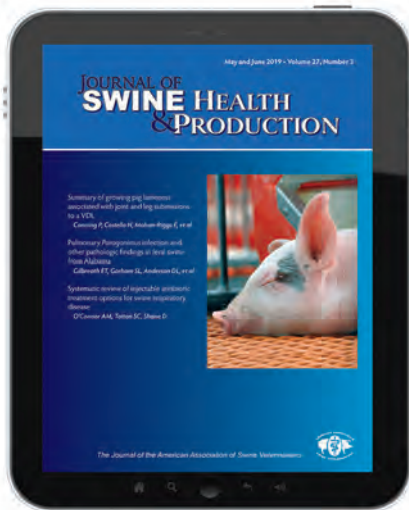
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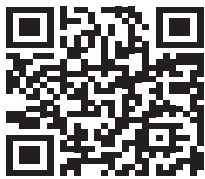
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About the cover...

A mid-day nap.

*Photo courtesy of
Mary Breuer,
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TABLE OF CONTENTS

President's message	109
Executive Director's message	113
Executive Editor's message	115
Errata	117
Retrospective study of lameness cases in growing pigs associated with joint and leg submissions to a veterinary diagnostic laboratory	118
<i>Canning P, Costello N, Mahan-Riggs E, et al</i>	
Pulmonary <i>Paragonimus</i> infection and other pathologic findings in feral swine (<i>Sus scrofa</i>) from Macon County, Alabama	125
<i>Gilbreath ET, Gorham SL, Anderson DL, et al</i>	
A systematic review and network meta-analysis of injectable antibiotic treatment options for naturally occurring swine respiratory disease	133
<i>O'Connor A, Totton SC, Shane D</i>	
Conversion tables	150
News from the National Pork Board	151
AASV news	154
Annual Meeting report	157
AASV Foundation news	171
Advocacy in action	181
Upcoming meetings	183

“As I write this, we have just completed the 50th meeting of the American Association of Swine Veterinarians. What an awesome experience!”

quoted from the Executive Director's message, page 113



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ANADA 200-495, Approved by FDA

Enrofloxacin® 100 100 mg/mL Antimicrobial Injectable Solution

For Subcutaneous Use In Beef Cattle And Non-Lactating Dairy Cattle For Intramuscular Or Subcutaneous Use In Swine Not For Use In Female Dairy Cattle 20 Months Of Age Or Older Or In Calves To Be Processed For Veal

Brief Summary: Before using Enrofloxacin® 100, consult the product insert, a summary of which follows.

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Federal (U.S.A.) law prohibits the extra-label use of this drug in food-producing animals.

To assure responsible antimicrobial drug use, enrofloxacin should only be used as a second-line drug for colibacillosis in swine following consideration of other therapeutic options.

PRODUCT DESCRIPTION: Each mL of Enrofloxacin 100 contains 100 mg of enrofloxacin. Excipients are L-arginine base 200 mg, n-butyl alcohol 30 mg, benzyl alcohol (as a preservative) 20 mg and water for injection q.s.

INDICATIONS:

Cattle - Single-Dose Therapy: Enrofloxacin 100 is indicated for the treatment of bovine respiratory disease (BRD) associated with *Mannheimia haemolytica*, *Pasteurella multocida*, *Histophilus somni* and *Mycoplasma bovis* in beef and non-lactating dairy cattle; and for the control of BRD in beef and non-lactating dairy cattle at high risk of developing BRD associated with *M. haemolytica*, *P. multocida*, *H. somni* and *M. bovis*.

Cattle - Multiple-Day Therapy: Enrofloxacin 100 is indicated for the treatment of bovine respiratory disease (BRD) associated with *Mannheimia haemolytica*, *Pasteurella multocida* and *Histophilus somni* in beef and non-lactating dairy cattle.

Swine: Enrofloxacin 100 is indicated for the treatment and control of swine respiratory disease (SRD) associated with *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Haemophilus parasuis*, *Streptococcus suis*, *Bordetella bronchiseptica* and *Mycoplasma hyopneumoniae*. Enrofloxacin 100 is indicated for the control of colibacillosis in groups or pens of weaned pigs where colibacillosis associated with *Escherichia coli* has been diagnosed.

RESIDUE WARNINGS:

Cattle: Animals intended for human consumption must not be slaughtered within 28 days from the last treatment. This product is not approved for female dairy cattle 20 months of age or older, including dry dairy cows. Use in these cattle may cause drug residues in milk and/or in calves born to these cows. A withdrawal period has not been established for this product in pre-ruminating calves. Do not use in calves to be processed for veal.

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

HUMAN WARNINGS: For use in animals only. Keep out of the reach of children. Avoid contact with eyes. In case of contact, immediately flush eyes with copious amounts of water for 15 minutes. In case of dermal contact, wash skin with soap and

water. Consult a physician if irritation persists following ocular or dermal exposures. Individuals with a history of hypersensitivity to quinolones should avoid this product. In humans, there is a risk of user photosensitization within a few hours after excessive exposure to quinolones. If excessive accidental exposure occurs, avoid direct sunlight. For customer service, to obtain a copy of the Safety Data Sheet (SDS) or to report adverse reactions, call Norbrook at 1-866-591-5777.

PRECAUTIONS:

The effects of enrofloxacin on cattle or swine reproductive performance, pregnancy and lactation have not been adequately determined.

The long-term effects on articular joint cartilage have not been determined in pigs above market weight. Subcutaneous injection can cause a transient local tissue reaction that may result in trim loss of edible tissue at slaughter.

Enrofloxacin 100 contains different excipients than other enrofloxacin products. The safety and efficacy of this formulation in species other than cattle and swine have not been determined.

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

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

ANIMAL SAFETY:

Cattle: clinical signs of depression, incoordination and muscle fasciculation were observed in calves when doses of 15 or 25 mg/kg were administered for 10 to 15 days. Clinical signs of depression, inappetence and incoordination were observed when a dose of 50 mg/kg was administered for 3 days. An injection site study conducted in feeder calves demonstrated that the formulation may induce a transient reaction in the subcutaneous tissue and underlying muscle.

Swine: Subcutaneous Safety: incidental lameness of short duration was observed in all groups, including the saline-treated controls. Musculoskeletal stiffness was observed following the 15 and 25 mg/kg treatments with clinical signs appearing during the second week of treatment. Clinical signs of lameness improved after treatment ceased and most animals were clinically normal at necropsy. An injection site study conducted in pigs demonstrated that the formulation may induce a transient reaction in the subcutaneous tissue.

Intramuscular Safety: Transient decreases in feed and water consumption were observed after each treatment. Mild, transient, post-treatment injection site swellings were observed in pigs receiving the 37.5 mg/kg BW dose. Injection site inflammation was found on post-mortem examination in all enrofloxacin-treated groups.

Norbrook Laboratories Limited, Newry, BT35 6PU, Co. Down, Northern Ireland

105 October 2017

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For the record – a historic event

Thank you to all who attended our recent AASV Annual Meeting: “Built to Last – Celebrating 50 Years of Progress.” The meeting exceeded expectations for the AASV’s primary mission, to provide education for swine veterinarians. It was a historic and memorable event not only because it was the organization’s 50th anniversary, but for many other reasons as well:

- The AASV Executive Director baton passed from Dr Tom Burkgren to Dr Harry Snelson, and the Director of Communications from Dr Snelson to Dr Abbey Canon.
- The AASV Foundation reached its goal of \$2 million.
- The release of the Golden Anniversary Video, Veterinarian’s Oath, and other video vignettes.
- African swine fever (ASF) and much more.

This is an effort to provide a brief overview of the meeting for both those who did or did not attend, and to offer a few of many memories, quotes, and facts for the record.



By the numbers

50 – The number of years since 30 veterinarians started the American Association of Swine Practitioners organization in 1969 at the American Veterinary Medical Association meeting in Minneapolis, Minnesota.

14 – The number of AASV’s “Golden” members who joined the AASV as charter members in 1969 and have maintained continuous membership for the past 50 years! Drs Dave Madsen and Conrad Schmidt were in attendance this year and were honored as Golden members.

10⁰ TCID₅₀ – The minimum infectious dose of ASF in water, as reported by Kansas State University’s Dr Megan Niederwerder.¹

\$10,500 – The highest AASV Foundation live auction bid, for a trip of a lifetime to New Zealand for two, donated by AMVC and PIC and purchased by Dr Mark Fitzsimmons. A total of \$80,000 was raised for the foundation.

Awards and scholarships

“On all these issues, Tom was the champion of science over emotion.” – Dr David Reeves, surrounded on stage by staff, current board officers, and past-presidents, described a plethora of accomplishments during Dr Tom Burkgren’s 25-year tenure as AASV’s executive director.

“What a wonderful place to have as my veterinary home for an entire career.” – Dr Steve Henry upon receiving the AASV Heritage Award. One of only 5 recipients of the award recognizing lifelong outstanding achievement in swine medicine.

“The idea of helping new graduates who are actively paying off their debt burden is fantastic.” – Dr Chelsea Stewart, the inaugural \$5000 scholarship recipient from a generous \$110,000 AASV Foundation contribution by the Dr Conrad Schmidt and Family Endowment.

“But most members are recognized by first name only (Tom, Harry, Sue, Joe...), reminds me of the old comedy series *Cheers* theme song ‘Where Everyone Knows Your Name.’” – Dr Ron White in his acceptance letter, as

“The meeting exceeded expectations for the AASV’s primary mission, to provide education for swine veterinarians.”

read by Dr Darrell Neuberger, for the Technical Service/Allied Industry Veterinarian of the Year Award.

“We made it!” – Dr Paul Ruen, chair of the AASV Foundation, upon reaching the big hairy audacious goal of \$2 million for the AASV Foundation to ensure our future and leave a legacy.

“This year marks the 15th anniversary of the awards program.” – Dr Reid Phillips announcing the 2019 Boehringer Ingelheim Awards for Advancing Research in Respiratory Disease recipients, providing over \$1.3 million to over 50 swine respiratory disease researchers since 2004.

Session presenters and the Golden Anniversary Video

“That began from an idea from our students, so our students have been great assets for us.” – Alex Hogg Memorial Lecturer Dr Deb Murray giving credit to an AASV student for the original idea of analyzing processing fluids for porcine reproductive and respiratory syndrome virus.

“My story, is your story, is our story!” – Howard Dunne Memorial Lecturer Dr John Waddell explaining that we all started somewhere and are always continuing to pass on our swine knowledge.

“Every day more than 6000 people die of malnourishment.” and “US agriculture is the ‘China’ of the agriculture world.” – Brett Stuart of Global AgriTrends discussing food scarcity and the role of US agriculture.

“What about a vaccine? What vaccine, there isn’t one!” – Dr Klaus Depner, invited speaker from Germany, replying to an attendee’s query about the future of an ASF vaccine. He then facetiously and pessimistically indicated there may be an ASF vaccine by 2049.

President’s message continued on page 111



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“...sharing and learning from at least three generations of veterinarians from all over the world.” – Dr Laura Batista on her meeting highlights. Veterinarians from 30 countries attended this prestigious international meeting.

“There is no doubt in my mind that in the end, the word that summarizes AASV well is family.” – Dr Alex Ramirez, an AASV past president, noting the endearing use of family reunion, extended family, etc in the Golden Anniversary Video when describing our organization.

Thanks again to everyone who helped make the meeting such a special event, including the attendees, speakers, invited guests, planning committee, sponsors, technical table exhibitors, auction donors and bidders, and the AASV staff. Special thanks to Dr Sarah Probst-Miller and her team at AgCreate for the exceptional videos. And of course, thanks to all of you for being part of our AASV family.

Nathan Winkelman, DVM
AASV President



Dr John Waddell delivers the 2019
Howard Dunne Memorial Lecture.



Dr Deborah Murray delivers the 2019
Alex Hogg Memorial Lecture.



Reference

1. Niederwerder MC, Stoian AMM, Rowland RRR, Dritz SS, Petrovan V, Constance LA, Gebhardt JT, Olcha M, Jones CK, Woodworth JC, Fang Y, Liang J, Hefley TJ. Infectious dose of African swine fever virus when consumed naturally in liquid or feed. *Emerg Infect Dis.* 2019;25(5). doi:10.3201/eid2505.181495.

Rethink the norm:

Are today's large litters getting adequate nutrition?

by Mark Eisenhart, DVM, Director of Technical Services, Tonisity



Genetic companies have done an amazing job creating sow lines that produce more live pigs. But this gain comes with a challenge: having enough nutrition to support piglet viability and larger litter growth.

Sometimes we forget that farrowing is not the end of development. In the first 10 days of life, the absorptive surface area of a pig's intestinal tract doubles. During this critical developmental period, nutritional supplementation of the intestinal tract can help pigs achieve maximum productivity and reach their full potential. This is why we recommend feeding Tonisity Px™ to pigs from 2 to 8 days of age.

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the enterocytes of the piglet intestine and has the same composition as its body's cells, making it easily absorbed. Equally important is its taste profile. It is designed just

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productivity. This results in more pigs weaned, less size variability and faster weight gain. These benefits provide pigs a solid foundation for continued performance and economic success.

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“The challenge is having enough nutrition to support piglet viability and larger litter growth.”

- Mark Eisenhart, DVM

Why intestinal development matters

Keeping pigs eating and drinking is crucial, says Nicholas Gabler, Ph.D., Iowa State University swine nutrition specialist. “Keeping the intestine hydrated and providing it with nutrients improves its development and ability to recover,” he says.

Dr. Gabler says products like Tonisity Px support the structural and functional aspects of the intestine. “Good intestinal function allows the pig to optimize

nutrient, water and energy absorption to support growth,” he explains.

“If we can provide nutritional and energetic support to the intestine – the largest immune organ in the body – we can help the pig facilitate efficient and effective nutrient digestion and absorption. Doing so allows for optimal uptake of nutrients to support lean tissue growth.”



Keeping the intestine hydrated and providing it with nutrients improves its development and ability to recover.

- Nicholas Gabler, Ph.D., Iowa State University swine nutrition specialist

AASV road trip

As I write this, we have just completed the 50th meeting of the American Association of Swine Veterinarians. What an awesome experience! It was like a family reunion at Disney with scientific presentations instead of bouncy castles. I think perhaps we should convert the reception to a potluck in the backyard. What a great opportunity to revisit our memories of past reunions and what it has meant to all of us to be members of this family.

The Annual Meeting is always as much about catching up with old friends as it is about continuing education. While it is the science that brings us together, it is the hallway talk that makes it fun. It is always interesting to learn about the changes in everyone's personal and professional lives. This year marked a significant change for our AASV family as well, as Dr Burkgren turns over his role as patriarch to the crazy uncle sitting at the kid's table.

While I am excited and energized about assuming the role as the executive director of

our association, I also recognize the daunting task of stepping into Tom's shoes. Have you noticed the size of those feet! I am considering having all the door headers in the office lowered so I will at least appear to fill the space. He is the only patriarch this family has ever known, and he has taken us on a great vacation. When he loaded up the car, all the kids in the backseat started yelling about where they wanted to go. Tom was able to organize the kids and prioritize a list of destinations for this great adventure. He encouraged the kids to be part of the decision-making process and to take turns driving the station wagon.

I was humbled by the number of people who approached me in Orlando and welcomed me to this role saying, "You'll do a great job!" My response was always, "thanks for your support and I'll need it." What I mean by that is, while I am the one with the title, directing this association is the job of all of us. Our association is blessed with a great staff including Sue, Sherrie, and Abbey in the office, the JSHAP staff driving our journal, and Dave directing our information technology. But, the real driver of the association is our membership. This is our association, and we all have an interest and responsibility in ensuring that it meets our needs and provides value.

It is my goal as executive director to stay true to our mission and provide high-quality continuing education opportunities for our members while advocating for the health and well-being of the pigs in our care. Science will continue to form the basis of how we approach issues facing swine health and production. It is important that we continue to support the swine veterinarians of the future by promoting the activities of our recent graduates and student members and strive to help them address the challenges they face. In addition, I want to ensure that we embrace the diversity of our membership and that every member feels welcome and valued. We need to make sure that we continue to explore how we provide value to, and effectively communicate with, our membership.

"It is my goal as executive director to stay true to our mission and provide high-quality continuing education opportunities for our members while advocating for the health and well-being of the pigs in our care."

Our members have fostered a close working relationship with the farmers they serve. The AASV and pork producers benefit through our interactions with the National Pork Board, the National Pork Producers Council, and the Swine Health Information Center. Our association with the veterinary diagnostic labs and university researchers provides access to a wealth of resources that benefit our ability to serve the membership by providing cutting-edge diagnostics, disease monitoring, and research. We continue to work closely with state and federal animal health officials to enhance our ability to prevent, diagnose, and respond to emerging disease threats. Similarly, we have forged relationships with other government agencies including the Food and Drug Administration, the Department of Homeland Security, and the Centers for Disease Control and Prevention to address issues including antimicrobial use, herd security, and public health. The station wagon is pretty crowded!

I want to thank Tom for his 25 years of service to the AASV and for his mentorship, guidance, and friendship over the 13 years I have had the pleasure of working with him. I look forward to his continued support as I transition into the role he so masterfully performed. I am also counting on your continued willingness to participate in the success of the AASV as we build upon our first 50 years. Thanks to each of you for giving me the opportunity to serve as your executive director. I am happy to say that I do not believe I have ever heard anyone in the station wagon say "are we there yet?", but I do hear a lot of "oohs" and "aahs." That is good, because I do not want to have to pull this car over.

Harry Snelson, DVM
Executive Director



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Implications

The journal staff has been working to update the author guidelines. Our goal is to provide more details and supporting files to assist authors with formatting their manuscripts for submission to the *Journal of Swine Health and Production*. Time is a hot commodity amongst authors, and the journal wants to provide as much guidance as possible to help speed up the formatting process for submitting authors. The other benefit to authors is that a correctly formatted manuscript does facilitate a smoother peer-review process, as a correctly formatted manuscript is easier for reviewers to review. So, I am hoping these changes and supporting files will result in a win-win! The full version of the author guidelines is now available online with an abbreviated version to be printed in the next issue of the journal. I want to use my messages in this and future issues to highlight some of the key format changes. In this message, I am going to begin with the implications section.

Perhaps the most notable change you will notice is in the implications section. You will now see that there are character restrictions for the implications section. The



"Many readers, practitioner or not, are overwhelmed with the number of manuscripts to read."

implications, in my opinion, are the most challenging part of the manuscript for authors to write, the most challenging aspect to peer-review, and, above-all, the most important section for a busy reader (ie, busy practitioner). Many readers, practitioner or not, are overwhelmed with the number of manuscripts to read. Many people will prescreen a manuscript using the abstract and the implications to make a decision as to whether they will continue reading. It is not only applied-based journals that include an implications section. Many scientific journals include an implications section, but sometimes under a different name, eg, key research findings.

Why the change in the implications formatting requirements? The primary reason is to keep them succinct. The secondary reason is that authors often present new information not addressed in the manuscript. It is also not uncommon for authors to over extrapolate information within the implications. These challenges are addressed in the peer-review process, but they are often a bottleneck for the review process and how timely a manuscript can move on to being accepted. The intention is to limit the characters so that significant thought and care goes into the construction of an implication or implications. What I am saying is that, yes, the character limit is going to make it harder to write implications. However, I think the reward will be well worth it. I will share a personal experience. I recently had to write key research findings for a manuscript submission with a very (very, very) short character restriction. It took many iterations between myself and my co-authors to finalize them. But wow, when we were done, they were really informative and yet succinct implications. In the end it made the manuscript far more informative and I think more assessable to my target audience. If I can do it, we all can!

On to the details, and so you do not need to search for some specific examples, here is a snippet from the online version of the author guidelines:

- Implications outline the practical application or impact of the study results or the “take-home” messages for readers. Implications should be presented as provisional to the parameters and conditions of the study and should not over-generalize the results.
- Manuscripts are limited to 3 bulleted implications, each with a maximum of 80 characters including spaces.
- Some questions that may be answered by the implications include:
 - How do the results of this study connect with what has been previously published?
 - What new ideas have been generated by this research?
 - What are the limitations of the data, methods, or results of this study?
 - What are the consequences of the most significant findings of this research?
 - How do the outcomes of this research impact the question or situation presented in the manuscript?

If you took a big gulp when you read 80 characters (including spaces), that means you recognized the challenge that authors will face. As I mentioned, the journal has implemented this and other formatting requirement changes all with the overall goal to streamline and simplify the manuscript submission and peer-review process. I am excited to see this change rollout in upcoming issues and I hope you are as well.

Terri O'Sullivan, DVM, PhD
Executive Editor





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Errata

Radke SL, Olsen CW, Ensley SM. Elemental impurities in injectable iron products for swine. *J Swine Health Prod.* 2018;26(3):142-145.

In Table 1, the detected concentrations listed for chromium are correct, however, there is 1 cell shaded blue (exceeds the permitted daily exposure [PDE] by >25%) that should be shaded yellow ($\leq 25\%$ higher than the PDE) and 5 cells shaded yellow ($\leq 25\%$ higher than the PDE) that should be unshaded because they are \leq to the chromium PDE.

Table 1: Detected content of arsenic, chromium and lead in parenteral iron products for swine, tested at two laboratories*

Brand name	Manufacturer†	Country	Molecule	Concentration (mg/mL)	Arsenic‡			Chromium			Lead‡		
					ISU	Lab 2	PDE¶	ISU	Lab 2	PDE¶	ISU	Lab 2	PDE¶
					$\mu\text{g}/200\text{mg}$ dose§	$\mu\text{g}/\text{kg}$	$\mu\text{g}/\text{kg}$	$\mu\text{g}/200\text{mg}$ dose§	$\mu\text{g}/\text{kg}$	$\mu\text{g}/\text{kg}$	$\mu\text{g}/200\text{mg}$ dose§	$\mu\text{g}/\text{kg}$	$\mu\text{g}/\text{kg}$
Aspen Anem-X 100	Sparhawk	United States (USA)	ID	100	3.4	2.0		30.2	27.0		<0.1	<0.1	
Durvet Iron-100	Sparhawk	USA	ID	100	4.0	1.9		36.2	32.9		<0.1	<0.1	
Ecotin 200	Iven Laboratories	Spain	ID	200	0.2	0.4		36.0	49.5		4.9	5.8	
FerroForte	Bimeda	Canada	ID	200	1.7	1.6		12.0	35.0		0.3	<0.1	
Ferrohipra 200	Hipra	Belgium	Glep	200	<0.1	<0.1		25.0	24.1		2.0	1.1	
GleptoForte	Ceva	USA	Glep	200	0.9	<0.1		32.4	29.6		0.6	0.5	
Gleptosil	Ceva	Germany	Glep	200	2.2	1.2		21.0	28.9		<0.1	<0.1	
Gleptosil	Sogeval	United Kingdom	Glep	200	1.4	0.5		18.0	27.0		<0.1	<0.1	
Prolongal	Bayer	Belgium	Glep	200	<0.1	<0.1	0.3	33.2	28.9	22.0	2.6	0.6	0.1
Uniferon 200	Pharmacosmos	USA	ID	200	<0.1	<0.1		0.4	0.7		<0.1	<0.1	
Ursoferran	Serumwerk	Germany	Glep	200	<0.1	<0.1		25.0	36.0		0.4	0.4	
Ursoferran	Serumwerk	Russia	Glep	200	0.1	<0.1		19.0	21.9		1.1	1.2	
VetOne	Sparhawk	USA	ID	100	2.0	2.2		19.4	36.7		1.2	1.5	
Viloferron	iron4u	Denmark	Glep	200	<0.1	<0.1		29.0	29.0		3.1	0.3	
Xue Duo Bang	Guangxi Research Institute of Chemical Industry	China	ID	100	1.4	1.8		65.4	39.8		0.6	<0.1	
Xue Wei Bao**	Guangdong Wens Dahunong Biotechnology	China	ID	100	1.8	NA		28.6	NA		<0.1	NA	

* All values are rounded to the nearest one significant figure. Yellow highlighted cells indicate the element was present at $\leq 25\%$ higher than the daily limits established for humans. Blue highlighted cells exceed the human daily exposure limit by $> 25\%$.

† Marketing Authorization holder/NADA owner.

‡ Values reported as $< 0.1 \mu\text{g}/200 \text{mg}$ dose were below the limit of detection for the assay.

§ For all 200 mg/mL products the reported elemental concentrations in $\mu\text{g}/200 \text{mg}$ dose are equivalent to parts per million. For 100 mg/mL products, detected concentrations in parts per million were doubled to represent a typical 200 mg dose.

¶ Permitted daily exposure is the published daily exposure limit for an adult human. Values were converted to $\mu\text{g}/\text{kg}$ assuming 50 kg as a conservative adult human body weight and using inclusion limits reported in USP < 232 >⁸ and ICH Q3D⁹ for human pharmaceutical products.

** Sample was not available for testing at both laboratories.

ISU = Iowa State University Veterinary Diagnostic Laboratory; Lab 2 = independent laboratory; PDE = permitted daily exposure; ID = Iron Dextran; Glep = Gletoferron; NA = not applicable.

Retrospective study of lameness cases in growing pigs associated with joint and leg submissions to a veterinary diagnostic laboratory

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Summary

Objective: The objective of this study was to categorize and quantify the most common causes of joint- or leg-associated lameness by summarizing available information from cases presented to the Iowa State University Veterinary Diagnostic Laboratory (ISU VDL) between 2010 and 2015.

Materials and methods: All cases of lameness or locomotor dysfunction in 7- to 40-week-old pigs submitted to the ISU VDL between May 1, 2010 and April 30, 2015 were retrieved. After removing cases that did

not meet the inclusion criteria, the remaining cases were individually reviewed and assigned a primary and secondary diagnosis.

Results: Of the 1847 cases retrieved, 464 met the inclusion criteria. The 4 most common primary diagnosis categories were *Mycoplasma hyosynoviae* (93 cases; 20%), metabolic bone disease (86 cases; 18.5%), infectious arthritis due to non-*Mycoplasma* bacterial infection (81 cases; 17.5%), and lameness with inconclusive findings (101 cases; 21.8%). There were 23.3% of the cases (108 of 464 cases) that had a secondary diagnosis

with metabolic bone disease (28.7%; 31 of 108 cases) identified as the most common secondary diagnosis.

Implications: This study reinforces the importance of careful clinical examination, proper sampling, and confirming causes with appropriate diagnostic testing for accurate diagnosis of lameness.

Keywords: swine, *Mycoplasma hyosynoviae*, lameness, arthritis, case series

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Resumen – Estudio retrospectivo de casos de cojera en cerdos de crecimiento asociados con el envío de articulaciones y piernas a un laboratorio de diagnóstico

Objetivo: El objetivo de este estudio fue categorizar y cuantificar las causas más comunes de cojera asociada con la articulación o la pierna resumiendo la información disponible de los casos enviados al Laboratorio de Diagnóstico Veterinario de la Universidad del Estado de Iowa (ISU VDL por sus siglas en inglés) entre 2010 y 2015.

Materiales y métodos: Se recuperaron todos los casos de cojera o disfunción locomotora

en cerdos de 7 a 40 semanas de edad enviados al ISU VDL entre el 1 de mayo de 2010 y el 30 de abril de 2015. Después de eliminar los casos que no cumplían con los criterios de inclusión, los casos restantes se revisaron individualmente y se les asignó un diagnóstico primario y uno secundario.

Resultados: De los 1847 casos recuperados, 464 cumplieron con los criterios de inclusión. Las 4 categorías de diagnóstico primario más comunes fueron *Mycoplasma hyosynoviae* (93 casos; 20%), enfermedad ósea metabólica (86 casos; 18.5%), artritis infecciosa debida a infección bacteriana

no relacionada con *Mycoplasma* (81 casos; 17.5%) y cojera sin hallazgos concluyentes (101 casos; 21.8%). Un 23.3% de casos (108 de 464 casos) tuvieron un diagnóstico secundario relacionado con enfermedad metabólica ósea (28.7%; 31 de 108 casos), identificado como el diagnóstico secundario más frecuente.

Implicaciones: Este estudio refuerza la importancia de un examen clínico cuidadoso, un muestreo adecuado y la confirmación de las causas con pruebas de diagnóstico apropiadas para un diagnóstico preciso de la cojera.

Résumé – Étude rétrospective des cas de boiterie chez des porcs en croissance associée à la soumission d'articulations et de pattes à un laboratoire de diagnostic vétérinaire

Objectif: L'objectif de la présente étude était de catégoriser et quantifier les causes les plus fréquentes de boiteries associées aux articulations ou aux pattes en résumant les informations disponibles des cas présentés au Iowa State University Veterinary Diagnostic Laboratory (ISU VDL) entre 2010 et 2015.

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

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Matériels et méthodes: Tous les cas de boiterie ou de dysfonction locomotrice chez les porcs âgés de 7 à 40 semaines soumis au ISU VDL entre le 1er mai 2010 et le 30 avril 2015 furent récupérés. Après avoir retiré les cas qui ne rencontraient pas les critères d'inclusion, les cas restants furent individuellement revus et on leur assigna un diagnostic primaire et secondaire.

Résultats: Des 1847 cas récupérés, 464 rencontraient les critères d'inclusion. Les quatre catégories de diagnostic primaire les plus fréquentes étaient *Mycoplasma hyosynoviae* (93 cas; 20%); maladie osseuse métabolique (86 cas; 18.5%); arthrite infectieuse bactérienne due à une infection autre qu'à *Mycoplasma* (81 cas; 17.5%), et boiterie avec troubles non-concluants (101 cas; 21.8%). Il y avait 23.3% des cas (108 des 464 cas) qui avaient un diagnostic secondaire, et une maladie osseuse métabolique (28.7%, 31 des 108 cas) a été identifiée comme le diagnostic secondaire le plus fréquent.

Implications: Cette étude montre l'importance d'un examen clinique minutieux, d'un échantillonnage adéquat, et de confirmer les causes avec un diagnostic approprié afin d'obtenir un diagnostic précis lors de boiterie.

Joint- and leg-associated lameness in growing pigs is a common diagnostic and therapeutic challenge for swine veterinarians. A diagnostic investigation usually starts when the caretaker identifies lameness in a group of pigs and notifies a veterinarian. The veterinarian will perform an assessment, which may involve submission of samples to a veterinary diagnostic laboratory (VDL). In recent years, there has been a great interest in *Mycoplasma hyosynoviae* (MHS), which is considered one of the major primary causes of joint-associated arthritis, but the organism may only be present transiently within the joint making diagnosis challenging.¹ Inconclusive diagnostic testing increases uncertainty of diagnosis and decreases confidence in specific recommendations for therapy. Sample submissions that do not generate actionable information or support a specific etiology for the lameness are reported by practitioners, but the frequency of these cases from VDL submission databases has not been quantified and reported in the peer-reviewed literature.

Increasing regulation and oversight of antimicrobial use in swine reinforces the value of an accurate diagnosis to support treatment

decisions and prudent antimicrobial use. While diagnostic laboratory data is not equivalent to field prevalence, it is helpful for swine practitioners to be aware of the spectrum and relative frequency of lameness causes as reported by a Midwestern VDL. Insight into capabilities and expectations of laboratory testing can assist veterinarians in proper sampling, test selection, interpretation of results, and provide insights into the relative importance of specific lameness etiologies for future research priorities. Specifically, insights from a study of submission trends and diagnostic approaches for cases of acute MHS synovitis may inform improvements in sampling and testing for this common etiology of growing pig lameness. Beyond general recommendations in swine texts, there is limited published information on submission practices for joint-associated lameness cases.²

The primary objective of this study was to categorize and quantify the most common causes of joint- or leg-associated lameness by summarizing available information from cases presented to the Iowa State University (ISU) VDL between 2010 and 2015. The second objective of this study was to summarize submission trends and features of those cases with an MHS diagnosis.

Materials and methods

Laboratory diagnostic submissions from the ISU VDL were used for this study, so no Institutional Animal Care and Use Committee approval was needed. All cases of lameness or locomotor dysfunction submitted to the ISU VDL between May 1, 2010 and April 30, 2015 were retrieved for review using the ISU VDL laboratory information management system (LIMS). Each individual laboratory accession was considered a single case irrespective of number of samples submitted. Inclusion criteria were selected with the aid of VDL diagnosticians and information technology specialists. All cases were individually reviewed to ensure each met the inclusion criteria: species (porcine), age or weight (7-40 weeks or > 16 kg), case type (field case), histopathology performed, and at least one diagnostic code assigned by a diagnostic pathologist. The 23 diagnostic codes and diagnostic assays that were used to search the LIMS for lameness cases are presented in Table 1. If the age or weight was not present in the data output from LIMS, the case remained in the database and the original submission sheet was reviewed

for any information that referenced age or weight. If no age or weight data was included on the submission sheet, the case was removed. Cases must have included joint tissue for histology to be included in this study. Cases involving serum, oral fluids, or swabs only were excluded.

For each qualifying accession, the submission form and laboratory report were reviewed and relevant information extracted into a spreadsheet. Information extracted from the LIMS included accession number, submission date, pig age, diagnostic code, diagnostician, histopathology observations, and all tests performed with results. The clinic and bill party information were used to remove those cases that were not diagnostic investigations of field cases, such as research and teaching accounts. Client name, submitting veterinarian, and premises identification were not extracted from the database to maintain confidentiality and anonymity.

To confirm that all qualifying cases did involve lameness and locomotion dysfunction, additional information from the submission sheet and final report was entered into the spreadsheet manually. The history, submission notes, and the final diagnosis and comments from the diagnostician on the final report were entered and evaluated. Specifically, the case had to include terms involving lameness or locomotion in the history and the completed diagnostic testing had to be relevant to locomotion dysfunction, lameness, or joint disease. For example, a case may have *Mycoplasma hyorhinis* (MHR) septicemia as a diagnostic code, but if the history did not report any information related to lameness and legs or joints were not submitted with the case, then the case was excluded.

Assigning primary and secondary diagnosis

After confirming that all cases remaining in the database involved locomotion dysfunction and met the inclusion criteria, the cases were individually reviewed and assigned a primary diagnosis and, when diagnostic criteria for more than one category was present, a secondary diagnosis. Specific criteria were created for each diagnosis and applied uniformly to the cases (Table 2). Unless designated as "if available" in Table 2, all criteria listed for a given category must have been satisfied for the diagnosis to be assigned to a case. Criteria for each diagnosis were determined by peer-reviewed literature and consultation with an

Table 1: Swine diagnostic codes and diagnostic assays used as inclusion criteria for cases of lameness or locomotor dysfunction submitted to the ISU VDL

Diagnostic codes	Joint arthritis, idiopathic
	Joint arthritis, <i>Actinobacillus suis</i>
	Joint arthritis, <i>Truperella pyogenes</i>
	Joint arthropathy
	Joint arthritis, bacterial, miscellaneous
	Joint arthritis, <i>Escherichia coli</i>
	Joint arthritis, <i>Erysipelothrix rhusiopathiae</i>
	Joint arthritis, <i>Haemophilus parasuis</i>
	Joint arthritis, <i>Mycoplasma</i> species
	Joint arthritis, <i>Mycoplasma hyorhinis</i>
	Joint arthritis, <i>Mycoplasma hyosynoviae</i>
	Joint arthritis, non-suppurative
	Joint osteochondrosis
	Joint arthritis, <i>Staphylococcus</i> species
	Joint arthritis, <i>Staphylococcus aureus</i>
	Joint arthritis, <i>Streptococcus</i> species
	Joint arthritis, <i>Streptococcus suis</i>
	Joint arthritis, suppurative
	Calcium deficiency
Vitamin D deficiency	
All bone osteopathies	
Septic <i>Mycoplasma hyorhinis</i>	
No diagnosis	
Diagnostic tests/assays	PCR- <i>Mycoplasma hyosynoviae</i>
	<i>Mycoplasma</i> culture

ISU VDL = Iowa State University Veterinary Diagnostic Laboratory; PCR = polymerase chain reaction.

ISU VDL diagnostician. Primary diagnosis refers to the findings in the case that are understood, to the best of the assessor's knowledge, to be the main or most acute cause of the lameness. Secondary or "other" diagnosis refers to a diagnostic category that was relevant to the case but was not the main or most acute cause of lameness. This determination was made from comments in the final report by the diagnostician, severity and prevalence of the abnormalities, and understanding of the pathophysiology of the given diagnostic category in question. Primary and secondary diagnostic categories were assigned to the entire submission, not each individual pig within a case.

Description of submission characteristics for *Mycoplasma hyosynoviae* cases

Cases that were assigned MHS as the primary diagnosis were then further reviewed to summarize case attributes related to submission habits. Specifically, the following data were collected and summarized: submission year, inclusion of a history on submission sheet (yes or no), inclusion of differential diagnosis in history (yes or no), number of differential diagnoses included in history, type and number of specimens submitted, number of MHS polymerase chain reaction (PCR) assays performed per case, number of animals from which the submitted specimens were procured, number of diagnostic tests requested, types of diagnostic tests requested, results from non-MHS related tests performed, and secondary diagnosis.

Results

Primary and secondary diagnosis for all lameness cases

The results of each step of the case database creation process are presented in Figure 1. The primary and secondary diagnosis associated with each of the 464 lameness cases is summarized in Table 3. The four most common primary diagnoses were almost equally represented: MHS (93 cases; 20%), metabolic bone disease (86 cases; 18.5%), infectious arthritis due to non-*Mycoplasma* bacterial infection (81 cases; 17.5%), and lameness with inconclusive findings (101 cases; 21.8%). Of the 23.3% of cases that had a secondary diagnosis (108 of 464 cases), metabolic bone disease was identified as the most common (28.7%; 31 of 108 cases).

Summary of submission characteristics for *Mycoplasma hyosynoviae* cases

The number of MHS diagnosed cases per full calendar year ranged from 7 cases in 2011 to 34 cases in 2013. A review of case characteristics revealed that the mean age of pigs diagnosed with MHS was 18.3 weeks (range, 10-32 weeks). A mean of 2.4 MHS PCR assays were conducted per MHS case (range, 1-26 assays). The cycle threshold values for MHS PCR ranged from 20.3 to > 44. Cycle threshold values > 44 were considered negative for MHS at the ISU VDL. For cases requesting 3 or more MHS PCR tests (n = 29), the mean percentage of MHS-positive PCRs was 54.7%.

Seventy-one percent (66 of 93) of cases listed differential diagnoses with their submission form and of these, 80.3% (53 of 66 cases) listed multiple possible differential diagnoses. Nine cases (9.7%) listed MHS as the sole differential. Of the 53 cases that listed more than one differential, the most common differentials were MHS (71.7%; 38 cases), MHR (41.5%; 22 cases), *Haemophilus parasuis* (41.5%; 22 cases), *Streptococcus suis* (39.6%; 21 cases), and *Erysipelothrix* species (35.8%; 19 cases). Metabolic bone disease, osteochondrosis (OCD), and trauma were listed 19 (35.8%) times cumulatively.

The majority (68.8%; 64 of 93) of submitting veterinarians selected diagnostic testing to be at the discretion of the VDL diagnostician, while 15.1% (14 of 93 veterinarians)

Table 2: Diagnostic criteria for each diagnostic category applied to cases associated with joint or leg lameness

Diagnostic category	Criteria for diagnostic category inclusion
Lameness with inconclusive findings (abnormal diagnostic testing results with inconclusive findings)	Lameness reported by practitioner or diagnostician Histology of joint revealed mild non-specific changes to the synovial tissue Additional testing not performed, or results of additional testing were inconclusive or not significant Description of inconclusive or nonspecific joint changes included in final report by pathologist [if available*]
MHS	Specimens submitted from animals with clinical lameness, joint swelling, or both At least one positive MHS PCR result on joint fluid or joint tissue Histology lesions consistent with MHS as per diagnostician comments in histology report or published histology findings associated with experimental and field MHS cases ^{1,3,4}
Metabolic bone disease	Abnormal results on any calcium, phosphorus, bone histopathology, vitamin D assay, or bone ash/density tests. Not all assays listed had to be performed to be included in the metabolic bone disease category Diagnostician comments that abnormality is contributing to locomotion issues
Infectious arthritis (bacterial, non- <i>Mycoplasma</i> species)	Histology on synovium indicative of infectious (non- <i>Mycoplasma</i>) process Significant findings on culture† Gross description of fluid indicative of infection, ie, purulent, serosanguinous [if available*] Positive PCR results on molecular testing for <i>Erysipelothrix</i> species or <i>Haemophilus parasuis</i> from joint specimens [if available*]
Lameness: no abnormal findings	Lameness reported by practitioner or diagnostician Culture with no significant findings† MHS PCR negative Histology of joint revealed no changes to synovial tissue
Osteochondrosis	Gross or histologically observed cartilage defects in articular cartilage
MHR	MHR PCR positive or MHR culture positive on joint fluid or joint tissue Histological changes to the synovium consistent with MHR Systemic gross and histological lesions from other tissues submitted indicative of systemic MHR cases [if available*] Serosanguinous synovial fluid or fibrin in synovial fluid [if available*]
Trauma	Fractures unrelated to abnormal bone histology indicative of metabolic bone disease OR Bursitis related to physical contact with slats, as associated in diagnostician comments
Osteomyelitis	Bacterial infection of the bone as per gross or histological assessment of the bone Significant findings on culture [if available*]

* Indicates that for some cases, this information or specimen may not be available or that relevant tests for this diagnostic category may not have been performed.

† Significant findings refer to growth of a bacterial species associated with arthritis as per the bacteriologist or published literature. MHS = *Mycoplasma hyosynoviae*; PCR = polymerase chain reaction; MHR = *Mycoplasma hyorhinis*.

left the test selection portion of the diagnostic form completely blank. Another 16.1% (15 of 93) of submitting veterinarians selected at least four unique diagnostic tests for their case.

Sample types submitted included 43% (40 of 93) of cases with at least one whole leg, 26.9% (25 of 93) with at least one whole pig, and 24.7% (23 of 93) with at least one joint swab or fluid. The mean number of legs submitted per case was 3.7 legs (range, 1-14 legs). Ninety percent (36 of 40) of cases were submitted with at least 2 legs and 45% (18 of 40) of cases were submitted with 3 to 8 legs. The mean number of whole pigs submitted per case was 4.4 whole pigs (range, 1-25 pigs). Thirty-six percent (9 of 25) of cases were submitted with 2 whole pigs, 28% (7 of 25 cases) were submitted with 3 to 5 pigs, and 28% (7 of 25 cases) were submitted with 6 or more pigs. Considering all sample types, submissions contained samples from a mean of 2.9 animals (range, 1-25 animals).

Of the 93 cases where MHS was the primary diagnosis, 30 (32.3%) cases had multiple diagnoses, with OCD (26.7%; 8 of 30 cases) and non-*Mycoplasma* bacterial infection (26.7%; 8 of 30 cases) being the most common secondary diagnosis.

The most commonly requested test for pathogens other than *Mycoplasma* species was aerobic culture and the mean number of cultures per case was 2.4 (range, 1-37 cultures), of which 77.7% (171 of 220 total cultures) returned no significant growth. This does not include *Erysipelothrix* specific

cultures. *Erysipelas* was commonly listed as a differential (35.8%; 19 of 53 cases) but none of the cases listed skin lesions as part of the history or gross lesion findings. Almost half (45 cases) of the 93 MHS cases had at least one *Erysipelothrix* culture or PCR performed, with a mean of 2.5 *Erysipelothrix* assays per case. Of these 45 cases, however, only 1 (2.2%) returned a positive result.

Discussion

This study summarizes the most frequently observed lameness diagnostic categories for case submissions involving joints and legs at the ISU VDL between 2010 and 2015. A similar study reported the frequency of diagnosis of arthritis, specifically MHS and MHR cases, between 2003 and 2010 at the ISU VDL.⁵ There were 431 clinical cases with infectious arthritis during that time period and MHS represented 17% of the arthritis cases.⁵ There were more MHR cases identified in that study than reported here, but that study included pigs < 7 weeks of age. Findings from the current study are also consistent with another summary of arthritis cases from 2003 to 2014 at the ISU VDL.⁶ This study found that 25% of the cases were idiopathic, 20% were MHS, 24% bacterial and 12% were MHR based on the diagnostic code alone.⁶ These results reinforce that many diagnostic investigations do not reveal a clear etiology of the lameness as a consequence of diagnostic testing alone.

Although these two studies are similar in topic to the current study, there are key distinctions between these papers and this

retrospective review.^{5,6} For example, one study was a diagnostic note on cases between 2003 and 2010 and focused on recommendations for diagnosing *Mycoplasma*-associated arthritis.⁵ Since that time frame there has been development of additional PCR tests for *Mycoplasma* species associated with arthritis available at ISU VDL and lameness in growing pigs, particularly MHS, has become an emerging issue within the swine industry. Thus, an updated retrospective review is warranted. Another publication on lameness submissions to ISU VDL reflected a more current timeframe but is a conference proceeding and not available publicly.⁶ Both of these articles do not provide information about how the relevant diagnostic lab data was procured from the lab information management system, include information about inclusion/exclusion criteria, or require histology as part of the case. These comparable studies provide pilot information about the number of lameness cases and the types of primary diagnosis found but do not apply a systematic diagnostic criterion consistently across cases. This study focused on cases for which sufficient testing (histology, for example) was performed to diagnose MHS and then described characteristics of that subset of submissions.

Studies aiming to summarize lameness etiologies have been performed in the context of field cases. One Danish study looked at the microbiological causes of lameness in pigs at slaughter in Denmark. *Erysipelothrix rhusiopathiae* and MHS each comprised about 10% of the cases, while 70% of joints

Figure 1: Summary of case selection process from a retrospective survey of lameness cases from the Iowa State University Veterinary Diagnostic Laboratory between May 2010 and April 2015

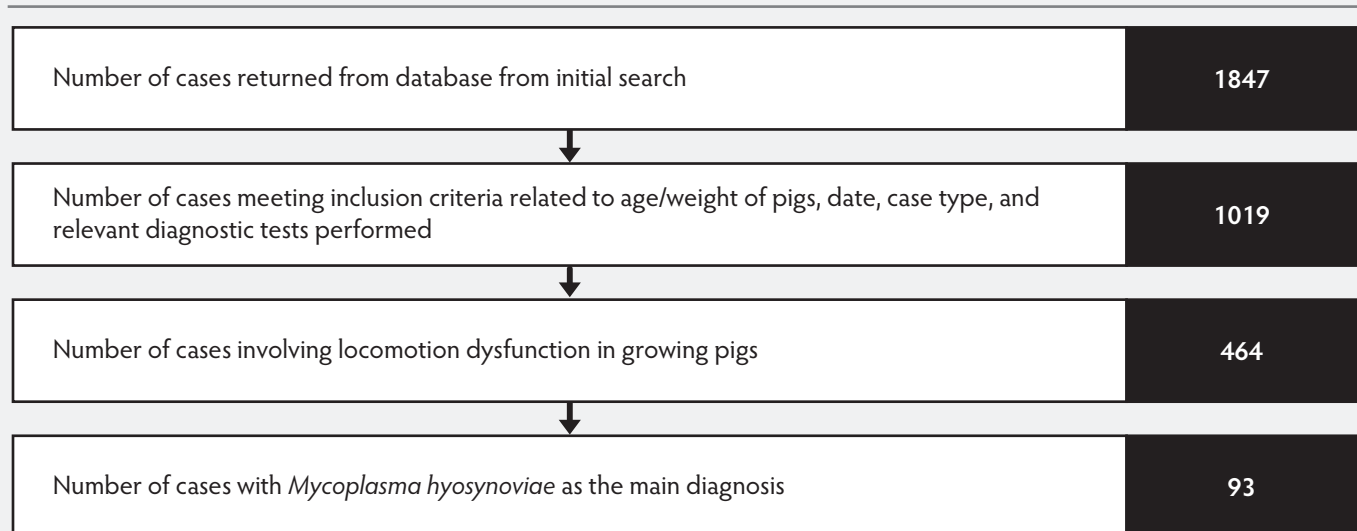


Table 3: Primary and secondary diagnoses for 464 lameness cases in growing pigs from a retrospective case survey at the Iowa State University Veterinary Diagnostic Laboratory between May 2010 and April 2015

Diagnosis	Primary diagnosis		Secondary diagnosis	
	Cases, No.	Cases, %	Cases, No.	Cases, %
Lameness with inconclusive findings	101	21.8	27	25.0
<i>Mycoplasma hyosynoviae</i>	93	20.0	1	0.9
Metabolic bone disease	86	18.5	31	28.7
Infectious (bacterial)	81	17.5	18	16.7
Lameness: no abnormal findings	43	9.3	0	0.0
Osteochondrosis	29	6.3	18	16.7
<i>Mycoplasma hyorhinis</i>	19	4.1	4	3.7
Trauma	10	2.1	8	7.4
Osteomyelitis	2	0.4	1	0.9
Total	464	100	108	100

were sterile. Gross changes to the joints were observed with *E rhusiopathiae* and MHS associated arthritis but gross pathological changes in the sterile joints were non-specific.⁷ In another Danish slaughter pig study, MHS was isolated from 60% of the pigs with arthritis in three of the five herds. Claw lesions (22%) and severe OCD (10%) made up the second and third most common diagnosis across all herds.⁸

This study supports that MHS is an important contributor to arthritis, but there are several other important known and unknown etiologies associated with lameness.⁹ In this study, four diagnostic categories (lameness with inconclusive findings, MHS, metabolic bone disease, and non-*Mycoplasma* bacterial infection) accounted for 77.8% of the cases and 23.3% of these cases had at least one other lameness-associated abnormality. This reinforces that lameness is often multifactorial, and that many swine lameness pathological processes may be cumulative contributing to the difficulty in assigning a single etiology causation. Additionally, the high rate of lameness with inconclusive findings and non-infectious lameness cases should prompt practitioners to perform complete diagnostic investigations before implementing expensive interventions or antibiotic treatment in the field. Generally, most of the culture results indicated no significant growth. It can be challenging to interpret the diagnostic significance of this finding because a negative culture result could occur under several circumstances. For example, use of non-*Mycoplasma* specific culture

media, the timing of when the bacteriological sample was collected with respect to the stage of disease in the animal, improper handling of bacteriological samples during transport, or that bacterial arthritis was not a contributor to the disease state of the joint would be potential explanations. Due to the retrospective nature of this study, the cause of the negative cultures could not be identified and further analyzed. However, the diagnostic criteria used in this study support that histology is a key tool to provide context to culture and PCR findings.

Lameness with inconclusive findings was the most commonly assigned (21.8% of cases) diagnostic category for this study. It is possible that submitter bias through inappropriate animal selection, sample selection, sample handling, or test selection could artificially increase this number. For example, in cases where practitioners submitted one intact joint, it could be possible that with additional specimens, the case could have received a diagnosis.

Conclusions obtained by retrospective description of data from a VDL should be approached carefully. The data utilized in this study was derived from diagnostic submissions and hence cannot be considered prevalence data. For each case, there were multiple sources of bias that make standardization and objective interpretation of VDL data very difficult. First, information is limited to the submission sheet, submitted specimens, and tests requested or the VDL diagnostician's decision on testing. Each case did not test for all possible causes of lameness and the case search

criterion focused on arthropathies. Since the completion of this analysis, multiple case reports have highlighted neurological and vesicular viral pathogens as important lameness etiologies, which were beyond the scope of this retrospective study at the time.¹⁰⁻¹⁴ Furthermore, the analysis was focused on infectious arthritis, specifically MHS, and the MHS case definition targeted acute cases. This study also did not include sows, boars, gilts, suckling, or nursery pigs; all of which contend with diverse lameness challenges.

Additionally, the retrospective case review process involves subjective steps completed by the veterinarian, laboratory technician, diagnostician, and case reviewer. For example, a diagnostician may interpret histopathologic findings differently depending upon their experience, current or popular health priorities within the industry, areas of expertise, and information provided about the case by the submitting veterinarian.

This retrospective study generated information that can support clinicians when diagnosing lameness in the field and when submitting lameness cases to a VDL. For example, this study quantifies the number of investigations that did not reveal a clear diagnosis (lameness with inconclusive findings) which is important for veterinarians to understand when developing a diagnostic plan for lameness and when communicating that plan to producers. This study also highlights that diverse etiologies contributed to the cause of lameness in the majority of cases. The role of infectious agents, such as MHS, have been heavily emphasized

in contributing to lameness, however this retrospective study suggests that for cases submitted to the laboratory, MHS was not found in a majority of cases. In terms of summarizing submission information for lameness cases, this study provides information on diagnostic submission habits that was previously not available. This information can serve as useful talking points when completing lameness submissions with a producer and outlines potential expectations for lameness diagnostic plans.

Implications

- In this study, the four diagnostic categories of lameness with inconclusive findings, MHS, metabolic bone disease, and bacterial infection comprised 77.8% of the cases.
- Examination of the submission sheet and diagnostic results for the MHS cases revealed varied approaches to MHS diagnosis with respect to the amount of information provided to the lab, number of tests requested, and number of specimens submitted for diagnostics.
- This study reinforces the importance of careful clinical examination, proper sampling, and confirming causes with appropriate diagnostic testing for accurate diagnosis of lameness.

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Conflict of Interest

None reported.

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Pulmonary *Paragonimus* infection and other pathologic findings in feral swine (*Sus scrofa*) from Macon County, Alabama

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Summary

Tuskegee University College of Veterinary Medicine (TUCVM) was integrated into a feral swine surveillance program to aid in monitoring feral swine in Macon County, Alabama. The program was initiated by the Wildlife Services division of the Animal Plant and Health Inspection Services of the United States Department of Agriculture. Feral swine were captured, humanely euthanized, and

blood was collected for various serological analyses. The carcasses were then submitted to the TUCVM diagnostic laboratory for postmortem examination and tissues were collected for additional disease surveillance. This report highlights pathologic findings identified in 15 feral hogs captured from Macon County, Alabama between March 14, 2012 and April 16, 2013, and serves as a record of some of the diseases the feral swine

in this area harbor. Some of the pertinent pathologic findings identified include pulmonary metastrongyliasis, pulmonary paragonimiasis and severe ectoparasitism.

Keywords: swine, Alabama, feral swine, *Metastrongylus*, *Paragonimus*

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Resumen – Infección pulmonar por *Paragonimus* y otros hallazgos pulmonares en cerdos salvajes (*Sus scrofa*) del Condado de Macon, Alabama

El Colegio de Medicina Veterinaria de la Universidad Tuskegee (TUCVM por sus siglas en inglés) se integró a un programa de vigilancia de cerdos salvajes para ayudar en el monitoreo de cerdos salvajes del condado de Macon, Alabama. El programa fue iniciado por la división de Servicios de Fauna Silvestre de los Servicios de Inspección de Animales, Plantas y Salud del Departamento de Agricultura de los Estados Unidos. Los cerdos salvajes fueron capturados, sacrificados

humanamente, y se recolectó sangre para varios análisis serológicos. Las canales fueron entregadas al laboratorio de diagnóstico de TUCVM para la examinación post mortem y se recolectaron tejidos para vigilancia adicional de enfermedades. Este reporte resalta los hallazgos patológicos identificados en 15 cerdos capturados en el condado de Macon, Alabama entre marzo 14, 2012 y abril 16, 2013, y sirve como un registro de algunas de las enfermedades que los cerdos salvajes albergan en esta área. Algunos de los hallazgos patológicos pertinentes identificados incluyen metastrongiliasis pulmonar, paragonimiasis pulmonar y ectoparasitismo severo.

Résumé – Infection pulmonaire à *Paragonimus* et autres trouvailles pathologiques chez des porcs sauvages (*Sus scrofa*) dans le comté de Macon, Alabama

La Tuskegee University College of Veterinary Medicine (TUCVM) a été intégrée dans un programme de surveillance des porcs sauvages afin d'aider à surveiller les porcs sauvages dans le comté de Macon, Alabama. Le programme fut initié par la division des Services de la faune du Animal Plant and Health Inspection Services du département de l'agriculture des États-Unis. Des porcs sauvages ont été capturés, euthanasiés de façon humanitaire, et du sang prélevé pour différentes analyses sérologiques. Les carcasses furent ensuite soumises au laboratoire de diagnostic de TUCVM pour un examen post-mortem et des tissus ont été prélevés pour la surveillance de maladies additionnelles. Le présent rapport souligne les trouvailles pathologiques identifiées chez 15 porcs sauvages capturés dans le comté de Macon, Alabama entre le 14 mars 2012 et le 16 avril 2013, et sert de registre de quelques-unes des maladies rencontrées chez les porcs sauvages dans cette région. Quelques-unes des trouvailles pathologiques pertinentes identifiées incluent la metastrongylose pulmonaire, la paragonimiasis pulmonaire et un ectoparasitisme sévère.

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Gilbreath ET, Gorham SL, Anderson DL, et al. Pulmonary *Paragonimus* infection and other pathologic findings in feral swine (*Sus scrofa*) from Macon County, Alabama. *J Swine Health Prod.* 2019;27(3):125-132.

Feral swine (*Sus scrofa*) are highly prolific and lack natural predators. Therefore, once established, they can readily overpopulate an area. Their numbers have progressively increased to high numbers in the United States, currently estimated at over 6 million,¹ with highest populations in Texas, California, Florida, and Hawaii.² They are also becoming more common in other regions of the nation, including Alabama.³ Their presence and increasing prevalence warrants concern of their potential impact on humans and other animals that share their habitat. Feral swine readily interact with and breed with domestic swine (*Sus scrofa domesticus*) and the ability for disease transmission between wild and domestic swine is high.^{4,5} Transmissible diseases known to be harbored and display seroprevalence by feral swine in the United States include pseudorabies virus^{6,7} and zoonotic diseases such as *Brucella*,⁵ *Toxoplasma gondii*,⁸ *Trichinella spiralis*,⁸ and influenza A virus.^{9,10} Furthermore, consumption of improperly cooked products (ie, skeletal muscle and intestine) of paratenic hosts of *Paragonimus*, such as wild boar, could result in human and animal infection as has been previously reported.^{11,12} Feral swine also have the potential to propagate foreign animal diseases, such as foot-and-mouth disease,¹³ hog cholera,¹⁴ and African swine fever.¹⁵ In addition to the potential for disease transmission to humans and various domestic species, their natural foraging behavior can result in massive crop destruction. They are also known to prey on small mammals, including goat kids and neonatal

lambs,¹⁶ resulting in their classification as agricultural nuisances.

In light of the growing prevalence of feral swine in Alabama and the United States^{1,17} and their ability to cause adverse effects on humans, domestic animals, and other wildlife species, monitoring these animals for pathologic conditions is paramount for public health, public education, and epidemiologic surveillance. This report highlights significant pathology identified in 15 feral swine captured in Macon County, Alabama between March 14, 2012 and April 16, 2013.

Case description

The Manually Initiated Nuisance Elimination trapping system (Jager Pro Hog Control, Fortson, GA) was used to capture feral swine. The capture devices were installed on the Russell Plantation which comprises 1687 acres of forestry land owned by Tuskegee University in Macon County, Alabama. Once pigs were captured in the trap, they were humanely killed by gunshot. All pigs appeared to be in good health based on observation of adequate activity, sufficient body condition score, and absence of external lesions or adverse clinical signs. Sterile swabs were used to obtain nasal samples and blood was collected via cardiac puncture using a 60 mL syringe with a 16-gauge, 10.16-mm needle. While in right lateral recumbency, the blood collection site was between the fourth and fifth rib behind the left elbow. Enough blood was collected from each animal to fill three 8.5 mL BD vacutainer blood tubes (Becton, Dickinson and Co, Franklin Lakes, NJ).

Serum samples were obtained and frozen until analysis by the US Department of Agriculture. Serum was analyzed for antibodies to pseudorabies virus (n = 15) via glycoprotein B enzyme-linked immunosorbent assay (ELISA), classical swine fever virus (n = 15), porcine hemagglutinating encephalomyelitis virus (n = 8), influenza A virus (n = 4), and *Trichinella* (n = 4) via ELISA, *Toxoplasma* via ELISA (n = 4) and microagglutination assay (n = 7), and *Brucella suis* (n = 15) via fluorescence polarization assay. Nasal swabs were analyzed for influenza A virus (n = 7) via real-time reverse transcription polymerase chain reaction. Tests were performed at various laboratories (Table 1). Carcasses were submitted to the Tuskegee University College of Veterinary Medicine for postmortem evaluation.

Case findings

Three of 7 serum samples submitted for *Toxoplasma* microagglutination assay were positive. The 4 samples submitted for *Toxoplasma* ELISA were negative. One of 15 samples submitted for pseudorabies virus was a suspect positive. Results of all other tests previously listed were negative.

Postmortem examinations were performed on feral swine that ranged from juvenile to adult animals weighing 9 to 57 kg. There were 10 females and 5 males. Of these, 1 female was pregnant with 8 fetuses with crown-to-rump lengths of 25 cm, which is most consistent with a gestational age of approximately 99 days based on an established prediction equation for gestational age.¹⁸ Feral swine

Table 1: Laboratory locations where various tests were performed on samples from 15 feral pigs captured in Macon County, Alabama

Test performed	Laboratory
Pseudorabies virus – glycoprotein B ELISA	University of Georgia Tifton Veterinary Diagnostic Laboratory, Tifton, GA and Wisconsin Veterinary Diagnostic Laboratory, Madison, WI
Classical swine fever virus – ELISA	Foreign Animal Disease Diagnostic Laboratory, Greenport, NY
Hemagglutinating encephalomyelitis virus - ELISA	National Institutes of Health, Bethesda, MD
Influenza A virus – ELISA	USDA APHIS National Wildlife Disease Program, Fort Collins, CO
<i>Trichinella</i> - ELISA	USDA APHIS National Wildlife Disease Program, Fort Collins, CO
<i>Toxoplasma</i> - ELISA	USDA APHIS National Wildlife Disease Program, Fort Collins, CO
<i>Toxoplasma</i> - microagglutination	USDA Agricultural Research Service, Beltsville, MD
<i>Brucella</i> - fluorescence polarization assay	Kansas State Federal Brucellosis Laboratory, Topeka, KS
Influenza A virus - rRT-PCR (nasal swab)	Thompson Bishop Sparks State Diagnostic Laboratory, Auburn, AL

ELISA = enzyme-linked immunosorbent assay; USDA = US Department of Agriculture; APHIS = Animal and Plant Health Inspection Service; rRT-PCR = real-time reverse transcription polymerase chain reaction.

have a gestational period of approximately 115 days and usually have 1 to 2 litters per year, with an average of 4 to 8 piglets per litter.⁴

All 15 pigs were infected with numerous ectoparasites; 46 ectoparasites were examined. Of the 36 ticks, 33 (91.7%) were identified as *Amblyomma americanum* and 3 (8.3%) were identified as *Dermacentor variabilis*. The ticks were characterized by a cephalothorax and 4 pairs of legs.¹⁹ Ten *Haematopinus suis* lice, (21.7% of the total ectoparasites collected) were identified. Lice had a distinct head, thorax, abdomen, and 3 pairs of legs (Figure 1).²⁰ Speciation of ectoparasites was done by a veterinary parasitologist via observation through a dissecting microscope.

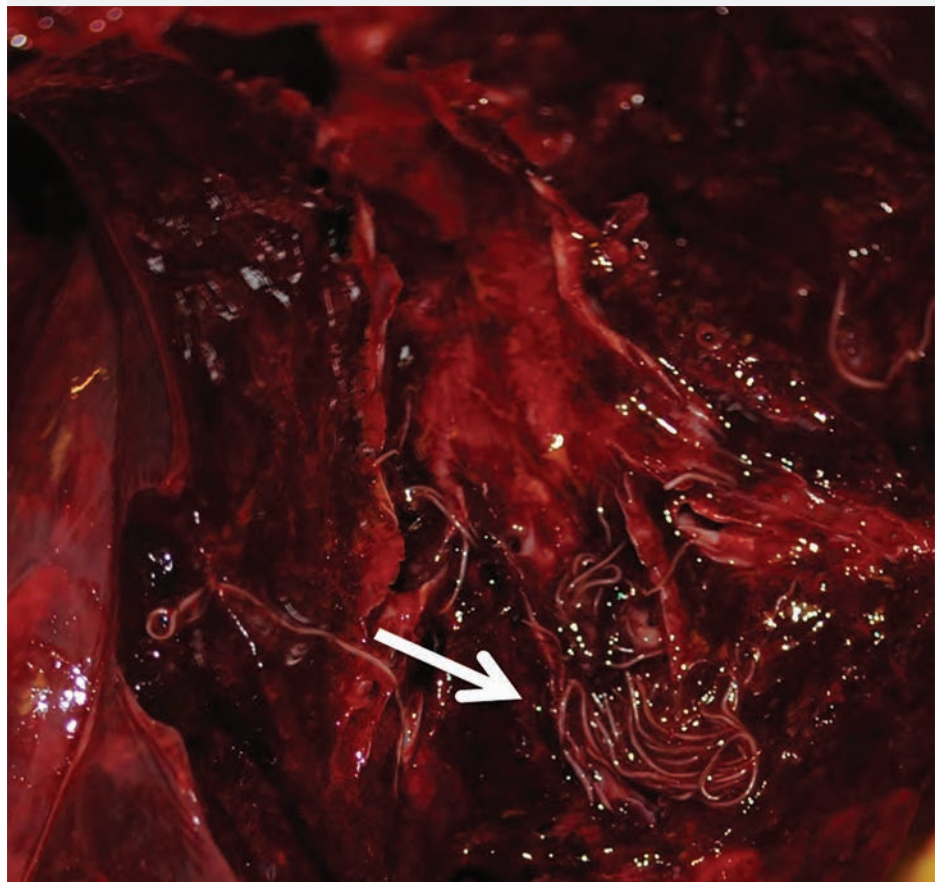
Intrabronchial and intrabronchiolar nematodes were macroscopically observed in 7 of 15 pigs (46.7%). In pigs with pulmonary nematodes, lung color was diffusely mottled, variably firm on palpation, and were associated with tracheobronchial lymph node hyperplasia. The pulmonary nematodes were white, thin, cylindrical, and 4 to 6 cm in length (*Metastrongylus* species; Figure 2). Histologically, bronchi and bronchioles contained cross-sections of intraluminal nematodes that measured 500 to 700 μm . They contained a body cavity, thin cuticle, coelomyarian musculature, intestinal tract lined by few multinucleated cells, and ovaries and uterus filled with oocytes and developing larva (Figure 3). Bronchi and bronchioles contained moderate amounts of intraluminal edema, fibrin, and mucus admixed with predominately eosinophils and fewer macrophages, lymphocytes, plasma cells, and neutrophils. Occasional free nematode eggs were present in bronchi. Bronchial and bronchiolar epithelium was hyperplastic with goblet cell metaplasia. There was marked peribronchial and peribronchiolar smooth muscle hypertrophy and bronchial associated lymphoid tissue hyperplasia. There were multifocal to coalescing areas of alveolar capillary congestion with associated intra-alveolar edema. To confirm species identity of the pulmonary nematodes, genomic DNA was extracted from 0.1 g of formalin-fixed paraffin embedded (FFPE) lung tissue.

Briefly, pulverized FFPE samples were suspended in 600 μL of TSK buffer (567 μL of TE buffer [10 mM Tris and 1 mM EDTA, pH = 7.5], 30 μL of 10% sodium dodecyl sulfate, and 3 μL of 20 mg/mL proteinase K)

Figure 1: Representation of arthropod ectoparasites on the feral pig carcasses. The larger ectoparasite on the left is a female *Amblyomma americanum* tick, the middle ectoparasite is a male *A americanum* tick, and the ectoparasite on the right is a *Haematopinus suis* louse.



Figure 2: Moderate numbers of white cylindrical *Metastrongylus* parasites (indicated by arrow) lie on the mucosal surface of 3 bronchi in the lung of a feral pig.



and incubated at 50°C overnight. Then, 114 µL of 5 M NaCl and 91 µL of 1 M NaCl and 10% (vol/vol) hexadecyltrimethylammonium bromide mixture were added. After a 15-minute incubation at 65°C, DNA was extracted twice with an equal volume of phenol-chloroform-isoamyl alcohol (25:24:1, vol/vol) and then once with an equal volume of chloroform-isoamyl alcohol (24:1, vol/vol). After precipitation with 900 µL of isopropanol, the DNA was washed with 70% (vol/vol) ethanol and resuspended in TE buffer. The lung samples came from 9 different pigs. Conventional polymerase chain reaction (PCR) was performed on 20 ng of DNA using primer sets specific for detection of *Metastrongylus salmi*, *Metastrongylus pudendotectus*, *Metastrongylus elongatus* (apri), *Paragonimus westermani*, and *Paragonimus kellicotti* (Table 2). The cycling conditions included an initial denaturation for 1 minute at 95°C, 35 cycles of denaturation at 95°C for 30 seconds, annealing at 55°C for 30 seconds, elongation at 72°C for 30 seconds, and a final extension step at 72°C for 5 minutes. The amplified gene fragments were sequenced and found to match the gene sequences reported in the GenBank corresponding to the genes' accession numbers. The PCR amplification targeted the 28s ribosomal RNA gene for *M salmi* and *M pudendotectus*, and the 18s ribosomal RNA gene for *M elongatus* (GenBank accession numbers AJ305404, AF210046 and AJ920363, respectively). As loading control, all samples were positive for *S scrofa* 12s ribosomal RNA gene (Figure 4A; GenBank accession number EF027294). Among the 9 samples tested by PCR, 8 were positive for *M salmi* (Figure 4B), while all 9 samples were

negative for both *M pudendotectus* and *M elongatus*.

An intrapulmonary trematode was observed in a pig that did not have grossly observable pulmonary nematodes. The trematode was 1.5 cm long, brown, flat, and tapered at both ends, consistent with *Paragonimus* species. Microscopically, the trematode cross section was 8 × 3 mm², contained multiple cuticular ridges and spines, had a body filled with parenchyma, and contained peripherally

located vitellaria (Figure 5A). Ceca, testes with mature sperm (Figure 5B), and a uterus with yellow-shelled eggs (Figure 5C) were present. Histologically, the lung of the pig infected with pulmonary trematodes contained multinodular aggregates of innumerable oocytes surrounded by thick bands of fibrosis (Figure 6). The oocytes were ovoid, 50 to 70 × 80 to 100 µm² with a distinct 3 µm thick, yellow-pigmented refractile cell wall, typical of trematode eggs. A single operculum with opercular ridges was occasionally evident

Figure 3: Cross sections of nematode parasites in a pulmonary bronchiole of a feral pig. There is a body cavity (asterisk), digestive tract (arrow), cuticle (arrow-head), and an ovary filled with eggs (hashtag). H&E stain; Magnification × 100.

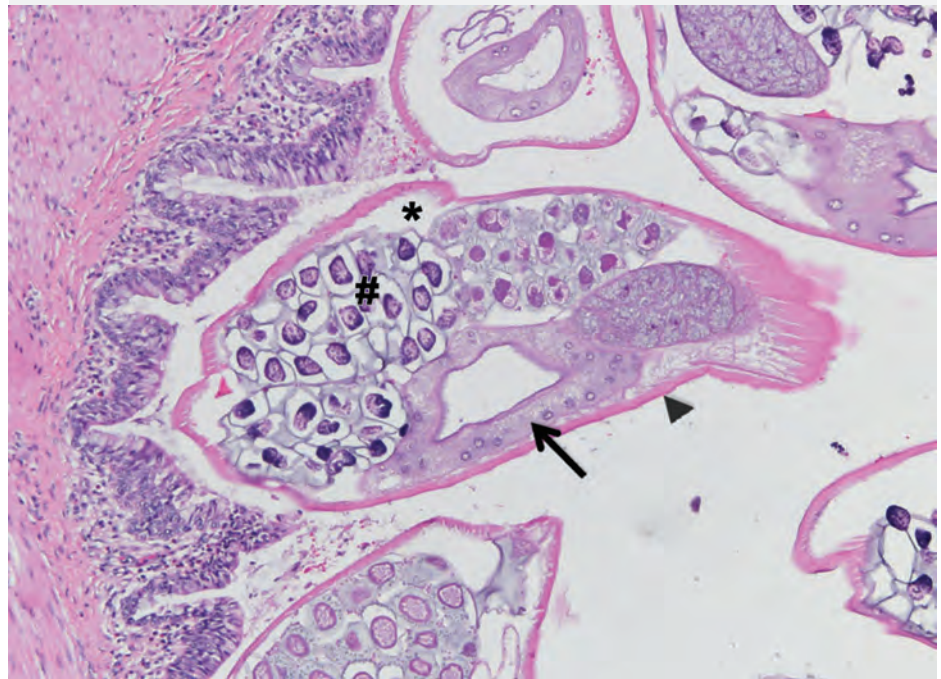


Table 2: Primer pairs used for detection of pulmonary parasites by polymerase chain reaction

Genus and species tested	Primer pairs
<i>Metastrongylus salmi</i>	Forward 5'-TTCAGGGTTGTTAACGAT-3' and Reverse 5'-TTGCTTGAACGGGTAA-3'
<i>Metastrongylus pudendotectus</i>	Forward 5'-CAGTGACCGGGTCGGTT-3' and Reverse 5'-TCCGTACCAGTTCCA-3'
<i>Metastrongylus elongatus</i>	Forward 5'-TGCATGTCGAGTTCAACTTC-3' and Reverse 5'-ATGCTGCGTTATTCAGAGTC-3'
<i>Paragonimus westermani</i>	Forward 5'-AGGCAATGTGGTGTTCAGGT-3' and Reverse 5'-ATCGGACTCGTGCAAGTA-3'
<i>Paragonimus kellicotti</i>	Forward 5'-ATATTGCGGCCACGGGTTA-3' and Reverse 5'-ACGTGGCACATACATAGATCA-3'
<i>Sus scrofa</i>	Forward 5'-AAACTGGGATTAGATACCCCA-3' and Reverse 5'-AGAACAGGCTCCTCTAGGT-3'

(Figure 7). The observed opercular ridges are a characteristic feature of *Paragonimus* species oocytes.²¹ Oocytes were surrounded by moderate to numerous lymphocytes, plasma cells, and macrophages, which often contained abundant brown granular pigment (hemosiderin) and few to moderate scattered eosinophils. In the surrounding lung tissue, within bronchi, bronchioles, and alveoli, there were small to moderate numbers of eosinophils, lymphocytes, plasma cells, and histiocytes, which were sometimes infiltrating peribronchiolar regions. The interstitium was mildly expanded by macrophages. Bronchioles and alveoli occasionally contained small amounts of hemorrhage, fibrin, and edema. There was a focally extensive abscess with a central area of necrosis, hemorrhage, and numerous oocytes admixed with numerous degenerate and few viable eosinophils, lymphocytes, plasma cells, macrophages, and neutrophils. The central necrosis was surrounded by lymphocytes, plasma cells, and

macrophages and rimmed by fibrosis which was further lined by hemorrhage, fibrin, and edema. The PCR was performed on DNA extracted from the 9 samples which included the FFPE trematode-infected lung tissue using primer pair for *P westermani* 28s ribosomal RNA gene (GenBank accession number HM172630) and *P kellicotti* 28s ribosomal RNA gene (GenBank accession number HQ900670). Among the 9 samples tested, 2 were positive for *P westermani* (Figure 4C) and *P kellicotti* was not detected. These results suggest that the trematode *P westermani* was present. Because this species of *Paragonimus* is not endemic in North America, additional ancillary diagnostics should be performed in future studies to definitively confirm the presence of *P westermani* in our samples. The PCR results do, nonetheless, confirm the macroscopic and microscopic diagnosis of *Paragonimus*.

One pig (6.7%) had a tortuous nematode within the mucosa of the dorsal tongue. The

nematode in the tongue was histologically observed in cross-section within the lingual epithelium. It was 60 to 70 μm in diameter and had a 5 to 7 μm cuticle, platymyarian musculature, a body cavity, and contained a small intestine and a uterus with unembryonated, thin-shelled eggs (Figure 8). The most common nematode in the tongue of the wild pig is *Eucoleus (Capillaria) garfiai*,²² and is the likely species in this case. This was considered an incidental finding of minimal pathologic significance.

In 1 pig (6.7%), there was a firm, red, $2 \times 2 \times 2 \text{ cm}^3$, nodular area of consolidation that extended into the underlying pulmonary parenchyma. Microscopically this was an area of lymphofollicular hyperplasia. Immunohistochemistry confirmed the presence of a mixed population of B and T lymphocytes, ruling out pulmonary lymphoma.

Additional incidental findings included 3 pigs with enlarged inguinal lymph nodes, 1 pig

Figure 4: Conventional polymerase chain reaction of formalin-fixed paraffin-embedded lung tissue from feral pigs for parasite identification. (A) All samples were positive for *Sus scrofa* 12s ribosomal RNA. (B) Rows 1-3 and 5-9 were positive for *Metastrongylus salmi*. Row 4 was negative for *M salmi*. All samples were negative for *Metastrongylus pudendotectus* and *Metastrongylus elongatus*. (C) Among the 9 samples tested from the lung tissue of the wild pig with the pulmonary trematode, 2 samples (rows 4 and 6) were positive for *Paragonimus westermani*.

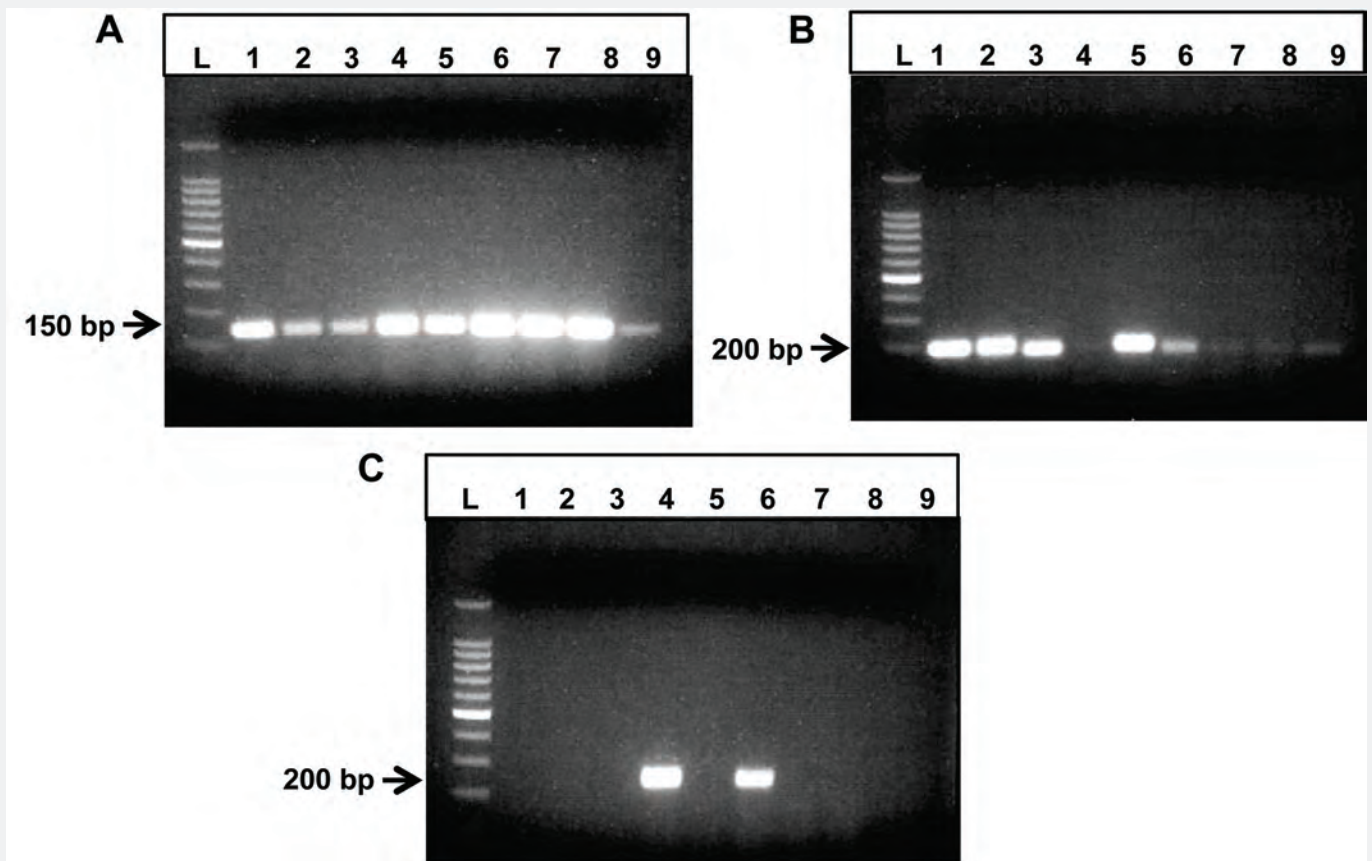
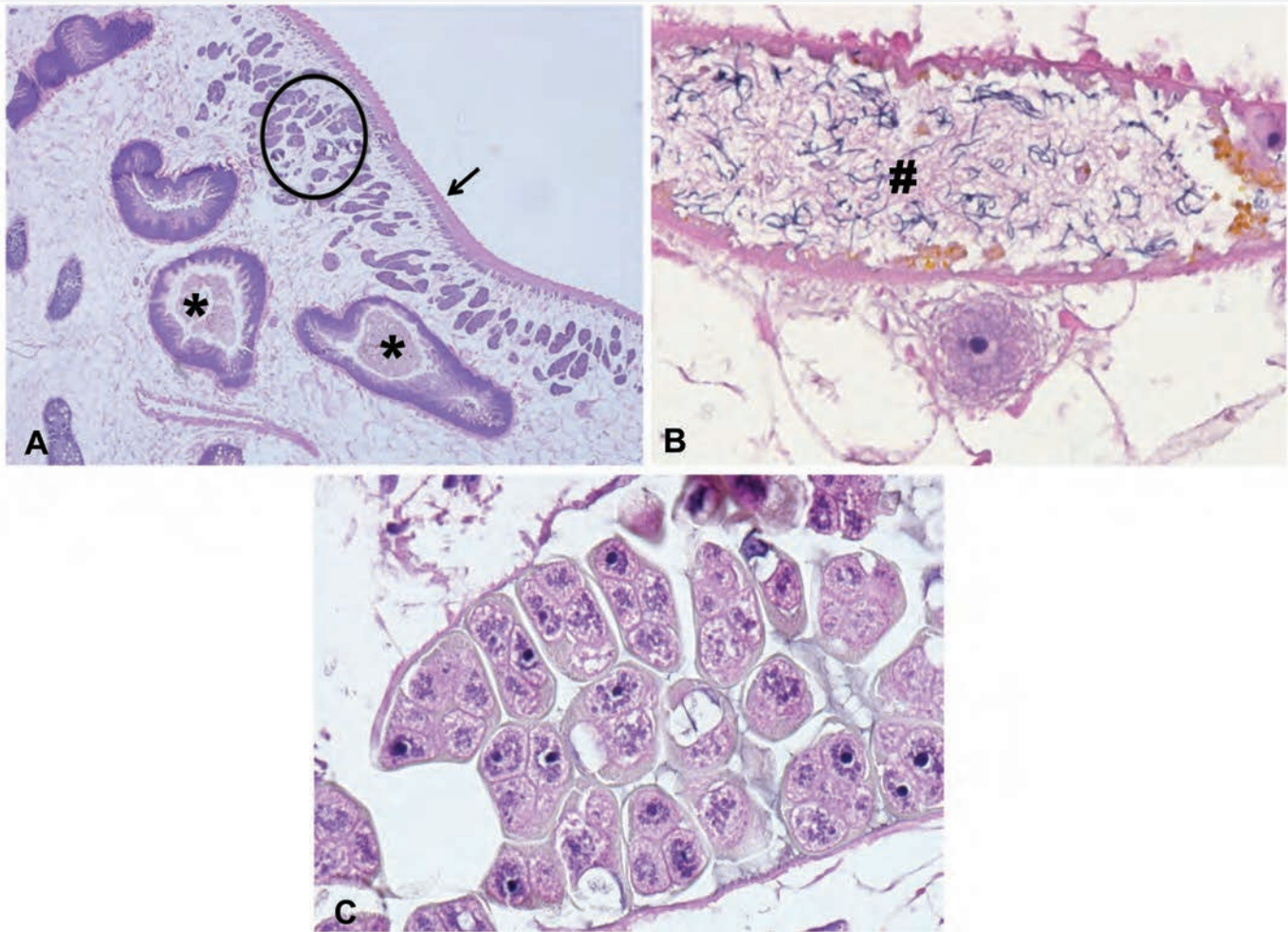


Figure 5: Sections of a trematode obtained from the lung of a feral pig. (A) The trematode has a thin cuticle with cuticular ridges and spines (arrow), prominent subcuticular vitellaria (circle), multiple cross-sections of a digestive tract (asterisk), and absence of a coelomic space. H&E stain; magnification $\times 40$. (B) Testis filled with mature sperm (hashtag). H&E stain; magnification $\times 600$. (C) Uterus containing yellow, thick-shelled eggs. H&E stain; magnification $\times 400$.



with enlarged mandibular lymph nodes, and 1 pig with enlarged mesenteric lymph nodes. Other significant macroscopic and microscopic findings were not observed.

Discussion

Feral swine in Macon County, Alabama were infested with several external parasites: the *H suis* louse, *D variabilis* tick (American dog tick), and *A americanum* tick (Lone star tick). *Haematopinus suis* can transmit swine pox virus²³ and *Mycoplasma suis*,²⁴ *D variabilis* can transmit Rocky Mountain Spotted Fever (*Rickettsia rickettsia*)²⁵ and tularemia (*Francisella tularensis*),²⁶ and *A americanum* can transmit tularemia, *Ehrlichia chaffensis*, and *Ehrlichia ewevingii* (the cause of human ehrlichiosis).²⁷ Feral swine in Macon County, Alabama were infected with *Metastrongylus* organisms, which is the pig lung worm that

can be transmitted between feral and domestic pigs. A novel finding in this case was the presence of the lung fluke, a *Paragonimus* organism. This trematode was macroscopically and microscopically observed in 1 pig; however, PCR detected DNA for *P westermani* in this pig as well as in 1 additional pig. This suggests that even though the trematode was not observed macroscopically or microscopically, the infection was still present. *Paragonimus* organisms are zoonotic agents that can be transmitted to humans and other animal species. Transmission commonly occurs by way of consuming infected crayfish, which are intermediate hosts, but can also occur through consumption of undercooked meat from paratenic hosts, such as feral swine.^{11,12,21} Antibodies to *Toxoplasma* organisms were detected in 3 pigs. This indicates that the animals were

exposed to this organism and generated an immune response. *Toxoplasma* is a zoonotic protozoan parasite that can be transmitted to humans and other homeothermic species via ingestion of oocysts from feline (definitive host) feces, ingestion of bradyzoites in tissues of intermediate hosts (ie, wild pigs), and transplacentally.²⁸ Transplacental transmission can cause fetal infection and abortion²⁹; therefore, pregnant women should be especially cautious when handling feral swine tissues.

It is important to be aware of diseases prevalent in feral swine that may come in contact with domestic animals and humans. Proper precautionary measures should be taken when coming in contact with feral swine, thereby minimizing the risk of disease transmission.

Implications

The sample of feral swine in Macon County, Alabama were:

- infested with ectoparasites that can transmit a variety of diseases to domestic swine, other animal species, and humans.
- infected with endoparasites that are transmissible to domestic swine, other animal species, and humans.
- serologically positive for *Toxoplasma* which is transmissible to domestic swine, other animal species, and humans.

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Conflict of interest

None reported.

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Figure 6: In the lung of a feral pig, aggregates of trematode oocytes have effaced normal lung architecture and are separated by bands of fibrous tissue and associated with inflammatory cells, hemorrhage, and hemosiderin-laden macrophages. Oocytes are round to oval with thick refractile walls. H&E stain; magnification $\times 40$.

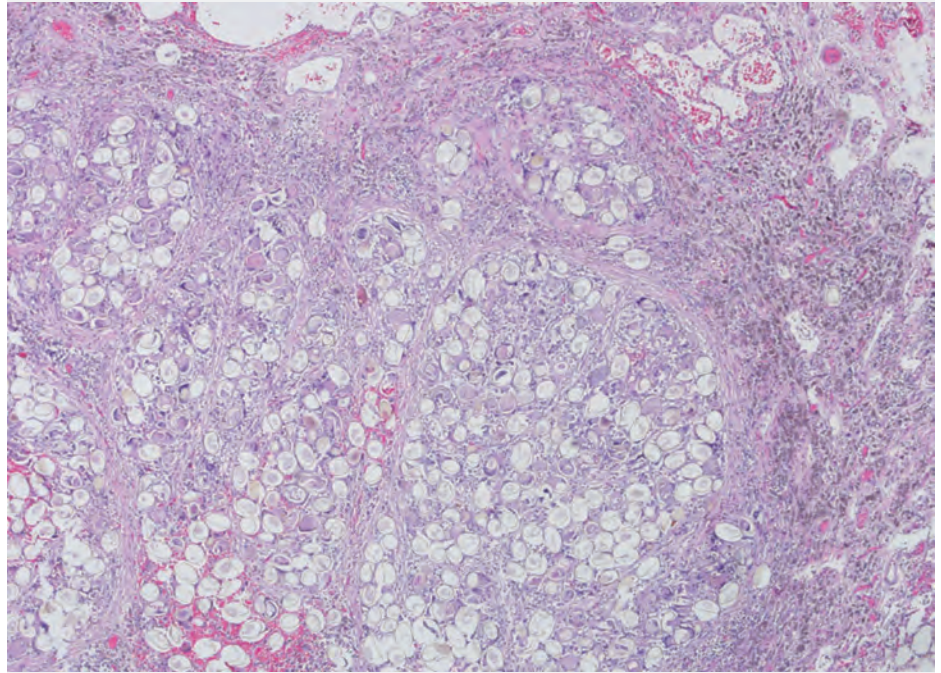
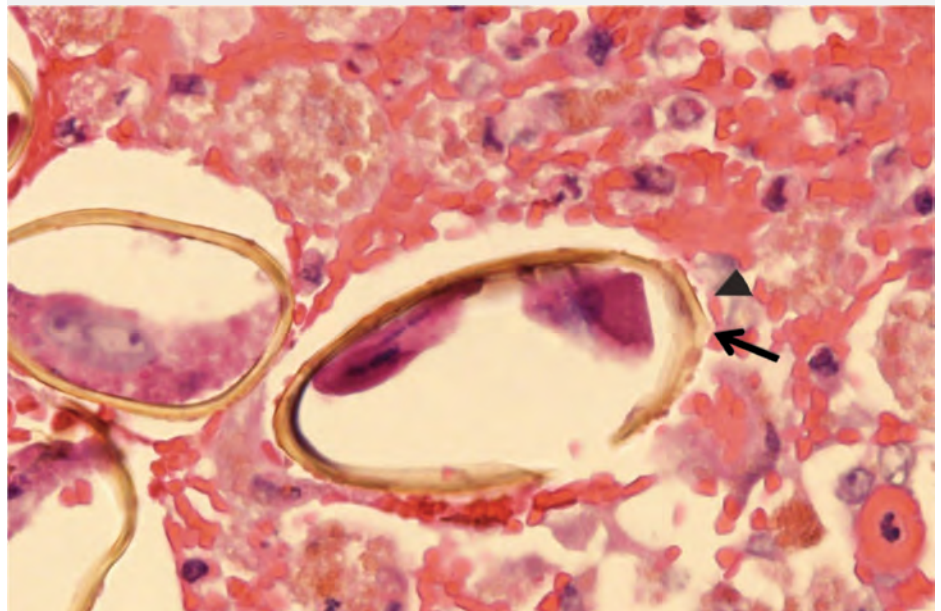


Figure 7: A trematode oocyte with a single operculum (arrowhead) and opercular ridges (arrow) in the lung of a wild pig. H&E stain; magnification $\times 600$.



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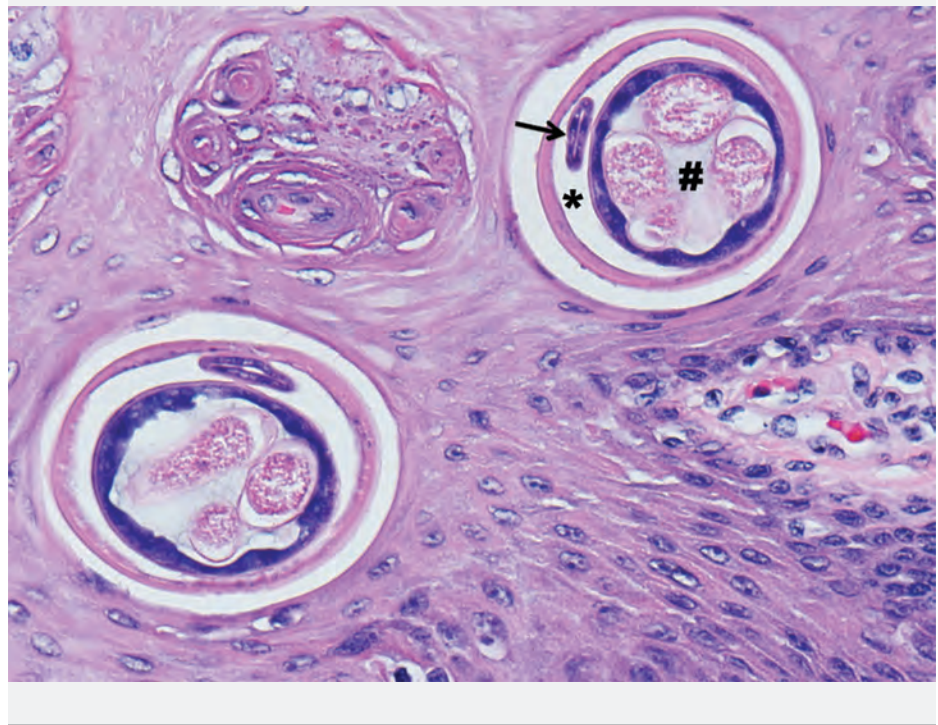
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Figure 8: Cross sections of a nematode in the lingual mucosa of a feral pig. The nematode contains a body cavity (asterisk), digestive tract (arrow), and uterus with unembryonated, thin-shelled eggs (hashtag). H&E stain; magnification $\times 400$.



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A systematic review and network meta-analysis of injectable antibiotic treatment options for naturally occurring swine respiratory disease

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Summary

Based on an *a priori* protocol, a review of injectable antibiotic regimens to treat swine respiratory disease (SRD) in weaned swine was conducted to assess the first-treatment failure at 5 to 14 days post-treatment. Information sources included Cambridge Agricultural and Biological Index, MEDLINE, Food and Drug Administration New Animal Drug Approval summaries, Swine Information Library abstracts, and bibliographies of relevant studies and reviews. Two reviewers screened the records, extracted data, and assessed bias

risk. From 1266 records screened, 25 relevant records described 41 relevant studies. Thirty-four relevant studies were included in a meta-analysis. The top 3 model-estimated SRD treatments based on mean rank were enrofloxacin (7.5 mg/kg once or 2.5-5 mg/kg once daily for 3-5 days; $n = 5$; rank = 2; 95% CI, 1-4), gamithromycin (6 mg/kg once, $n = 2$; rank = 5; 95% CI, 1-14), and marbofloxacin (8 mg/kg once, $n = 1$; rank = 6; 95% CI, 1-16). When treating SRD, this information should be combined with antibiotic treatment selection criteria

including sensitivity testing results, the farm's pathogen susceptibility monitoring data, local antibiotic prescribing policies, product label recommendations for use and warnings, cost, convenience, importance of the antibiotic to human health, and prudent antibiotic use guidelines.

Keywords: swine, antibiotics, meta-analysis, respiratory disease, systematic review

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Resumen - Una revisión sistemática y meta-análisis en la red de las opciones de tratamiento con antibióticos inyectables para enfermedades respiratorias porcinas que ocurren naturalmente

En base de un protocolo *a priori*, se realizó una revisión de los regímenes de antibióticos inyectables para tratar la enfermedad respiratoria porcina (SRD, por sus siglas en inglés) en cerdos destetados para evaluar el fracaso del primer tratamiento entre los 5 y los 14 días posteriores al tratamiento. Las fuentes de información incluyeron el Índice Agrícola y Biológico de Cambridge, MEDLINE, resúmenes de la Aprobación de Nuevos Medicamentos para Animales de la Administración de Alimentos y Medicamentos,

resúmenes de la Biblioteca de Información Porcina y bibliografías de estudios y revisiones relevantes. Dos revisores seleccionaron los registros, extrajeron los datos y evaluaron el riesgo de parcialidad. De los 1266 registros seleccionados, 25 registros relevantes describieron 41 estudios relevantes. Se incluyeron 34 estudios relevantes en un meta-análisis. Los 3 principales modelos de tratamiento para SRD basados en la categoría promedio fueron enrofloxacin (7.5 mg/kg una vez o 2.5-5 mg/kg una vez al día durante 3-5 días; $n = 5$; categoría = 2; IC 95%, 1-4), gamitromicina (6 mg/kg una vez, $n = 2$; categoría = 5; IC 95%, 1-14) y marbofloxacina (8 mg/kg una vez, $n = 1$; categoría = 6; IC 95%, 1-16). Cuando se trata la SRD,

esta información debe combinarse con los criterios de selección del tratamiento con antibióticos, incluidos los resultados de las pruebas de sensibilidad, los datos de monitoreo de susceptibilidad a patógenos de la granja, las políticas locales de prescripción de antibióticos, las recomendaciones de uso y las advertencias en la etiqueta del producto, el costo, conveniencia, la importancia del antibiótico con relación a la salud humana, y pautas prudentes sobre uso de antibióticos.

Résumé – Revue systématique et méta-analyse en réseau des options de traitement par antibiotiques injectables pour les maladies respiratoires naturellement présentes chez le porc

Sur la base d'un protocole *a priori*, une analyse des schémas thérapeutiques d'antibiothérapie par injection pour traiter les maladies respiratoires porcines (MRP) chez les porcs sevrés a été réalisée pour évaluer l'échec du premier traitement 5 à 14 jours après le traitement. Les sources d'information comprenaient le Cambridge Agricultural and Biological Index, MEDLINE, les résumés du Food and Drug Administration sur les approbations des nouveaux médicaments pour les animaux, les résumés de la Swine Information Library, et les bibliographies des études et revues pertinentes. Deux examinateurs ont étudié les dossiers, extrait les données et évalué le

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

Supplementary materials 1: Protocol (SM1) is available online at <http://www.aasv.org/shap/issues/v27n3>.

Supplementary materials 2: Tables and Figures (SM2) is available online at <http://www.aasv.org/shap/issues/v27n3>.

O'Connor AM, Totton SC, Shane D. A systematic review and network meta-analysis of injectable antibiotic treatment options for naturally occurring swine respiratory disease. *J Swine Health Prod.* 2019;27(3):133-149.

risque de biais. Sur 1266 dossiers examinés, 25 dossiers pertinents décrivaient 41 études pertinentes. Trente-quatre études pertinentes ont été incluses dans une méta-analyse. Les trois principaux traitements des MRP estimés selon le modèle sur la base du rang moyen étaient l'enrofloxacin (7.5 mg/kg une fois ou 2.5 à 5 mg/kg une fois par jour pendant 3-5 jours; n = 5; rang = 2; IC à 95%, 1-4), la gamithromycine (6 mg/kg une fois, n = 2; rang = 5; IC 95%, 1-14) et la marbofloxacin (8 mg/kg une fois, n = 1; rang = 6; IC 95%, 1-16). Lors du traitement des MRP, ces informations doivent être associées à des critères de sélection de traitement aux antibiotiques, notamment les résultats des tests de sensibilité, les données de surveillance de la sensibilité des agents pathogènes de la ferme, les règles locales de prescription d'antibiotiques, les recommandations d'utilisation et avertissements des étiquettes, le coût, la commodité, l'importance de l'antibiotique pour la santé humaine et les directives d'utilisation prudente des antibiotiques.

Respiratory disease represents a major health issue in swine production. Although prevention of respiratory disease is the preferred management approach, antibiotic treatment is required to ensure the best possible outcome regarding animal health and well-being when cases of swine respiratory disease (SRD) do occur. Many products are registered around the world for the treatment of SRD. Ideally, veterinarians would read the available literature about the efficacy of SRD treatments and combine the information. However, there are numerous barriers to such synthesis. First, veterinarians often lack both the access to and time for review of the literature. Further, many studies conducted and published for registration purposes often compare response to treatment in untreated animals. Such comparisons are often of little interest to producers or veterinarians who might be interested in comparisons between two or more active products. It is also extremely difficult, without statistical methods, to appropriately combine and compare studies from different trials and sample sizes. Because of these factors, the comparative efficacy of many antibiotic treatments for SRD are rarely known, despite this being critical information for producers and veterinarians. Knowledge of comparative efficacy is critical because it establishes a baseline for antibiotic selection.

Although comparative efficacy is important it is clearly not the only metric of importance

in antibiotic selection. Veterinarians should also consider this alongside other relevant factors for antibiotic treatment selection, which may include sensitivity testing results for target animals, pathogen susceptibility monitoring data for the farm, local antibiotic prescribing policies, the recommendations for use and warnings on the product labels and leaflets, cost, convenience, importance of the antibiotic to human health, and guidelines for prudent antibiotic use.

Ideally, comparative efficacy would be assessed in large multi-arm randomized controlled clinical trials; however, such trials are rarely conducted or publicly available. An alternative approach to assessing comparative efficacy in large trials is a network meta-analysis, also known as a mixed treatment comparison meta-analysis. This approach has been widely used in human health, and evidence from bovine respiratory disease suggests that estimates of comparative efficacy obtained from network meta-analysis are very reasonable approximations of those observed in controlled trials.^{1,2}

The objective of this study was to evaluate the comparative efficacy of injectable antibiotic treatments for SRD and assess the risk-of-bias potential associated with the body of work. The project sought to provide estimates of comparative efficacy and ranking of efficacy based on the first treatment failure between 5 and 14 days post-treatment for antibiotics used to treat swine. The review question was framed using a format that explicitly defined the population, the intervention, the comparator, and the outcome of interest (sometimes known as the PICO format): In weaned swine with naturally occurring undifferentiated or differentiated SRD in modern production systems (population), what is the comparative efficacy of injectable antibiotic treatments (interventions, comparator) for the first treatment failure occurring between 5 and 14 days post-treatment (outcome)?

Materials and methods

Protocol and registration

The review protocol was developed before the start of the review. Development of a protocol prior to conduct of the review is standard practice for systematic reviews, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement provides the following rationale:

A protocol is important because it pre-specifies the objectives and methods of the systematic review.

For instance, a protocol specifies outcomes of primary interest, how reviewers will extract information about those outcomes, and methods that reviewers might use to quantitatively summarize the outcome data (see Item 13). Having a protocol can help restrict the likelihood of biased post hoc decisions in review methods, such as selective outcome reporting.

As a pharmaceutical company funded this review, concerns about selective inclusion of literature or selective reporting of outcomes and the influence of the company on the report might be relevant to readers, therefore a protocol is particularly important. The final protocol was approved and time-stamped on September 30, 2017. There is no mechanism to register protocols for systematic reviews in livestock at present, therefore, the time-stamped protocol was made and is included in the supplementary materials (SM1: Protocol). This report is prepared based on the PRISMA extension for network meta-analyses published in 2015.³

Eligibility criteria

The eligibility criteria described herein do not differ from those proposed in the protocol.

Population. The population of interest was weaned swine, which might variably be described as nursery pigs, grower pigs, finishers, or based on weight and age. The swine also had to be diagnosed with naturally occurring, undifferentiated or differentiated SRD in modern swine production systems. Studies based only on sows, gilts, or boars were not considered relevant. No restrictions were placed on the country of conduct.

Interventions. Individual animal interventions of interest included injectable antibiotics listed in Table 1. The list of known SRD treatment regimens was provided by the sponsor designate (Dr Shane), who consulted work colleagues about treatment regimens of interest. These regimens were the registered label dose of the antibiotic in either Europe or the United States, and thus multiple antibiotic treatments and regimens would be considered extra-label use in the United States. Treatment regimens of parenteral products for SRD control, SRD control interventions added to food or water, antibiotics combined with non-steroidal anti-inflammatory drugs, and off-label use regimens were not considered relevant to the conclusions of the review. When the label included multiple dose regimens, these were combined into a single treatment. For example, if a three-arm trial had one placebo

group, a second group that assessed a single intramuscular dose of 3.0 mg/kg of ceftiofur sodium, and a third group that assessed a single intramuscular dose of 5.0 mg/kg of ceftiofur sodium, the second and third groups would be combined and compared to the placebo because these two doses are listed as equivalent on the product label and, therefore, these data were considered to represent one treatment. The rationale for this approach was that if labeled as such, the

regimens were assumed to be therapeutically non-inferior. All non-active controls including placebo, saline, non-drug sterile diluent, or no treatment were combined into one group defined as non-active controls. A single comparator of interest was not identified, as the purpose of the review was to compare the efficacy across all the available interventions.

Outcome. The outcome of interest was first-treatment failure risk measured in the 5 to 14 days post-treatment. When the day of

treatment was defined as day 0, then outcomes measured on days 4 and 13 were within the relevant follow-up period. When the day of treatment was defined as day 1, then outcomes measured on days 5 and 14 were within the relevant follow-up period. When the outcome was measured on multiple days in the 5 to 14 day period, the results closest to 7 days post-treatment were used. The rationale was that this period is commonly used by the US Food and Drug Administration (FDA) for registra-

Table 1: Injectable antibiotic regimens reported in studies and the final regimes used in a mixed-treatment comparisons meta-analysis

Antibiotic regimen	Short name	Prespecified regimen	Abbreviation
Amoxicillin: 15 mg/kg 2 doses 48 hours apart	Amoxicillin	Yes	AMX
Amoxicillin and clavulanic acid: 7.0 and 1.75 mg/kg, respectively, once daily for 3 days	Amoxicillin/clavulanic acid (7.0/1.75 mg/kg 3 days)	No	AMXOL
Ampicillin: 6 mg/kg once	Ampicillin	Yes	.
Ceftiofur (HCl or NA not reported); 3 mg/kg once daily for 3 days	Ceftiofur (HCl or NA)	No	CEFOL1
Ceftiofur crystalline free acid: 5.0 mg CE/kg once	Ceftiofur CFA	Yes (FDA)	CCFA
Ceftiofur hydrochloride: 3-5 mg/kg once daily for 3 days	Ceftiofur HCL (MD)	Yes (FDA)	.
Ceftiofur hydrochloride: 5 mg/kg once	Ceftiofur HCl (5 mg/kg once)	No	CEFOL3
Ceftiofur sodium: 1-2 mg/kg once daily for 3 days	Ceftiofur NA (1-2 mg/kg 3 days)	No	CEFOL4
Ceftiofur sodium: 3-5 mg/kg once daily for 3 days	Ceftiofur NA (MD)	Yes (FDA)	CEF
Danofloxacin: 1.25 mg/kg or 2.5 mg/kg once	Danofloxacin (1.25 or 2.5 mg/kg once)	No	DANOF
Danofloxacin: 1.25 mg/kg once daily for 3 days	Danofloxacin	Yes	.
Enrofloxacin: 2.5 mg/kg once daily for 3 days	Enrofloxacin (2.5 mg/kg 3 days)	No	ENFOL1
Enrofloxacin: 7.5 mg/kg once or 2.5-5 mg/kg once daily for 3-5 days	Enrofloxacin	Yes	ENF
Enrofloxacin: 7.5 mg/kg once or once daily for 2 days	Enrofloxacin (7.5 mg/kg once or twice)	No	ENFOL2
Florfenicol: 15 mg/kg twice 48 hours apart	Florfenicol	Yes	FLO
Gamithromycin: 6 mg/kg once	Gamithromycin	Yes	GAM
Gentamicin sulfate: 2-5 mg/kg twice daily for 3 days	Gentamicin	Yes	.
Lincomycin hydrochloride: 5 mg/lb (2.27 mg/kg) once	Lincomycin hydrochloride	Yes	.
Marbofloxacin: 8 mg/kg once or 2 mg/kg once daily for 3 days	Marbofloxacin	Yes	MAR
No treatment: saline, non-drug, sterile diluent, placebo	Non-active control	Yes (FDA)	NAC
Oxytetracycline: 9 mg/lb (4.1 mg/kg) once or 5-10 mg/kg once	Oxytetracycline	Yes (FDA)	OXY
Penicillin: 3000 units/lb once daily for 4 days or 15 IU/kg once daily for 4 days	Penicillin	Yes (FDA)	.
Tiamulin: 15 mg/kg once daily for 3 days	Tiamulin	No	TIAOL
Tildipirosin: 4 mg/kg once	Tildipirosin	Yes	TIL
Tulathromycin: 2.5 mg/kg once	Tulathromycin	Yes (FDA)	TUL
Tylosin Injectable: 4 mg/lb (1.8 mg/kg) once	Tylosin	Yes (FDA)	.

HCl = hydrochloride; NA = sodium; CE = ceftiofur equivalents; CFA = crystalline free acid; FDA = on-label US Food and Drug Administration approved doses; MD = Multidose.

tion purposes. The definition of treatment failure, or the inverse of treatment success, was described by the investigators of the original research report. For the meta-analysis, when the success risk was defined, this was converted to failure risk.

Study design. Studies relevant to the review had to contain a concurrent control group (active comparator or placebo) and at least one of the registered antibiotic regimens listed in the protocol (Table 1). Experimental challenge trials, cluster-randomized trials, and observational studies were not considered relevant. Experimental challenge studies were not considered relevant, as the external validity of the disease model to practice can be unclear. Cluster-randomized trials were not considered because the treatments are administered to an individual pig at diagnosis with SRD and cluster-randomized studies are a design associated more commonly with prophylactic or metaphylactic antibiotic uses. Observational studies were excluded because the potential for bias due to indication is very high for such studies. Random allocation to treatment group was not used as an exclusion criterion due to evidence that this may be rare in SRD trials.

Report characteristics. Eligible studies had to be written in English and publicly available, although not necessarily open access, in conference proceedings or peer-reviewed journals.

Information sources

The information sources used were Cambridge Agricultural and Biological Index (CABI), MEDLINE, the Swine Information Library (SIL), and FDA Freedom of Information (FOI) New Animal Drug Approval (NADA) summaries for registered regimens, and the bibliographies of relevant studies and potentially relevant reviews identified during screening. The European Medicines Authority data was not searched because neither the European Public Assessment Report nor the product information provides data similar to the FDA FOI NADA summaries. The Iowa State University Web of Science interface was used to search CABI and MEDLINE for literature from 1970-2017. The rationale for this limit was that few studies of antibiotics of greatest interest would be published before 1970 and the authors' experience suggests that such studies are often very poorly reported and of little value for meta-analyses. One impact of this approach is that pre-1970 literature may

include placebo versus penicillin studies and these studies have no opportunity to be considered for the review. However, the decision was made that the benefit of finding such studies for inclusion was not considered sufficient relative to the cost needed to screen, retrieve, and extract data from them. The SIL enables access to the American Association of Swine Veterinarians Annual Meeting Proceedings (1999-2017), the International Pig Veterinary Society Congress proceedings (2000-2016), the Iowa State University Swine Diseases Conference proceedings (1996-2016), and the Allen D. Lemman Swine Conference proceedings (2007-2016). These dates were dictated by the availability of electronic versions. The FDA FOI NADA summaries were available online (<https://animaldrugatfda.fda.gov/adafda/views/#/foiDrugSummaries>).

Search

The citation searches began on October 5, 2017 and were completed on November 30, 2017 after all relevant studies had been identified and their bibliographies assessed. The CABI search results are reported in the supplementary materials (SM2: Table S1). Details about the conduct of the search such as how the SIL was searched as it doesn't have indexation, handling of duplicates, and linked references are available in the supplementary materials (SM2: Tables and Figures).

Study selection

The screening was conducted using systematic review management software (Distiller SR; Evidence Partners, Ontario, Canada). Forms for study selection and data extraction were pre-tested during the protocol drafting phase to ensure consistent interpretation of relevant studies and data by the two independent reviewers. The two reviewers (Drs O'Connor and Totton), both experienced systematic reviewers and veterinary epidemiologists, independently assessed the abstracts and titles for relevance based on the eligibility criteria. The entire article was acquired if one reviewer indicated the record might meet the inclusion criteria. The full text was then assessed for relevance by both reviewers. Four sequential questions based on the PICO elements of eligibility criteria were used to evaluate relevant studies. If a study failed a question, no further evaluation was conducted. All relevant studies were included in the systematic review. However, studies were only eligible for the meta-analysis if the

numerical outcome data could be extracted and at least one treatment arm was connected to the rest of the evidence network.

Duplication refers to multiple citations of the same publication. Duplicates were removed initially in the reference management software, then again in the systematic review management software. Linked publications, ie, the same studies reported in part or in full in different sources, were sometimes identified during the relevance screening but more commonly during data extraction.⁴ For linked publications, the more complete record was used as the citation. Reference lists from relevant reports and reviews were hand searched for additional relevant manuscripts. If these studies were published in years outside the original search range, they were still included. When disagreements arose about the relevance of the study between the two reviewers, these were resolved by discussion. It was not found necessary to consult the sponsor designate during the eligibility assessment.

Data collection process

The systematic review management software was used to extract data into pre-tested forms by two reviewers (Drs O'Connor and Totton) working independently. The unit of concern for dataset extraction was the study level if available. As investigators can vary in reporting the outcome, the order of preference for extracting the outcome dataset was as follows: an adjusted estimate of the summary effect size, an unadjusted estimate of the effect size, and the group-level frequency data. The rationale for this preference was that swine populations are clustered in pens, rooms, and barns and often across multiple sites, therefore adjusted estimates that correctly account for non-independence of observations provide the least biased estimate of the variance. Interestingly all studies reported group-level data rather than summary-level data. Investigators were not contacted when data were missing. If studies were linked, all the available information was used but the version that was the most complete was cited, which was usually the one with site-specific results.

Data items. Data items extracted related to the conduct of the study, the definition of SRD, the trial interventions, and the outcome. The detailed list of items extracted from each paper is provided in the protocol (SM1: Protocol).

Geometry of the network. Network geometry was assessed using an approach

previously proposed.⁵ The probability of an inter-species encounter (PIE) index was calculated using custom-written R script and the C-score test was performed via R package EcoSimR (version 0.1.0.).⁶ The PIE index is a continuous variable that decreases in value as unevenness increases. Values < 0.75 can be considered to reflect the limited diversity of interventions. Co-occurrence was also assessed using the C-score, which describes, based on a checkerboard analysis, if pairwise comparisons of specific treatments are preferred or avoided.⁵

Risk of bias within individual studies. The risk-of-bias form was based on the Cochrane Risk of Bias (ROB) 2.0 tool for randomized trials. However, this form was modified as follows to ensure relevance to the topic area.⁷

To assess bias due to the randomization process (ROB1), the ROB 2.0 tool provides the following signaling questions (SQ) to guide the reviewer:

SQ 1.1 - Was the allocation sequence random?

SQ 1.2 - Was the allocation sequence concealed until participants were recruited and assigned to interventions?

SQ 1.3 - Were there baseline imbalances that suggest a problem with the randomization process?

In addition to the Cochrane guidance for SQ 1.1, *yes* was indicated if the study was conducted for regulatory purposes, ie, an FDA study or if the study was conducted using Good Clinical Practice Guidelines.

Also, the response to SQ 1.2 about allocation concealment was ignored. In ROB 2.0, any study that did not report allocation concealment was automatically at high risk of bias. The response to SQ 1.2 was not considered in the overall assessment of bias due to randomization. The schema used was as follows: If the response to SQ 1.1 was *yes* or *probably yes* and the response to SQ 1.3 was *no* or *probably no*, the study was considered low risk of bias for that domain. If the response to SQ 1.1 and SQ 1.3 was *no information*, the study was considered high risk of bias for that domain. If the response to SQ 1.1 was *no* or *probably no*, the answer to SQ 1.3 was not influential and the study was considered high risk of bias. If the response to SQ 1.1 was *yes* or *probably yes* and the response to SQ 1.3 was *no information*, the study was considered to be of some concern

of bias for that domain. If the response to SQ 1.1 was *no information* and the response to SQ 1.3 was *no* or *probably no*, the study was considered to be of some concern of bias for that domain.

The rationale for this modification was that it was considered unlikely in swine production settings that caregivers would have differential preferences for groups of animals to receive a particular intervention. This modification was planned in the protocol.

Bias due to deviations from intended interventions (ROB2) refers to deviations due to care-giving or failure to complete an allocated treatment. The potential for this bias is very low in commercial settings using short-duration antibiotic treatments, so few or no deviations were assumed even in the absence of reporting on blinding of outcome assessors. No changes to the Cochrane ROB 2.0 SQs or ROB algorithm were made.

Bias due to missing outcome data (ROB3) refers to loss to follow-up, and neither the SQs nor the risk algorithm proposed by Cochrane ROB 2.0 tool were modified.

Bias in the measurement of the outcome (ROB4) refers to bias introduced due to knowledge of the intervention by outcome assessors. Even if outcome assessors were aware of the intervention or if this was unclear, the risk of bias was considered low if the definition of treatment success included an objective measure such as temperature and that a threshold for considering an animal to be pyrexia was reported.

Bias in selection of the reported results (ROB5) was also assessed. For this review, only studies that reported the results at 5 to 14 days post-treatment were included, and other studies that were potentially relevant but reported a different outcome were not included. Bias was considered possible when multiple poorly defined or undefined metrics of the outcome were used.

The risk-of-bias information was not included in the meta-analysis nor used as exclusion criteria. Instead the risk of bias was included mainly to convey to end users that substantial information about the conduct of the studies is missing, and the impact of this information on the certainty of the conclusions that can be reached.

Summary measures. The primary approach to summarizing the data was the comparative efficacy rankings. The rationale for using

these as the primary outcome is that they are a relative measure of efficacy. Given the potential for publication bias in the topic area, it is theoretically possible that all companies owning products relevant to the review are publishing the most promising studies. Therefore, the actual magnitude of effect size observed in the studies might be biased upwards. For example, companies owning products relevant to the review might have conducted several placebo-vs-active trials but presented only the one with the largest effect size. If this occurs, the effect sizes might be distorted. However, if all companies owning products relevant to the review engage in this practice, the relative comparisons should still be reasonable. Interestingly, it was previously speculated that this bias might occur; however, previous research in bovine respiratory disease did not find empirical evidence of this bias.^{1,2} For each simulation based on the probability of treatment failure, each treatment received a ranking. Lower rankings indicated a lower probability of treatment failure. All treatment regimens included in the meta-analysis received a ranking including off-label regimens, therefore, the range of rankings was 1 to 19 for each simulation. The reported data are the mean rankings and related 95% CI. Despite some reservations, the risk ratio (RR) and related 95% CI for all possible comparisons was also reported. This outcome was chosen because ease of interpretation is greater for the RR than for the odds ratio. The extracted data were organized such that an event (treatment failure) was an adverse outcome. Drugs with greater efficacy had lower event percentages. This approach was used because some studies reported success percentages (ie, failure to retreat), while others reported failure percentages (ie, retreatments). The data items, randomization to treatment arm (reported/not reported), outcome assessor blinding (reported/not reported), and pharmaceutical company sponsorship of treatment were also extracted and used for the assessment of methodological heterogeneity. When the RR is < 1, this implies that the drug in the numerator has a lower treatment failure risk than the drug in the denominator and is, therefore, more effective at treating SRD. When the RR is > 1, this implies that the drug in the numerator has a higher treatment failure risk than the drug in the denominator and is less effective at treating SRD. The baseline risk used to convert the odds ratios to the RR was obtained by using the distribution of the placebo group. Using these data,

the prior distribution of the log odds ratio (\mathcal{N} [mean (SD)]) was reported as $\mathcal{N}(-0.9633 [0.7344])$.

Planned method of statistical analysis

The proposed method has been previously described in detail.⁸ Briefly:

$$r_{jk} \sim \text{Bin}(p_{jk}, n_{jk}), \theta_{jk} = \text{logit}(p_{jk})$$

and

$$\mu_{jb}, \text{ if } k = b; b = A, B, C, \dots$$
$$\theta_{jk} = \{\mu_{jb} + \delta_{jbb}, \text{ if } k > b; b = A, B, C, \dots$$

where p_{jk} is the probability of the event in trial j under treatment k and δ_{jbb} is the trial-specific log odds ratio of treatment k relative to the corresponding baseline treatment b in trial j . The trial-specific treatment effects are distributed as:

$$\delta_{jbb} \sim \mathcal{N}(d_{bb}, \sigma^2_{bb}),$$

with priors

$$d_{bb} \sim \mathcal{N}(0 [10000]),$$

and under the homogeneous variance assumption that $\sigma^2_{bb} = \sigma^2$, where $\sigma \sim U(0, 5)$.

Handling of multi-arm trials. The covariance between δ_{jAB} and δ_{jAC} was assumed to be $\sigma^2/2$ for multi-arm trials.^{9,10}

Selection of prior distributions in Bayesian analysis. The prior distributions were originally based on the previously reported approach.^{10,11} In prior similar models, $\sigma \sim U(0, 2)$ and $\sigma \sim U(0, 5)$ were assessed, and $\sigma \sim U(0, 5)$ was preferred. That assessment was repeated and the same prior used in a previous model was retained.^{1,2}

Implementation and output. All posterior samples were generated using Markov Chain Monte Carlo (MCMC) simulation implemented using Just Another Gibbs Sampler (JAGS) software (version 3.4.0). All statistical analyses were performed using R software (version 3.2.1).¹² The model was fitted using JAGS, an MCMC sampler, by calling JAGS from R through the rjags package.¹³ Three chains were simulated, and the convergence was assessed using Gelman-Rubin diagnostics. Five thousand “burn-in” iterations were discarded and inferences were based on an additional 10,000 iterations. The model output included all possible pairwise comparisons using log odds ratios for inconsistency assessment, RRs for comparative efficacy reporting, and the treatment failure rankings for comparative efficacy reporting.

Assessment of model fit. The fit of the model was assessed based on the log odds ratio by examining the residual deviance between the predicted values from the network meta-analysis model and the observed value for each study.⁸ The deviance to the number of data points were compared and a ratio of one was vaguely equated for these two numbers as a good fit. When this ratio seemed subjectively large, the output was searched for signs of potential issues, including unrealistic outcomes such as rankings with no variation or very large credible intervals. If these were noted, treatment groups were combined or studies that appeared to be associated with the poor fit were removed and the reduced model was re-evaluated. Trace plots for the treatment effects were monitored to identify major issues with convergence.

Assessment of inconsistency. The back-calculation method was used to assess the consistency assumption.⁸ The inconsistency evaluation did not rely only on the P values. The estimates from the direct and indirect models were also compared and the standard deviation of each estimate was considered. Comparisons for which the direct and indirect estimates had different signs were further evaluated and discussed.

Risk-of-bias assessment. The potential systematic biases resulting from the methodological variables, blinding, randomization, and sponsorship were described using indicator variables. The effect size and related 95% CI were reported. The impact of small-study effects was not assessed, as the potential to detect asymmetry was limited by the number of valid pairs available and any funnel plots would be too sparse to be meaningfully interpreted.

Additional analyses

No additional analyses were conducted.

Results and discussion

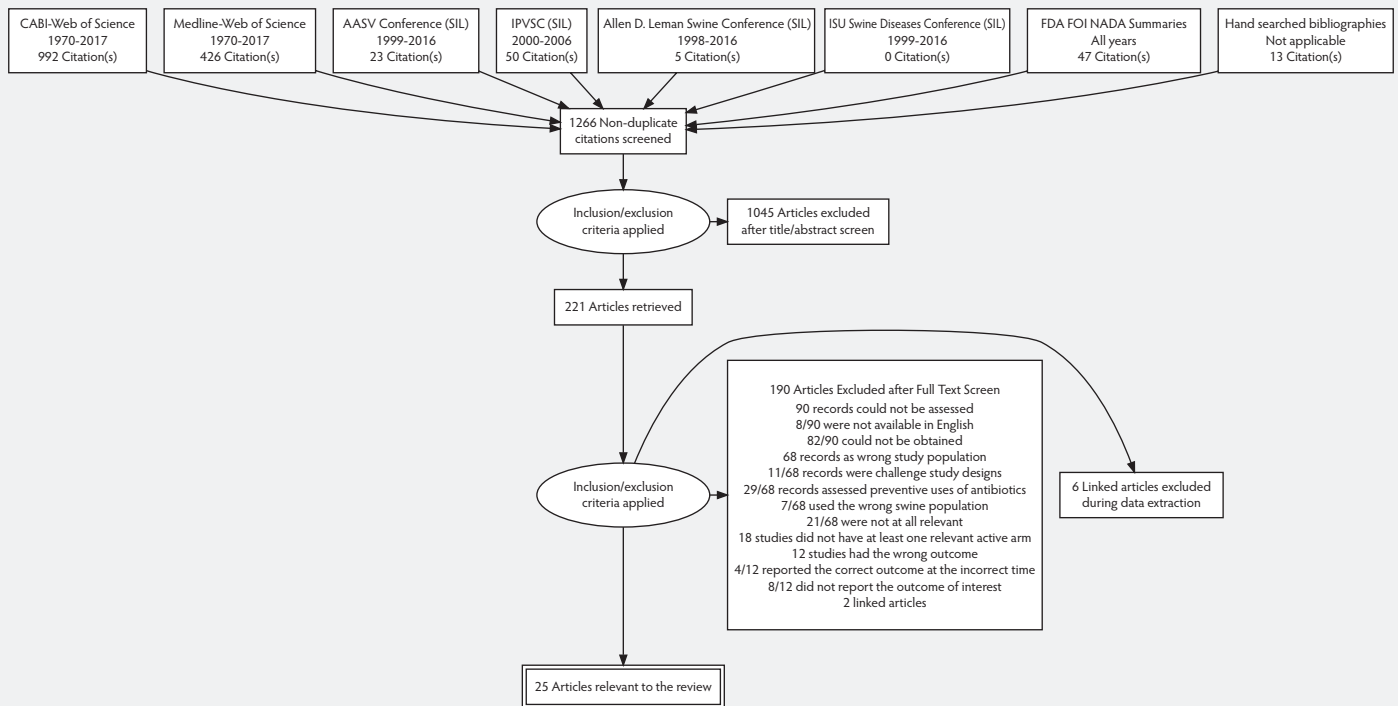
Study selection

The flow chart for records retrieved for the review is reported in Figure 1. There were 1266 records screened, and 25 relevant records describing 41 relevant studies were identified. Thirty-four of the 41 relevant studies could be included in the meta-analysis. Of 1266 records screened, 221 were retrieved for full-text evaluation. One hundred ninety of the 221 full texts were

excluded (see SM2: Table S2). This included two sets of linked publications, so exclusion reasons are available for 188 records. Thirty-one records were determined to contain studies relevant to the review. These are listed as 25 relevant articles in Figure 1 due to 6 linked publications.¹⁴⁻³⁸ Those 25 records contained 41 unique studies considered relevant to the review. Four unique studies from 3 records were excluded from the meta-analysis because, although meeting all the relevance criteria, they did not report the outcome data.^{16,29,31} One unique study compared danofloxacin (1.25 mg/kg once daily for 3 days) to benzyl penicillin with dihydrostreptomycin. This was the sole study that evaluated these treatments, and therefore there was no link to the remaining evidence network. Consequently, this study was also excluded from the meta-analysis.³⁶

During the model assessment, two unique studies in the same manuscript were removed from the network meta-analysis because the results were inconsistent with the network.³⁵ These 2 studies reported results for treatment failure where arm 1 was a non-active control (Farm A: 29 of 29; Farm B: 30 of 30), arm 2 was ceftiofur hydrochloride (3 mg/kg once daily for 3 days; Farm A: 8 of 30; Farm B: 2 of 30), and arm 3 was ceftiofur hydrochloride (5 mg/kg once daily for 3 days; Farm A: 7 of 30; Farm B: 0 of 30). As these doses were both on the same label, this represented two arms of multi-dose ceftiofur hydrochloride. This extremely high level of efficacy was unusual for ceftiofur regimens in the dataset. When these data were included in the model, the model was unstable. For example, multi-dose ceftiofur hydrochloride was ranked the highest with zero rank variation, yet the next nearest ceftiofur regimen was nine regimens lower. To explore the issue, the impact of creating a single category of multi-dose ceftiofur (3-5 mg/kg once daily for 3 days), which ignored the sodium or hydrochloride, was evaluated. However, this approach did not solve the issue. For example, several RR estimates were greater than 1000 indicating a major issue with model fit. Finally, the impact of excluding the 2 studies was assessed, which resolved the issue and the resulting model is reported here. Exclusion of this manuscript does not represent a deviation from the protocol, as consistency assessment is a required aspect of the meta-analysis.⁸ Therefore, a total of 7 of the 41 relevant studies were excluded and the resulting 34 studies were used in the final reported meta-analysis.

Figure 1: The PRISMA flowchart describing the flow of literature through the review. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses; CABI = Cambridge Agricultural and Biological Index; AASV = American Association of Swine Veterinarians; SIL = Swine Information Library; IPVSC = International Pig Veterinary Society Congress; ISU = Iowa State University; FDA FOI NADA = Food and Drug Administration's Freedom of Information New Animal Drug Application.



Presentation of network structure

The final evidence network used in the meta-analysis represented 34 studies and 73 arms. Some arms used treatment regimens that were off-label. These off-label arms were included in the network meta-analysis because they contributed data for estimation of regimens that were of interest. These non-protocol regimens are listed in Table 1. Information about the number of arms and the reporting of blinding and randomization is presented in Table 2.

Summary of network geometry

The geometry of the network was sparse, with most regimens being assessed only once. The network would be considered quite diverse as measured by the PIE index (0.79). A PIE index > 0.75 often indicates the network was quite diverse.⁵ This result is consistent with the visual examination of the network which includes a large number of treatments (Figure 2). However, this analysis can only consider the treatments included in the analysis, the diversity of which is bolstered by treatments not relevant to the review. Further, no studies were found for 5 of the 17 antibiotic regimens identified as relevant to the review in the protocol (Table 1).

Therefore, the real diversity was considered to be lower than the PIE suggested, as it includes non-relevant regimens. However, the regimens for which data were available were likely of greatest interest to producers and those regimens for which no reports were found are likely of less interest. The C-score was 10.11 and the C-score test had a large *P* value (*P* = .55). These metrics seek to evaluate how random encounters occur in ecological populations and, when used in a network meta-analysis, they assess if there are particular pairwise comparisons that occur more or less often than expected by random encounter. Although the results of hypothesis testing suggest little evidence of non-random pairs, visual examination of the network does suggest pairwise comparisons used in the network are not random, with a strong preference for comparisons with placebo-controlled trial arms.

Study characteristics and study results

The descriptive information for the studies included in the meta-analysis is provided in Table 2. As the population definition was quite narrow, that information is not presented due to space limitations. The definitions of

SRD (SM2: Table S3) and treatment success (SM2: Table S4) are presented in the supplementary materials. Studies varied in how success or failure was defined. Interestingly most studies tended to report metrics of success, and this differs from a review of bovine respiratory disease where most studies tended to define the outcome based on failure, ie, first-treatment failure risk.

Individual risk of bias

For each study eligible for the review, the risk-of-bias judgment for each bias domain is presented in Table 3. The impact of modification on the risk of bias due to allocation can be seen. As no studies reported using allocation concealment, the original schema would have resulted in all studies being classified as high risk of bias for this domain. As the Cochrane ROB tool assigns the highest risk of bias across the domains to the report, then all reports would have been given an overall high risk of bias. Based on the change, some studies, generally those conducted for regulatory purposes and those reporting using Good Clinical Practices, are at low risk of bias. However, because the Cochrane ROB tool was modified, an overall ROB was not explicitly provided.

Table 2: Characteristics of relevant studies included in the meta-analyses

Reference number	Year	Country	Arm 1 Regimen	Arm 1 Events*	Arm 1 Total	Arm 2 Regimen	Arm 2 Events*	Arm 2 Total	Arm 3 Regimen	Arm 3 Events*	Arm 3 Total	Random	Blinded
14	1996	United States	Enrofloxacin (7.5 mg/kg once)	33	49	Non-active control	49	49	NA	NA	NA	No	Yes
14	1996	United States	Enrofloxacin (7.5 mg/kg once)	4	39	Non-active control	33	36	NA	NA	NA	No	Yes
15	2010	United States	Enrofloxacin (7.5 mg/kg once)	29	75	Non-active control	55	75	NA	NA	NA	Yes	Yes
15	2010	United States	Enrofloxacin (7.5 mg/kg once)	6	75	Non-active control	50	75	NA	NA	NA	Yes	Yes
17	NR	United States	Ceftiofur CFA	175	233	Non-active control	195	237	NA	NA	NA	Yes	Yes
18	NR	France, Germany	Florfenicol	14	109	Oxytetracycline (20 mg/kg once)	31	110	NA	NA	NA	No	No
19	NR	Denmark, France, Germany	Amoxicillin	4	77	Ceftiofur CFA	3	77	NA	NA	NA	Yes	Yes
20	NR	Italy	Enrofloxacin (2.5 mg/kg for 3 days)	30	67	Enrofloxacin (5 mg/kg for 3 days)	10	48	NA	NA	NA	No	Yes
21	2007	Spain	Florfenicol	8	31	Amoxicillin	12	29	NA	NA	NA	No	Yes
22	NR	Slovenia	Amoxicillin and clavulanic acid (7.0 and 1.75 mg/kg, respectively, on days 0, 1, and 2)	21	34	Tulathromycin	22	35	NA	NA	NA	Yes	Yes
22	NR	Germany	Amoxicillin and clavulanic acid (7.0 and 1.75 mg/kg, respectively, on days 0, 1, and 2)	5	26	Tulathromycin	2	19	NA	NA	NA	Yes	Yes
23	NR	Spain	Florfenicol	1	25	Ceftiofur (unclear if HCl or Sodium)	4	25	NA	NA	NA	Yes	Yes
24	NR	Germany	Amoxicillin	23	102	Enrofloxacin (7.5 mg/kg once or twice)	14	96	NA	NA	NA	Yes	Yes

Table 2 cont'd: Characteristics of relevant studies included in the meta-analyses

Reference number	Year	Country	Arm 1		Arm 2		Arm 3		Blinded				
			Regimen	Events*	Total	Regimen	Events*	Total		Regimen	Events*	Total	
24	NR	Denmark, Germany	Enrofloxacin (7.5 mg/kg once or twice)	2	85	Florfenicol	6	84	NA	NA	NA	Yes	Yes
25	NR	Germany	Tildipirosin	17	254	Tulathromycin	20	254	NA	NA	NA	Yes	Yes
26	NR	Germany	Tildipirosin	6	96	Tulathromycin	6	96	NA	NA	NA	Yes	Yes
27	NR	Japan	Gamithromycin	7	42	Danofloxacin (1.25 mg/kg or 2.5 mg/kg)	6	21	NA	NA	NA	No	Yes
27	NR	Germany	Gamithromycin	5	15	Tildipirosin	11	152	NA	NA	NA	No	Yes
30	NR	France, United States	Ceftiofur HCl (5 mg/kg once)	140	152	Non-active control	139	152	NA	NA	NA	No	Yes
32	NR	United States	Tulathromycin	10	48	Non-active control	14	48	NA	NA	NA	Yes	Yes
32	NR	United States	Tulathromycin	14	44	Non-active control	23	44	Ceftiofur Sodium (3 mg/kg for 3 days)	9	44	Yes	Yes
32	NR	United States	Tulathromycin	17	48	Non-active control	35	49	Ceftiofur Sodium (3 mg/kg for 3 days)	29	47	Yes	Yes
32	NR	United States	Tulathromycin	9	48	Non-active control	29	48	Ceftiofur Sodium (3 mg/kg for 3 days)	11	48	Yes	Yes
32	NR	United States	Tulathromycin	9	48	Non-active control	25	48	Ceftiofur Sodium (3 mg/kg for 3 days)	20	48	Yes	Yes
32	NR	Canada	Tulathromycin	18	30	Non-active control	17	30	NA	NA	NA	Yes	Yes
32	NR	France	Tulathromycin	4	40	Florfenicol	1	20	NA	NA	NA	Yes	Yes

Table 2 cont'd: Characteristics of relevant studies included in the meta-analyses

Reference number	Year	Country	Arm 1		Arm 2		Arm 3		Blinded				
			Regimen	Events*	Total	Regimen	Events*	Total		Regimen	Events*	Total	
32	NR	Germany	Tulathromycin	8	78	Tiamulin	7	39	NA	NA	Yes	Yes	
32	NR	The Netherlands	Tulathromycin	13	44	Tiamulin	13	22	NA	NA	Yes	Yes	
32	NR	United Kingdom	Tulathromycin	17	41	Tiamulin	13	20	NA	NA	Yes	Yes	
32	NR	United Kingdom	Tulathromycin	1	37	Tiamulin	3	16	NA	NA	Yes	Yes	
33	NR	Canada	Florfenicol	19	71	Non-active control	25	42	NA	NA	Yes	Yes	
34	2009	United States	Tildipirosin	155	434	Non-active control	261	434	Tulathromycin	155	535	No	Yes
37	1992	Korea	Ceftiofur Sodium (3 mg/kg for 3 days)	6	30	Ceftiofur Sodium (2 mg/kg for 3 days)	35	60	NA	NA	No	No	
38	2013-2014	Germany, Hungary	Marbofloxacin (8 mg/kg once)	22	121	Enrofloxacin (7.5 mg/kg once or twice)	22	118	NA	NA	Yes	Yes	

*The event is first-treatment failure.

NA = not applicable; NR = not reported; CFA = crystalline free acid; HCl = hydrochloride.

Individual study results

The individual results for studies included in the final meta-analysis are reported in Table 2.

Synthesis of results

The final meta-analysis included results from 34 of the 41 relevant studies. For the final model, the deviance was 80, while the number of data points was 73, suggesting reasonable fit of the model as the deviance should be close to the number of data points. Convergence of the Bayesian model was within normal limits based on visual inspection of trace plots. The results of the model are presented several ways. The estimates of mean rank are provided in Figure 3. This plot only includes label-dose regimens, ie, those identified in the protocol *a priori*. The rankings for all regimens used in the meta-analysis, including off-label regimens, are provided in Table 4. Off-label regimens were excluded from Figure 3 to avoid the perception of promoting the use of off-label regimens. However, for transparency of the results, the ranks for all regimens in the meta-analysis are presented in the tables, knowing that most people will rely upon the figures for the results. Lower rankings are associated with fewer treatment failures. Not surprisingly, there is considerable overlap of confidence intervals of the rankings. This reflects the small number of studies informing some ranking estimates and the variation in observed results reported in the primary research. For example, marbofloxacin had a high level of efficacy. However, without more publicly available studies, the result remains a single, potentially random observation, and therefore the point estimate is tempered by the measures of uncertainty. Table 4 also shows that the other ceftiofur regimens were clustered together with mid-level rankings at best, which supports the decision to remove the inconsistent study.³⁵ The distribution of probability of treatment response for the label-dose protocols are presented in the supplementary materials (SM2: Table S5 and Figure S1). The top 4 model-estimated SRD treatments based on the mean rank were the enrofloxacin (7.5 mg/kg once or 2.5-5 mg/kg once daily for 3-5 days; n = 5; rank = 2; 95% CI, 1-4), gamithromycin (6 mg/kg once; n = 2; rank = 5; 95% CI, 1-14), marbofloxacin (8 mg/kg once; n = 1; rank = 6; 95% CI, 1-16) and florfenicol (15 mg/kg twice 48 hours apart; n = 6; rank = 7; 95% CI, 3-13).

Figure 2: The network of treatment arms used in the mixed-treatment comparison meta-analysis. The size of the dot is a relative indicator of the number of arms and the width of the lines is a relative indicator of the number of indirect comparisons. The number of study arms reporting the injectable antibiotic regimen is presented in parentheses. Antibiotic regimen abbreviation definitions are listed in Table 1.

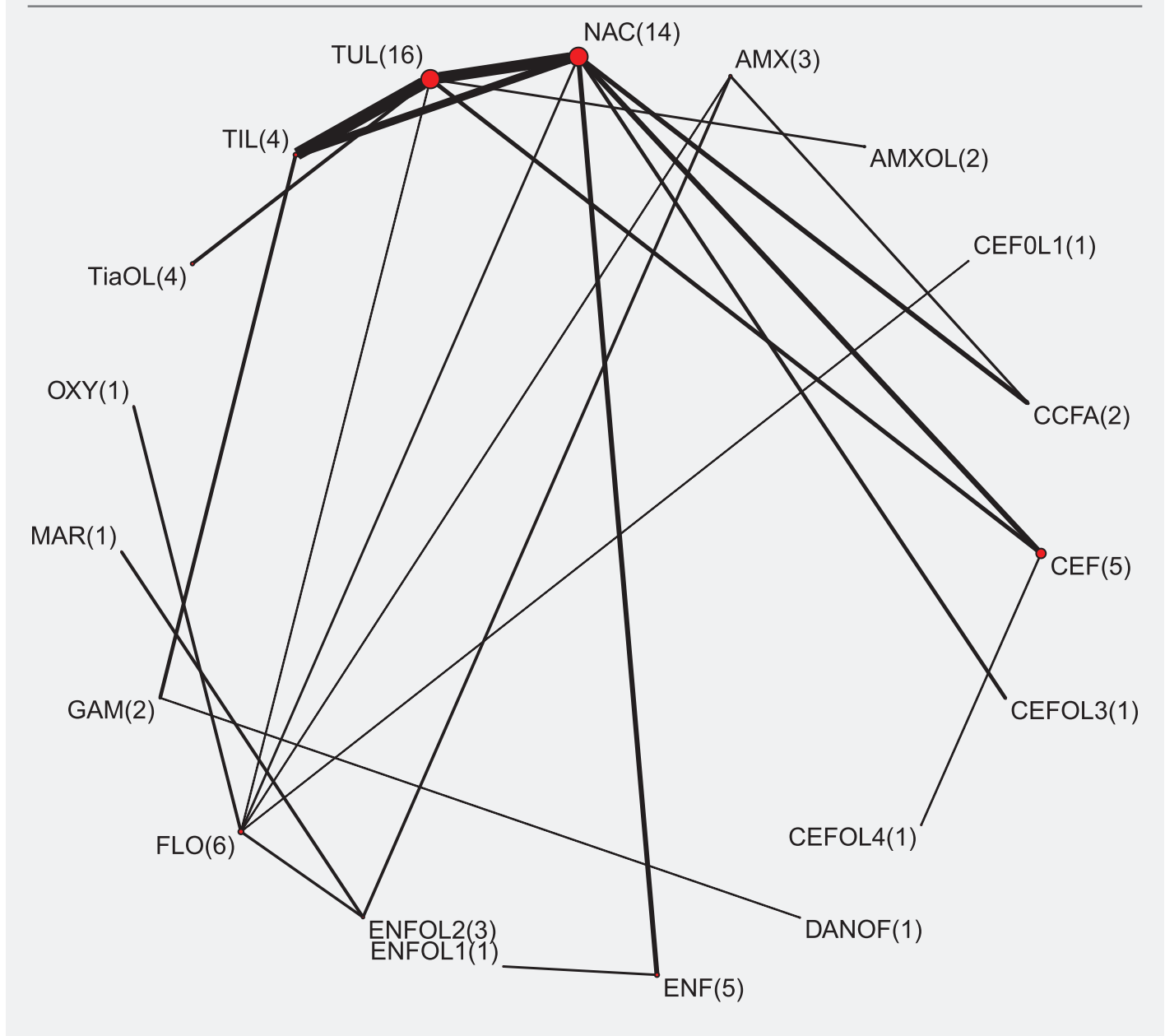


Table 5 provides the comparative RRs for only the label-dose regimens, ie, those identified in the protocol *a priori*. The data are organized such that the event is the risk of treatment failure for the treatment in the row divided by the risk of treatment failure in the column. For example, in the first row of the table, all the RR estimates are greater than one, meaning that the risk of treatment failure was higher in the non-active control groups when compared to all other antibiotics. The upper right-hand quadrant reports the estimated RR and the lower

quadrant reports the 95% CI. The risk of treatment failure was 16-fold higher for untreated animals compared to enrofloxacin (RR = 16; 95% CI, 4-48). Only 3 antibiotics did not have a credible interval that excluded one when compared to non-active control: oxytetracycline, amoxicillin, and marbofloxacin. Given the point estimate and mean rank for marbofloxacin, this finding is likely a function of identification of only one publicly available study reporting the efficacy of marbofloxacin.

Exploration of inconsistency

The consistency between the direct and indirect sources of evidence of the final model using 34 trials and 73 arms is reported in Table 6. In this model, no evidence of inconsistency was found between the direct and indirect estimates. However, this should not be interpreted as proof that inconsistency does not exist. The small number of studies available means that the precision of direct estimates is low (ie, wide credible intervals) making it difficult to detect differences in direct and indirect estimates.

Table 3: Risk of Bias for all 25 relevant studies identified in the systematic review⁷

Reference number	SQ.1.1*	SQ.1.2†	SQ.1.3‡	Original ROB1§	Modified ROB1¶	ROB2**	ROB3††	ROB4‡‡	ROB5§§
14	Probably yes	Probably no	Probably no	High	Low	Low	Low	Low	Low
15	Probably yes	Probably no	Probably no	High	Low	Low	Low	Low	Low
16	Probably yes	Probably no	Probably no	High	Low	Low	Concerns	Low	Low
17	Probably yes	Probably no	Probably no	High	Low	Low	Low	Low	Low
18	No information	Probably no	No information	High	High	Low	Concerns	Low	Concerns
19	Probably yes	Probably no	No information	High	Concerns	Low	Low	Low	Low
20	No information	Probably no	No information	High	High	Low	Low	High	High
21	No information	Probably no	No information	High	High	Low	Concerns	Low	Concerns
22	No information	Probably no	No information	High	High	Low	High	Low	Concerns
23	No information	Probably no	Probably no	High	Concerns	Low	Concerns	Low	Concerns
24	Probably yes	Probably no	No information	High	Concerns	Low	Low	Low	Low
25	Probably yes	Probably no	Probably no	High	Low	Low	Concerns	Low	Low
26	No information	Probably no	No	High	Concerns	Low	Concerns	Low	Concerns
27	No information	Probably no	No information	High	High	Low	Concerns	Low	Concerns
28	No information	Probably no	No information	High	High	Low	Low	Concerns	Concerns
29	No information	Probably no	No information	High	High	Low	Concerns	Low	Concerns
30	No information	Probably no	No information	High	High	Low	Low	Low	Concerns
31	No information	Probably no	No information	High	High	Low	Concerns	Low	Concerns
32	No information	Probably no	No information	High	High	Low	Low	Low	Concerns
33	Probably no	Probably no	No information	High	High	Concerns	Concerns	Low	Concerns
34	No information	Probably no	No information	High	High	Low	Concerns	Low	Concerns
35	No information	Probably no	No information	High	High	Low	Low	Low	Concerns
36	No information	Probably no	No	High	Concerns	Low	Concerns	Low	Concerns
37	No information	Probably no	No information	High	High	Low	High	Concerns	Concerns
38	Probably yes	Probably yes	No	Low	Low	Low	Low	Low	Low

* Was the allocation sequence random?

† Was the allocation sequence concealed until participants were recruited and assigned to interventions?

‡ Were there baseline imbalances that suggest a problem with the randomization process?

§ Risk of bias due to randomization process.

¶ In ROB 2.0, any study that did not report allocation concealment was automatically at high risk of bias, however this item was not considered in the overall assessment of bias due to randomization.

** Risk of bias due to deviations from intended interventions.

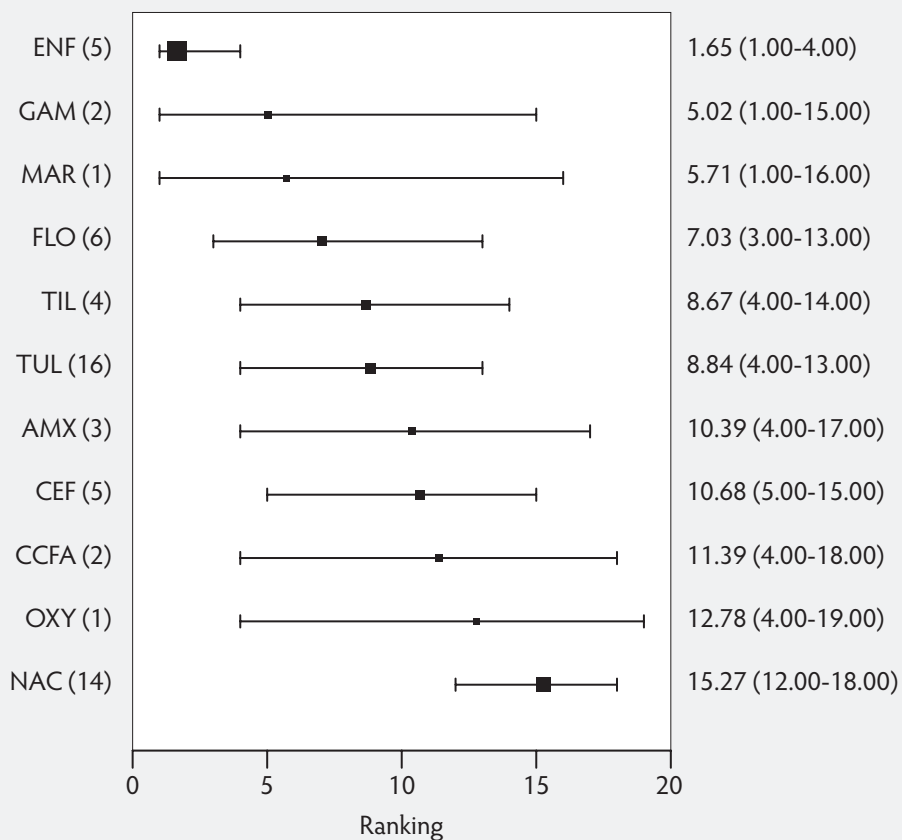
†† Risk of bias due to missing outcome data.

‡‡ Risk of bias in the measurement of the outcome.

§§ Risk of bias in selection of the reported results.

SQ = signaling question; ROB = risk of bias.

Figure 3: The ranking plot of relevant treatments. A ranking of 1 has the lowest treatment failure risk and 19 has the highest treatment failure risk. Ranking means (2.5 % lower limit of CI, 97.5% upper limit of CI) are reported for registered antibiotic regimens only. The number of study arms are presented in parentheses for each injectable antibiotic regimen reported. Antibiotic regimen abbreviation definitions are listed in Table 1.



Assessing sources of systematic bias

The beta for the sponsorship indicator variable was -0.08 (95% CI, -1.39 to 1.32), while $\beta_{\text{randomization}} = -4.27$ (95% CI, -18.59 to 10), and $\beta_{\text{blinding}} = -1.13$ (95% CI, -4.47 to 1.14). These results do not suggest systematic bias in either direction thus they were not included in the final network meta-analysis model.

Risk of bias across studies

Risk of bias across studies, such as looking for evidence of small-studies effect, was not assessed because the number of individual studies available for assessment within each treatment and pairwise comparison was low.

Limitations

The major limitation of this review is the paucity of data available for inclusion in the review. Although SRD is an important disease, it is surprising that only 41 publicly available studies could be identified

for inclusion in the review and data from only 34 studies could be included in the meta-analysis. If company websites had been included as a source of evidence, more studies might have been identified. Such sites were not included because they are not a time-stamped source and, therefore, not a reproducible source of data. After a review is published, relevant studies can be added to or removed from company websites without traceable documentation. This is not possible with conference proceedings and journals indexed in the SIL or CABI. Another aspect of the scientific literature in this body of work that should be addressed is the poor reporting associated with conference proceedings. As reported previously, many studies in swine production are not published in peer-reviewed journals.³⁹ Therefore, the studies in conference proceedings are a vital resource for practitioners and research synthesis. Further, conference proceedings are not subjected to peer review and authors

are not required to indicate if the findings presented are the final results, which has the potential to increase favorable findings.

Another possible concern is the potential omission of antibiotic regimens of interest. A *post hoc* evaluation by the sponsor designate of possible SRD antibiotics did identify several registered antibiotic regimens in Europe that were not included in the protocol. For completeness, we re-assessed if studies excluded at level 2, because they were considered to have not used a relevant regimen, used these European-registered regimens. One study featured a treatment arm with oxytetracycline given at a dose of 20 mg/kg.⁴⁰ If the pigs were still sick 48 h after the first injection, they were given a second injection at the same dose. Injecting twice at this dose is not a registered use in the United States. The results for this arm were presented without distinguishing which pigs received 1 vs 2 injections and, therefore, this study would not have been eligible for the review. A second study included one treatment arm with amoxicillin at 7 mg/kg for 3 or 5 days (treatment was only given for 5 days if pigs were still sick at that point).⁴¹ The outcome reported was cure risk by day 5. The other treatment arm received marbofloxacin at 2mg/kg once daily for 3 to 5 days rather than 3 days, which was the regimen of interest in the protocol. The combined registered (2mg/kg once daily for 3 days) and unregistered (2mg/kg once daily for 5 days) marbofloxacin dose regimen was the rationale for exclusion. The amoxicillin regimen was not identified *a priori* as a regimen of interest, although it is registered in Europe. If either regimen had been of interest, the results of the study could not have been included in the meta-analysis because neither treatment arm linked to the rest of the evidence network, ie, both arms were unique treatment regimens. As these are post-hoc regimens introduced for discussion and transparency, these studies are not included in the PRISMA diagram (Figure 1).

Another possible concern is the impact of the funding source on the meta-analysis. The highest-ranked product found by the review is owned by the sponsoring company. However, the data informing the review are publicly available data and are verifiable even though the company likely has additional data that could further narrow the 95% CI. Therefore, the authors propose that others using the same criteria would reach the same conclusion. To further address this concern several steps were taken: 1) a time-stamped *a priori*

Table 4: Mean ranking for treatment efficacy for antibiotic regimens for SRD based on mixed-treatment comparison meta-analysis.

Treatment arm	Ranking,* mean (SD)	95% Credible Interval and median rank		
		2.50%	50%	97.5%
Enrofloxacin	1.65 (1.01)	1	1	4
Gamithromycin	4.82 (3.53)	1	4	14
Enrofloxacin (7.5 mg/kg once or twice)	5.34 (3.15)	1	5	13
Enrofloxacin (2.5 mg/kg 3 days)	5.45 (3.73)	1	4	15
Marbofloxacin	5.76 (4.27)	1	4	16
Florfenicol	7.06 (2.76)	3	7	13
Danofloxacin (1.25 or 2.5 mg/kg once)	8.42 (5.45)	1	7	19
Tildipirosin	8.68 (2.92)	4	9	14
Tulathromycin	8.83 (2.32)	4	9	13
Amoxicillin	10.44 (3.69)	4	11	17
Amoxicillin/clavulanic acid (7.0/1.75 mg/kg 3 days)	10.45 (4.09)	3	11	18
Ceftiofur (MD)	10.69 (2.77)	5	11	15
Ceftiofur CFA	11.41 (3.53)	4	12	17
Oxytetracycline	12.80 (4.26)	4	14	19
Ceftiofur HCl (5 mg/kg once)	14.84 (3.55)	5	16	19
Ceftiofur (HCl or NA)	15.07 (4.75)	3	17	19
Non-active control	15.27 (1.59)	12	15	18
Tiamulin	15.44 (2.43)	10	16	19
Ceftiofur NA (1-2 mg/kg 3 days)	17.57 (2.31)	11	18	19

* A ranking of 1 has the lowest treatment failure risk and 19 has the highest treatment failure risk. Rankings are reported for all regimens included in the meta-analysis.

MD = Multidose; CFA = crystalline free acid; HCl = hydrochloride; NA = sodium.

protocol was created and followed with no deviations from the protocol, 2) the role of the sponsor designate was transparently reported and documented, and 3) once the protocol was time-stamped the sponsor designate was not responsible for the steps of the review from the search to the first draft of the full manuscript. Once the first draft was written, no further analyses were conducted, and the sponsor designate was only able to contribute to the interpretation and discussion.

It is important to recognize that a systematic review is neither a formal guideline for clinical use nor a recommendation for use. Inference is limited to the review question, which was comparative efficacy, whereas guidelines for clinical use should consider multiple factors. Comparative efficacy is only one dimension that should be considered when selecting an antibiotic. Other dimensions should include the spectrum (broad or narrow) of antibiotic, the sensitivity and speci-

ficity of the diagnosis of SRD, the organism likely to be involved based on the veterinarian's knowledge of the farm where the animals are raised, and guidelines from leading agencies about antibiotic stewardship in swine production.

Implications

- The results of network meta-analysis can provide information about the comparative efficacy of antibiotics when primary studies of active-to-active trials are missing. This gives producers and veterinarians information that might otherwise not be available.
- The network used was reasonably small due to an absence of publicly indexed data; however, the estimates suggest that the top 4 model-estimated SRD treatments based on the mean rank were enrofloxacin (7.5 mg/kg once or 2.5-5 mg/kg once daily for 3-5 days;

n = 5; rank = 2; 95% CI, 1-4), gamithromycin (6 mg/kg once, n = 2; rank = 5; 95% CI, 1-14), marbofloxacin (8 mg/kg once, n = 1; rank = 6; 95% CI, 1-16), and florfenicol (15 mg/kg twice 48 hours apart, n = 6; rank = 7; 95% CI, 3-13).

- Producers would have greater confidence in the comparable efficacy of products available if more, better-reported trial results were available in publicly indexed locations.
- With respect to antibiotic choices, comparative efficacy is only one metric that should be considered when selecting an antibiotic. Other metrics should include the antibiotic spectrum (broad or narrow), the organism likely to be involved based on the veterinarian's knowledge of the system the animals are raised in, and guidelines from leading agencies about appropriate antibiotic stewardship in

Table 5: Risk ratio of all possible comparisons within the evidence network. The upper right-hand quadrant represents the estimated risk ratio and the lower quadrant represents the 95% CI. Risk ratios are reported for registered antibiotic regimens only.

NAC	2.46	1.92	1.88	16.46	3.53	8.86	9.42	1.95	2.54	2.30
(0.65-8.01)	AMX	1.04	1.16	10.15	1.76	5.32	3.89	0.99	1.55	1.40
(0.69-5.32)	(0.22-3)	CCFA	1.28	11.07	2.24	5.92	5.37	1.24	1.71	1.55
(1-3.65)	(0.21-3.45)	(0.31-3.4)	CEF	9.45	2.03	4.94	5.40	1.13	1.44	1.30
(4.17-43.18)	(1.54-37.44)	(2.1-36.28)	(2.59-26.95)	ENF	0.27	0.67	0.67	0.15	0.20	0.18
(1.09-9.96)	(0.52-4.45)	(0.49-6.94)	(0.52-5.92)	(0.05-0.82)	FLO	3.26	2.55	0.57	0.96	0.87
(1.02-40.76)	(0.34-27.1)	(0.46-28.95)	(0.54-22.05)	(0.05-3.1)	(0.25-15.78)	GAM	3.67	0.56	0.59	0.60
(0.77-46.01)	(0.49-15.93)	(0.41-26.91)	(0.37-26.55)	(0.04-3.29)	(0.28-11.47)	MAR	MAR	0.56	0.87	0.79
(0.39-7.36)	(0.15-3.44)	(0.16-4.7)	(0.17-4.3)	(0.02-0.58)	(0.14-1.56)	(0.06-13.97)	(0.03-2.35)	OXY	2.35	2.11
(1.07-5.75)	(0.26-4.97)	(0.36-4.99)	(0.52-3.38)	(0.04-0.53)	(0.2-2.74)	(0.02-2.53)	(0.05-3.64)	(0.29-8.57)	TIL	1.02
(1.24-4)	(0.28-4.06)	(0.4-3.92)	(0.65-2.33)	(0.05-0.44)	(0.22-2.13)	(0.08-1.87)	(0.05-3.17)	(0.3-6.98)	(0.46-1.92)	TUL

Antibiotic regimen abbreviation definitions are listed in Table 1.

swine production.

Acknowledgments

Authorship roles

Dr O'Connor developed the review protocol, coordinated the project team, conducted relevance screening, extracted data, conducted the data analysis, interpreted the results, and wrote the first manuscript draft. Dr Totton assisted with development of the protocol, conducted relevance screening, extracted data, provided guidance for the interpretation of results, commented on manuscript drafts, and approved the final manuscript version. Dr Shane conceived of the project question and the eligibility criteria, assisted with identifying relevant information sources, assisted with designing the terms used in the search strategy, approved the review protocol, and contributed to the interpretation of the results and conclusions. Dr Shane did not participate in relevance screening of retrieved records, extraction of data, or conduct of the data analysis.

Publication declaration

The authors declare that this is a full and accurate description of the project and no important information or analyses are omitted.

Sponsorship

This study was funded by Bayer Animal Health. The sponsor and sponsor designate had a role in developing the protocol to ensure that the review studied the target swine populations, interventions, outcomes, and study designs of interest. It was determined *a priori* (SM1: Protocol) that during the review process, if needed, the sponsor designate would provide feedback about potentially relevant studies only when the 2 main reviewers were in conflict about eligibility. The sponsor designate was otherwise not involved in eligibility assessment of citations retrieved by the search, data extraction, or conduct of the analysis. The first draft of the results was provided for the sponsor designate's interpretation of the results and the discussion. It was decided *a priori* (SM1: Protocol) that the sponsor had a role in developing the protocol, providing feedback on the draft of the discussion and conclusions, and, consistent with standards for authorship, should be listed as a co-author on any publications and conflicts of interest noted.

Conflict of interest

Drs O'Connor and Totton were funded by Bayer Animal Health for the conduct of the review. Dr Shane is the sponsor designate and employed by Bayer Animal Health.

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.

Table 6: Results of the indirect comparison for the consistency assumption.

Comparison*	Dir, d (SD)†	MTC, d (SD)‡	Rest, d (SD)§	w (SD)	P value¶
Enrofloxacin vs Enrofloxacin (2.5 mg/kg 3 days)	1.16 (2.91)	1.17 (0.80)	1.17 (0.84)	-0.01 (3.03)	1.00
Enrofloxacin (7.5 mg/kg once or twice) vs Marbofloxacin	-0.04 (2.90)	-0.03 (1.06)	-0.02 (1.14)	-0.01 (3.11)	1.00
Enrofloxacin (7.5 mg/kg once or twice) vs Amoxicillin	-0.55 (2.94)	0.96 (0.84)	1.09 (0.88)	-1.64 (3.07)	0.59
Florfenicol vs Enrofloxacin (7.5 mg/kg once or twice)	1.37 (3.03)	-0.43 (0.79)	-0.57 (0.82)	1.93 (3.14)	0.54
Florfenicol vs Tulathromycin	1.18 (3.17)	0.33 (0.53)	0.31 (0.54)	0.87 (3.21)	0.79
Oxytetracycline vs Florfenicol	1.00 (2.90)	-1.00 (0.86)	-1.19 (0.9)	2.19 (3.04)	0.47
Tiamulin vs Tulathromycin	-1.16 (0.66)	-1.13 (0.48)	-1.1 (0.69)	-0.06 (0.95)	0.95
Tildipirosin vs Gamithromycin	0.87 (2.93)	-0.92 (0.87)	-1.1 (0.91)	1.97 (3.07)	0.52
Tulathromycin vs Tildipirosin	0.04 (0.65)	-0.05 (0.41)	-0.11 (0.53)	0.15 (0.84)	0.86
Tulathromycin vs Amoxicillin/clavulanic acid (7.0/1.75 mg/kg 3 days)	-0.31 (1.69)	0.24 (0.64)	0.33 (0.69)	-0.64 (1.83)	0.73
Non-active control vs Enrofloxacin	-3.73 (1.50)	-3.04 (0.48)	-2.96 (0.5)	-0.76 (1.58)	0.63
Non-active control vs Florfenicol	-1.39 (2.95)	-1.35 (0.62)	-1.35 (0.63)	-0.04 (3.02)	0.99
Non-active control vs Tildipirosin	-0.99 (2.88)	-1.07 (0.47)	-1.07 (0.48)	0.08 (2.92)	0.98
Non-active control vs Tulathromycin	-1.05 (0.31)	-1.02 (0.29)	-0.82 (0.78)	-0.24 (0.84)	0.78
Non-active control vs Ceftiofur CFA	-0.44 (2.90)	-0.65 (0.64)	-0.66 (0.65)	0.22 (2.97)	0.94
Non-active control vs Ceftiofur (MD)	-1.00 (0.65)	-0.76 (0.38)	-0.64 (0.47)	-0.36 (0.8)	0.65
Non-active control vs Ceftiofur HCl (5 mg/kg once)	0.11 (2.95)	0.08 (0.79)	0.08 (0.82)	0.03 (3.06)	0.99
Amoxicillin vs Florfenicol	-0.75 (2.96)	-0.52 (0.71)	-0.51 (0.73)	-0.25 (3.05)	0.94
Ceftiofur (HCl or NA) vs Florfenicol	-1.93 (3.22)	-1.92 (1.47)	-1.92 (1.66)	-0.01 (3.62)	1.00
Ceftiofur CFA vs Amoxicillin	-0.35 (3.01)	-0.19 (0.72)	-0.18 (0.74)	-0.17 (3.1)	0.96
Ceftiofur (MD) vs Tulathromycin	-0.49 (0.79)	-0.26 (0.34)	-0.21 (0.38)	-0.28 (0.87)	0.75
Ceftiofur NA (1-2 mg/kg 3 days) vs Ceftiofur NA (1-2 mg/kg 3 days)	1.07 (2.93)	0.00 (0.94)	-0.12 (1)	1.19 (3.09)	0.70
Danofloxacin (1.25 or 2.5 mg/kg once) vs Gamithromycin	-0.68 (2.90)	-0.71 (1.23)	-0.72 (1.35)	0.04 (3.2)	0.99

* The first treatment listed is the reference (denominator) and the second treatment listed is the comparator (numerator).

† Posterior mean (d) and SD of log-odds ratio of treatment effects calculated using direct evidence only.

‡ Posterior mean (d) and SD of log-odds ratio of treatment effects calculated using all the evidence.

§ Posterior mean (d) and SD of log-odds ratio of treatment effects calculated using indirect evidence only.

¶ The Z distribution test was used.

Dir = direct evidence; d = posterior mean; MTC = all evidence; rest = indirect evidence; w = inconsistency estimate; CFA = crystalline free acid; MD = multidose; HCl = hydrochloride; NA = sodium.

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* Non-refereed references.



CONVERSION TABLES

Weights and measures conversions

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

Temperature equivalents (approx)

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

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

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

Conversion chart, kg to lb (approx)

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

1 tonne = 1000 kg

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

1 ppm = 1 mg/L

Foreign animal disease action at Pork Forum

Protecting the United States from foreign animal diseases (FAD) took center stage at the 2019 National Pork Industry Forum in Orlando, Florida. Both delegate assemblies heard directly from US Department of Agriculture's (USDA) Undersecretary Greg Ibach via a videotaped message (library.pork.org/media/?mediaId=83AEBE74-7B2B-4C11-AED37382AC75D8E5). Undersecretary Ibach outlined the new steps that the USDA is taking to protect the US swine herd.

The Pork Act delegate body also passed advisements at Forum, including three specific

to African swine fever. Highlights include:

- Developing best practices and protocols to minimize risk.
- Developing a complete list of all porcine-originated ingredients and their risks for transmission of FADs through feed.
- Committing resources to support, promote and deliver information on critical research needs and results.

According to Dr Dave Pyburn, senior vice president of the National Pork Board's Science and Technology Department, one of

the most tangible actions taken by USDA is the agency's commitment to add 60 more beagles to the illegal meat smuggling interdiction team. He said, "The industry greatly appreciates this action as we have recently seen how important it is to keep illegal meat products from ASF-positive countries out of the United States."

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

Checkoff research update: Stemming African swine fever transmission through feed

In groundbreaking research funded in part by the Pork Checkoff, researchers have confirmed that African swine fever (ASF) transmission to pigs is possible through feed. According to lead investigator Dr Megan Niederwerder, Kansas State University assistant professor, her team of colleagues also have identified the oral dose necessary for ASF infection. She says the next step will be to identify ways to reduce or eliminate the ASF risk. This may include sourcing feed ingredients from countries without foreign animal diseases, using chemical mitigants, following recommended ingredient storage time, and using heat treatments.

The study, "Infectious Dose of African Swine Fever Virus When Consumed Naturally in Liquid or Feed," has been e-published prior to its May inclusion in the CDC's *Emerging Infectious Diseases* journal (wwwnc.cdc.gov/eid/article/25/5/18-1495_article). In light of this additional confirmation that ASF can be introduced into a herd via feed, it's a good idea to remember the "Seven Key Questions to Ask Your Feed Supplier about ASF" (www.pork.org/blog/seven-key-questions-ask-feed-supplier/).

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



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* Potency and efficacy of autogenous biologics have not been established



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USDA sets 2020 Dietary Guidelines advisory committee

The US Department of Agriculture and Health and Human Services 2020 Dietary Guidelines advisory committee held its first public meeting March 28-29. Members of the public were invited to attend the meeting in person or via webinar. The independent advisory committee, which includes

20 scientists, reviews scientific evidence related to developing the 2020-2025 Dietary Guidelines for Americans. As this committee sets nutritional policy for the United States, the Pork Checkoff Science and Technology department closely monitors the committee's work and offers registered

dietitians and others with the best available science related to fresh pork in the diet.

For more information, contact Adria Huseth, AHuseth@pork.org or 515-223-2632.

Checkoff collaborates to extend research funds

The National Pork Board, the Foundation for Food and Agriculture Research, and the National Corn Growers Association are working together to bring more than \$2 million in combined funding to develop novel technologies to identify and monitor indicators of pig health, welfare, and productivity.

Together these organizations have developed common research priorities and jointly funded seven research projects beginning in 2019. Through a focus on continuous improvement, pork producers are on the forefront of "smart farming" through improved management practices.

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

Fact sheets updated for international biosecurity

With African swine fever in China and other foreign animal diseases spreading worldwide, US swine veterinarians and pig farmers need the best available information to help mitigate these herd health risks. To help with this, the Pork Checkoff and its partners, the Center for Food Security and Public Health and the American Association of Swine Veterinarians, recently revised two fact sheets—the *Pork Industry Guidelines: International Travel Biosecurity* and *Pork Industry Guidelines: Hosting International Visitors*. Whether you are headed overseas and will have exposure to pigs, pork, or other high-risk items or areas or will be hosting an international group on a farm or clinic, now is the time to get these updated and free fact sheets. They can be found at www.pork.org/fad and at the Pork Store via www.pork.org in downloadable form or hard copy.

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



AASV NEWS

AASV installs 2019 officers

Dr Nathan Winkelman was installed as the president of the American Association of Swine Veterinarians on March 12, 2019 during the association's 50th Annual Meeting in Orlando, Florida. He succeeds Dr C. Scanlon Daniels, who is now immediate past president. Dr Jeffrey Harker has ascended to president-elect. The newly elected vice president is Dr Mary Battrell.

AASV President Dr Nathan Winkelman (UMN '84) was raised on a diversified crop and livestock farm near St James, Minnesota. Nate received a BS degree in animal science and DVM from the University of Minnesota. Upon graduation, he joined a swine-exclusive veterinary practice in Morris, Minnesota, with Drs Rod Johnson and Tony Scheiber. Currently, Dr Winkelman is a partner with Dr Adam Mueller in Swine Services Unlimited, Inc, a swine research and consulting practice in Rice, Minnesota. He has served on the AASV Board of Directors and currently sits on the AASV Foundation Board. In addition, Dr Winkelman is an active participant in the National Pork Board's Operation Main Street program giving presentations to various groups to raise awareness about modern pork production.

When asked to comment on the future of AASV and his tenure as president, Dr Winkelman said, "We have just celebrated 50 years of AASV progress and may well see as much technological change, swine disease control and elimination, and progress into the next half century as in the last. I'm proud to represent a group of swine veterinarians dedicated to improving the health and welfare of their clients' pigs." He continued, "Strong AASV leadership will work diligently with our allied industry partners and affiliated organizations on our current challenges and opportunities facing the global and domestic swine industry. Heightened awareness regarding transboundary disease prevention, preparedness in case



AASV officers (left to right) Dr Nate Winkelman (President), Dr Jeff Harker (President-elect), Dr Mary Battrell (Vice President), and Dr C. Scanlon Daniels (Past President)

of a foreign animal disease outbreak, and improving market access for ag exports are issues front and center." Speaking directly to AASV members, Winkelman concluded, "Please let us know your concerns and how we can serve you better at any time. Thanks again for the opportunity to serve as your AASV president."

AASV President-elect Dr Jeffrey Harker (Purdue '94) grew up on a diversified livestock and grain farm in south central Indiana. After graduation, Dr Harker joined Dr Max Rodibaugh at Swine Health Services as an associate veterinarian and then became a partner in 2001. Their practice (now AMVC Swine Health Services) is dedicated to swine and serves a very diverse swine clientele ranging from small show pig herds to contract growers in integrated production. Dr Harker has served on the AASV Board of Directors, has represented AASV in the American Veterinary Medical Association's House of Delegates, and has served on the AASV Annual Meeting Planning Committee. Dr Harker has also been involved with the National Pork Board's Operation Main Street program since it began several years ago.

AASV Vice President Dr Mary Battrell (ISU '95) was born and raised on a diversified crop and livestock family farm in Albany, Ohio. She earned a bachelor's degree in agriculture from The Ohio State University followed by a master's degree in animal science with a focus in ruminant nutrition from the University of Tennessee. Upon graduation, she moved to Iowa and worked as a sales representative for the Upjohn Company.

Dr Battrell earned her doctor of veterinary medicine and a master's degree in swine production medicine from Iowa State University in 1995. She began her veterinary career in North Carolina working for Dr Fred Cunningham, then was employed at Brown's of Carolina for three years before joining Pharmacia as a technical services veterinarian. Since 2000, Dr Battrell has worked for Smithfield Hog Production, where she is currently the staff veterinarian for Smithfield Hog Production's East Central Region and is responsible for the health and well-being of 140,000 sows farrow-to-finish. She has been actively involved in the development of the

Smithfield Animal Care Program and their Contingency Plan for a Foreign Animal Disease. Dr Battrell was the 2018 recipient of the AASV Swine Practitioner of the Year award.

When asked to comment on what this election meant to her, Dr Battrell responded, "I am grateful for the opportunity to become more involved in the continued success of this association. AASV has so many talented members and allies. I am confident that working together we

will accomplish great things for our pigs, producers, and this association."

Dr Battrell and her husband, Wayne Banks, reside in Garland, North Carolina, with their son Don Banks.

AASV Past President Dr C. Scanlon Daniels (ISU '98) grew up on a family owned and operated livestock enterprise in central Iowa. He attended Iowa State University where he received a BS in animal science

and a DVM. He also has an MBA from the University of Guelph. Dr Daniels has been previously employed as a staff veterinarian by Iowa Select Farms and Seaboard Foods. Currently, he operates a diversified food-animal veterinary practice, laboratory, and multi-species contract research organization in Dalhart, Texas. Dr Daniels has been active in multiple AASV committees and has served on the AASV Board of Directors representing District 7 on two occasions.

AASV members receive discount on the 11th edition of *Diseases of Swine* – now with color photos

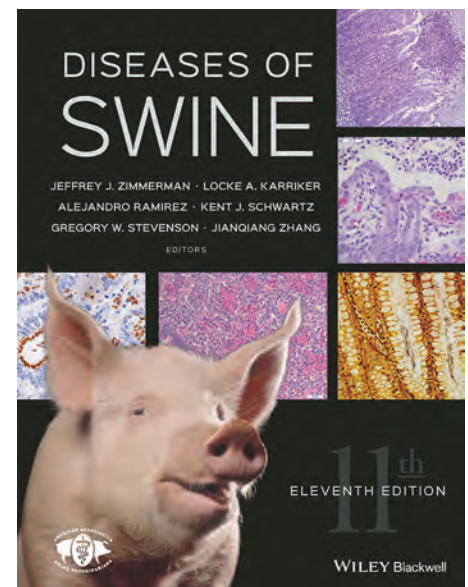
The classic veterinary reference *Diseases of Swine* has been completely revised and is now available to order at www.wiley.com. Members of AASV receive a 20% discount when purchasing the book using the order promo code available at www.aasv.org/members.

Diseases of Swine has been the definitive reference on swine health and disease for over 60 years. This new edition has been completely revised to include the latest information, developments, and research in the field. Now with full color images throughout, this comprehensive and authoritative resource has been redesigned for improved consistency and readability, with a reorganized format for more intuitive access to information.

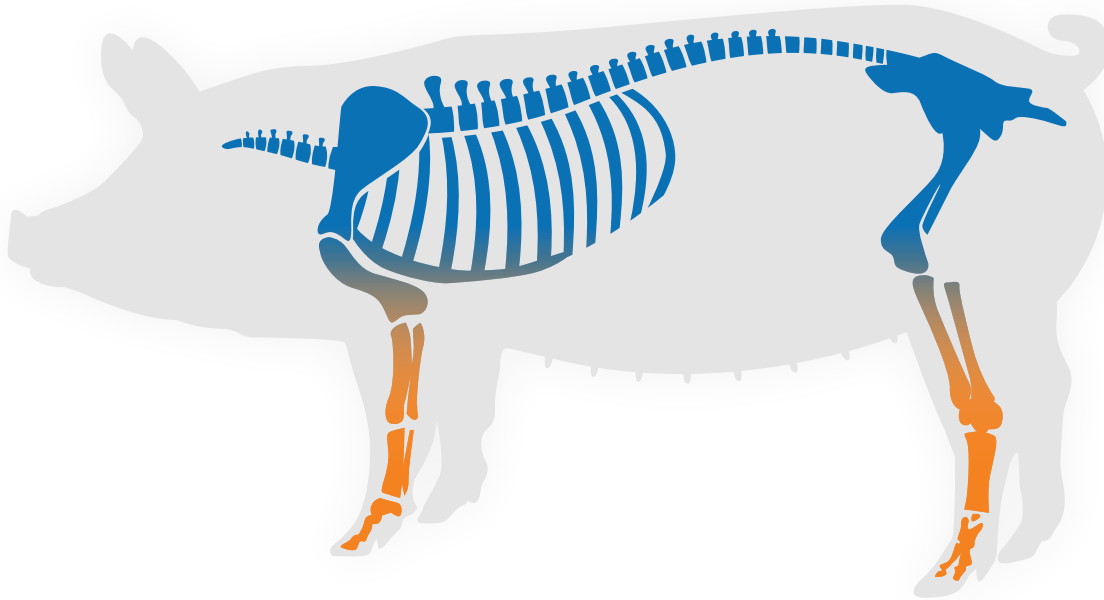
The book's editors, Drs Jeffrey Zimmerman, Locke Karriker, Alejandro Ramirez, Kent Schwartz, Gregory Stevenson, and Jianqiang Zhang, are all AASV members and faculty at Iowa State University.

Diseases of Swine covers a wide range of essential topics on swine production, health, and management, with contributions from more than 100 of the foremost international experts in the field. This revised edition makes the information easy to find and includes expanded information on welfare and behavior.

Written for veterinarians, academicians, students, and individuals and agencies responsible for swine health and public health, *Diseases of Swine* is considered by many to be an essential guide to swine health.



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AASV celebrates 50 years with record attendance at annual meeting

The American Association of Swine Veterinarians (AASV) held its 50th Annual Meeting in Orlando, Florida, March 9-12, 2019. The meeting, held at the Hilton Orlando Buena Vista Palace, drew record attendance of 1237 total attendees, including 770 paid registrants (also a record) and 110 veterinary students from 23 colleges of veterinary medicine. The conference participants hailed from 30 countries, with 308 attendees from outside the United States. The total attendance also included 290 exhibit representatives from 97 companies and organizations.

The meeting participants enjoyed the opportunity to attend numerous educational sessions, including 10 pre-conference seminars, 2 general sessions, 3 breakout sessions, 1 research topics session, 3 industrial partners sessions, the student seminar, and a poster session featuring 28 student posters, 25 research posters, and 14 industrial partner posters. Three Saturday seminars, AASV's Got Talent, Emerging Technologies for the Swine Industry, and Effective Outbreak Investigations, were extremely popular with more than 95 attendees each, while the Diagnostics seminar garnered the most attention of the seminars on Sunday morning (137 attendees). Ninety-nine students or recent graduates attended the Swine Medicine for Students pre-conference seminar on Sunday morning. As always, the student seminar session held Sunday afternoon was very well attended. In addition, 14 AASV committees met during the annual meeting to discuss important issues in swine health, public health, animal well-being, and production.

Dr John Waddell opened the Monday general session with the Howard Dunne Memorial Lecture. During his presentation, entitled "Built to last: 50 years of AASV," he reflected on the past 50 years of the organization. He shared memories of swine veterinarians who gathered together in 1969 to organize the American Association of Swine Practitioners and focused on the people who continue the AASV legacy.

Dr Deborah Murray presented the Alex Hogg Memorial Lecture entitled "Today's swine veterinarian: Challenges and opportunities for the future." Her presentation described the changing profession and evolving needs

of AASV members. She highlighted the novel ideas that students, the next generation of swine veterinarians, can bring to the industry. Strong mentorship offered by AASV members to younger veterinarians is important to encourage those ideas.

Accomplishments, lessons learned, and memories over the past 50 years were shared in special videos throughout the meeting, including the AASV Golden Anniversary video shown during the Monday general session. The videos were produced by AgCreate Solutions, Inc under the direction of AASV member Dr Sarah Probst-Miller, the company's creative director and president. The Golden Anniversary video, along with the Veterinarian's Oath video, session introduction videos, and general session presentation recordings, are available for viewing at www.aasv.org/members/only/video/.

The Monday afternoon concurrent sessions encouraged veterinarians to consider disease control and elimination, vaccinology and immunology, and production innovations. The Tuesday general session focused on critical transboundary disease threats and outbreak preparedness.

The AASV Awards Reception was held Monday night, followed by the AASV Foundation's annual fund-raising auction. Dr Ron Brodersen, 2015 AASV president and 2019 AASV Awards Selection Committee chair, introduced the recipients of the Swine Practitioner of the Year Award (Dr William Hollis), the Howard Dunne Memorial Award (Dr Peter

Davies), the Meritorious Service Award (Dr David Madsen), the Young Swine Veterinarian of the Year Award (Dr Paul Thomas), and the Technical Services/Allied Industry Veterinarian of the Year Award (Dr Ron White). Dr Paul Ruen, AASV Foundation chair, presented the Heritage Award to Dr Steven Henry. This is only the fifth time the Heritage Award has been given.

A special thank you and award of gratitude was given to AASV Executive Director Dr Tom Burkgren. He is retiring after 25 years of service to the AASV. Past presidents, staff, and family gathered on stage during the awards ceremony to thank Dr Burkgren.

Swine Practitioner of the Year

Dr William Hollis was named the 2019 Swine Practitioner of the Year. The award is given to the swine practitioner who has demonstrated an unusual degree of proficiency and effectiveness in the delivery of veterinary service to clients.

Dr Hollis was born in Bushnell, Illinois, where he attended high school. During 1986-1987, Hollis served as the Illinois FFA president, and the National FFA vice president in 1988. He received a bachelor of science in agriculture and a doctor of veterinary medicine (1996) from the University of Illinois.

Hollis is currently a partner and veterinarian of Carthage Veterinary Service (CVS), which consults in over 10 states and provides consulting services in several other countries.



Dr Tom Burkgren, pictured with family, AASV staff, and AASV past presidents, was recognized for his 25 years of service to the organization.



Dr William Hollis, recipient of the AASV Swine Practitioner of the Year Award.

In December 2018, Hollis was elected president of Professional Swine Management, the swine management service company he and other CVS partners founded in 2000.

Recognized by his peers as demonstrating strong proficiency and effectiveness in veterinary service, Hollis understands what constitutes sound science and bases decisions on data and information analysis, diagnostic interpretation, and intervention planning and communication. As a farm management advisor, he strives to build client partnerships that are both sustainable and profitable, facilitates producer family and industry networking, and invests in farm and industry staff training.

Hollis is a Pork Quality Assurance Plus Advisor, serves on the National Pork Producers Council Animal Health Food Security Policy Committee, and serves on the National Pork Board Swine Health Committee. He has served on the American Veterinary Medical Association House of Delegates representing AASV, on the AASV Board of Directors representing District 5, and continues to serve on the AASV Operation Mainstreet Committee. Hollis is an active participant in the National Pork Board Operation Main Street program giving local presentations to raise awareness about modern pork production.

Asked to comment about receiving this award, Hollis replied, "This is a dream come

true to be recognized by my peers in the industry. There have been many people in my life who have helped me continue to grow as a veterinarian and a business owner. My family has supported some crazy long days and time away. I really appreciate the recognition."

Hollis and his wife, Brigit, who is also a veterinarian, have been married 23 years and reside in Hamilton, Illinois. They have an 18-year-old daughter, Bailey, and a 16-year-old son, Ben.

Howard Dunne Memorial Award

Dr Peter Davies received the 2019 Howard Dunne Memorial Award which recognizes an AASV member who has made important contributions and provided outstanding service to the association and the swine industry.

Davies was born and raised in Perth, Western Australia, and spent much of his youth in the wool and wheat producing region around Newdegate where his grandfather was a pioneer farmer and his uncle always kept a few pigs for fun. There, he became interested in "all creatures great and small," and never considered a profession other than veterinary medicine.

Davies received a bachelor of veterinary science with honors from the University of Melbourne in 1975, and a doctor of philosophy from the University of Sydney in 1983. He has practiced as a clinical veterinarian in Australia, New Zealand, the United Kingdom, and Ireland. From 1984-1986, he worked as a livestock advisor on an agricultural and community health project for small farmers in the northeast of Brazil. During 1987, recognizing the importance of veterinary expertise and specialty with life balance, he became involved in swine research as a senior veterinary officer for the South Australia Department of Agriculture, from where he was recruited to work at the University of Minnesota in 1991.

Davies has educated veterinary students in swine health and production, epidemiology, and food safety at North Carolina State University, Massey University in New Zealand, and the University of Minnesota, where he was the Allen D. Leman Chair of Swine Health and Productivity during 2003-2009. Described as a lifelong learner, Davies has facilitated lifelong learning opportunities for practitioners, including a peer group program titled Epidemiological Skills for Swine Practitioners. Davies and the

current Leman Chair, Dr Cesar Corzo, are collaborating to create an updated iteration of that program to commence later in 2019. Davies has served on several National Pork Board and AASV committees, has provided leadership for AASV and Leman Swine conferences, and regularly has been an invited speaker at international meetings on swine health and pork safety.

Dr Davies has an extensive body of research and publications in swine health, antimicrobial use and resistance, and zoonotic and food-borne pathogens, including *Salmonella* and methicillin resistant *Staphylococcus aureus* (MRSA). He is now in the midst of a 5-year study of infectious disease risks at the human-swine interface funded by the National Institute of Occupational Safety and Health. Focused on MRSA, hepatitis E, and influenza, the research participants are practicing AASV members along with a control group of companion animal veterinarians.

Davies was a member of the International Scientific Committee of the International Research Center in Veterinary Epidemiology, Copenhagen, Denmark, during 2000-2007, currently serves on the Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria, and is on the editorial board for the Merck Veterinary Manual.

When asked what it meant to him to receive the Howard Dunne Memorial Award, he responded, "I am humbled and honored to have my name added to the list of Howard



Dr Peter Davies, recipient of the Howard Dunne Memorial Award.

Dunne Award recipients – a list of AASV icons, mentors, and friends who have served and guided the swine veterinary community through the years. I am indebted to countless colleagues who have educated me along the way, and to the AASV for including me in its culture of exchanging experiences and lifelong learning – every conversation is an education!”

Davies and his wife, Rebecca, live in Minneapolis, Minnesota. They have two sons, JT and Brendan.

Meritorious Service Award

Dr David Madsen was named the 2019 recipient of the American Association of Swine Veterinarians’ Meritorious Service Award. The award recognizes individuals who have provided outstanding service to the AASV.

Born into a Nebraska family that raised purebred Hampshire pigs, Madsen became determined to become a veterinarian after following a local veterinarian on his father’s farm. He earned his doctor of veterinary medicine in 1969 from Purdue University. At graduation, he was the only member of his class with an interest in pigs. He was a swine veterinarian and practice owner in Illinois, Indiana, and Missouri, then moved to Nebraska to initiate SwinePro Associates, LLC, in partnership with Jack Anderson, DVM, in 1994. Madsen was also the Director of Health Services for



Dr David Madsen, recipient of the AASV Meritorious Service Award.

Heartland Pork in Iowa, Premium Standard Farms/Murphy Brown in Missouri, and Smithfield in Princeton, Missouri. In his career as a swine veterinarian and producer, Madsen has seen the emergence of many important swine diseases, including atrophic rhinitis, pseudorabies, circovirus, *Streptococcus suis*, and porcine reproductive and respiratory syndrome.

Madsen attended the pioneer class of the Executive Veterinary Program at the University of Illinois and achieved Diplomate status of the American Board of Veterinary Practitioners in Swine Health Management in 1995, where he later served 10 years as the Vice-Regent, Credentials.

Madsen became a charter member of the American Association of Swine Practitioners (now AASV) in 1969. He served as a District Director for the AASV Board in 1992 and as AASV president in 2001. He represented AASV in the American Veterinary Medical Association’s (AVMA) House of Delegates for 12 years, and was selected to represent all food-animal veterinarians on the 7-person committee to write the AVMA Overarching Principles of Animal Welfare. Serving on the AASV Foundation Board, Madsen was integral in the support of future swine veterinarians. He proposed that the foundation develop a free pre-conference seminar for students and recent graduates by funding the speaker expenses. He planned and moderated the first AASV student pre-conference seminar; that event has grown into one of the best-attended AASV conference seminars. Madsen proposed the phrase, “Ensure Our Future: Leave a Legacy,” adopted as the motto by the AASV Foundation Board.

When asked to comment about receiving the award, Madsen responded, “AASV has been a large part of my professional, educational, and personal career, providing lifelong learning and introducing me to a large number of outstanding individuals. Although it took me 23 years to become involved with association tasks, my involvement was both rewarding and enlightening, to say nothing of challenging and entertaining. I would trade my experiences through AASV with no other opportunities.”

David and his wife, Sandie, have a daughter, Jenna, who lives in Minnesota with her husband, John, and daughters Ellie and Sophia. Retiring in 2014, David and Sandie currently live in Dillon, Montana, where he serves as Swine Outreach Coordinator for

the Montana Board of Livestock, working with 4-H and FFA groups across the state. He also works as a part-time general practitioner in a mixed practice and provides surgical services for the local animal shelter.

Young Swine Veterinarian of the Year Award

The AASV’s Young Swine Veterinarian of the Year Award was presented to Dr Paul Thomas. It is given annually to an AASV member five or fewer years post-graduation who has demonstrated the ideals of exemplary service and proficiency early in his or her career.

Thomas grew up on a farrow-to-finish swine and row-crop farm near Camanche, Iowa. Family has made a large impact on his career choices. His father encouraged all Thomas children to learn as much science as possible. He has three brothers and a sister-in-law who are all veterinarians; spending time with his older brother, Pete, in the Iowa State University Veterinary Diagnostic Lab solidified his interest in veterinary medicine.

Dr Thomas received a bachelor of science in animal science (2009), doctor of veterinary medicine (2013), and a master of science in veterinary preventive medicine (2015), all from Iowa State University. He also completed a post-doctoral fellowship with the Swine Medicine Education Center (SMEC) and AMVC Management Services as an associate veterinarian, where he is currently employed.



Dr Paul Thomas, recipient of the AASV Young Swine Veterinarian of the Year Award.

Dr Thomas works with sow farms and grow finish pigs within the AMVC system, consults with clients, and supports SMEC operations by teaching 4th year veterinary students and conducting PigPROS seminars to introduce industry stakeholders to the process and constraints of modern pork production. Early in his career, Dr Thomas is a respected role model for students, colleagues, and other young swine veterinarians. As a teacher, he creates a rich, witty, and interactive learning environment for all participants. As a veterinarian, he adapts easily to provide the best service for each client and communicates in a way that caretakers, co-workers, clients, owners, and superiors can all understand, respect, and appreciate.

Upon acceptance of the award, Dr Thomas commented, "I'm very honored to receive this award. I have a great deal of respect for the AASV and my colleagues in this profession, so to be recognized by them means a lot to me. I'm very thankful to the veterinarians and staff I work with at AMVC and SMEC for the incredible mentorship and support I've received from them early in my career and to my wife, Jennifer, for her constant support."

Jennifer says, "I am so proud of my husband. As his wife, I know how dedicated he is to his profession, job, and clients. Paul always strives to do the maximum in whatever he is trying to achieve and always puts his clients and others first."

Thomas and Jennifer have a 1-year-old son, Augustin (Gus), and live in Audubon, Iowa.

Technical Services/Allied Industry Veterinarian of the Year Award

Dr Ron White received the 2019 American Association of Swine Veterinarians' Technical Services/Allied Industry Veterinarian of the Year Award. Established in 2008, the award recognizes swine industry veterinarians who have demonstrated an unusual degree of proficiency and effectiveness in delivery of veterinary service to their companies and their clients, as well as given tirelessly in service to the AASV and the swine industry.

Originally from Osceola, Iowa, White helped many farmers in his area, including one who raised timber pasture pigs. He first became interested in science, livestock, and veterinary medicine by growing up on an acreage raising 4-H projects and helping a

local farmer gather, process, and sort pigs. Dr White received his doctor of veterinary medicine degree from Iowa State University in 1990, and completed the Executive Veterinary Program at the University of Illinois in 1998.

Beginning his career in mixed animal practice as an associate and owner, Dr White joined Solvay Animal Health as a technical services veterinarian specializing in swine medicine in 1994. He then joined Fort Dodge Animal Health as the Swine Unit Business manager and served as Senior Swine Research Manager. In 2005, Dr White joined Iowa Select farms as Director of Biosecurity and Health before joining Pfizer Animal Health in 2008. Dr White currently serves as Group Director, International Diagnostic Medicine for Zoetis. Dr White has served on a variety of AASV committees and chaired the AASV Foundation golf outing for many years. Recognizing the importance of student encouragement and inclusion at meetings, Dr White has also reviewed student presentations.

Dr White has presented information on livestock health and production at numerous international and regional meetings. He thoroughly enjoys meeting new veterinarians and producers, understanding different production systems, and investigating methods to improve herd health and production through improved use of diagnostics, and credits the inclusiveness of AASV with providing the connectivity to many contacts.

When asked to comment on what the award meant to him, Dr White said, "I am grateful to receive the 2019 AASV Technical Service/Allied Industry Veterinarian of the year award. I am truly honored and humbled to receive this award. AASV has been a large part of my professional career providing education and interaction at meetings with swine veterinarians from around the world. I would like to thank the AASV membership, my family for their support, and my colleagues for the fantastic technical support network."

White and his wife, Sue, reside in Ames, Iowa, and have two sons, Brady and Trevor.



Dr Ron White, recipient of the AASV Technical Services/Allied Industry Veterinarian of the Year Award. *Photo courtesy of Ron White.*

Annual Business Breakfast

American Association of Swine Veterinarians President Dr Scanlon Daniels reported on the association's membership and activities during the annual business breakfast on Tuesday, March 12th. The 2019 AASV officers, Drs Nathan Winkelman, President; Jeff Harker, President-elect; Mary Battrell, Vice President; and Scanlon Daniels, Past President, were installed. The board welcomed recently elected district directors: Drs Gregory Kline (re-elected District 3), Megan Potter (re-elected District 7), Monte Fuhrman (re-elected District 8), and Cristina Quijano Alvarez (District 10). Dr Daniels also welcomed Jamie Madigan (North Carolina State University, 2021), incoming alternate student delegate, to the AASV Board of Directors, and thanked outgoing student delegate Jordan Gebhardt (Kansas State University, 2019). Jonathan Tubbs (Auburn, 2020) assumes the role of student delegate. Honored guests at the business breakfast included Dr John de Jong (American Veterinary Medical Association president), Dr Chuck Lemme (American Veterinary Medical Association Executive Board liaison to the AASV), Dr Patrick Webb (National Pork Board), and Dr Dan Kovich (National Pork Producers Council).

AASV Foundation announces student scholarships

The American Association of Swine Veterinarians Foundation awarded scholarships totaling \$25,000 to 15 veterinary students.

Kimberlee Baker, Iowa State University, received the \$5000 scholarship for top student presentation. Her presentation was titled “Detecting porcine reproductive and respiratory syndrome virus (PRRSV) via polymerase chain reaction (PCR) by pooling pen-based oral fluid samples.” Zoetis provided the financial support for the Top Student Presenter Award.

Additional scholarships totaling \$20,000 were funded by Elanco Animal Health as shown in the accompanying photos.

Four veterinary student presenters received \$2500 scholarships: Sam Baker, Iowa State University; Enise DeCaluwe-Tulk, University of Guelph; Erin Kettelkamp, University of Illinois; and Marjorie Schleper, University of Minnesota.

Five veterinary student presenters received \$1500 scholarships: Daniel Brown, University of Illinois; Brandi Burton, University of Illinois; Kayla Castevens, North Carolina State University; Anne Szczotka, Iowa State University; and Abby Vennekotter, University of Illinois.

Those student presenters receiving \$500 scholarships were: Matt Finch, Iowa State University; Matthew Herber, University of Pennsylvania; Joshua Hewitt, Iowa State University; Sophia Leone, Colorado State University; and Katelyn Rieland, University of Minnesota.

Forty-four veterinary students from 14 universities submitted abstracts for consideration. From those submissions, 15 students were selected to present during the annual meeting. Zoetis, sponsor of the Student Seminar, provided a \$750 travel stipend to each student selected to participate.



Recipient of the \$5000 scholarship for Best Student Presenter during AASV's Student Seminar: Kimberlee Baker, Iowa State University. Pictured with Kimberlee is Dr Lucina Galina (left) of Zoetis, sponsor of the Student Seminar and Best Student Presenter Award.



Dr Doug Sullivan (far right) presented scholarships sponsored by Elanco Animal Health. Recipients of the \$2500 AASV Foundation scholarships were (from left): Erin Kettelkamp, University of Illinois; Marjorie Schleper, University of Minnesota; Enise DeCaluwe-Tulk, University of Guelph; and Sam Baker, Iowa State University.



Dr Doug Sullivan (far right) presented scholarships sponsored by Elanco Animal Health. Recipients of the \$1500 AASV Foundation scholarships were (from left): Anne Szczotka, Iowa State University; Brandi Burton, University of Illinois; Abby Vennekotter, University of Illinois; and Kayla Castevens, North Carolina State University. Not pictured: Daniel Brown, University of Illinois.



Dr Doug Sullivan (far right) presented scholarships sponsored by Elanco Animal Health. Recipients of the \$500 AASV Foundation scholarships were (from left): Sophia Leone, Colorado State University; Joshua Hewitt, Iowa State University; Matthew Herber, University of Pennsylvania. Not pictured: Matt Finch, Iowa State University; and Katelyn Rieland, University of Minnesota.

AASV announces student poster competition awardees

The American Association of Swine Veterinarians (AASV) provided an opportunity for 15 veterinary students to compete for awards in the Veterinary Student Poster Competition. Newport Laboratories sponsored the competition, offering awards totaling \$4000.

Based on scores received in the original judging of abstracts submitted for the AASV Student Seminar, the top 15 abstracts not selected for oral presentation at the annual meeting were eligible to compete in the poster competition. A panel of three AASV practitioners interviewed the competing students and scored their posters to determine the scholarship awards.

Newport Laboratories announced the following awards during the AASV Luncheon on March 11th.

\$500 scholarship: Jordan Buchan, University of Guelph – Top student poster entitled “How neonatal factors affect reproductive performance of swine replacement breeding stock”

\$400 scholarships: Amanda Anderson, Iowa State University; and Jacob Baker, Iowa State University

\$300 scholarships: Andrew Noel, Iowa State University; David Pillman, University of Minnesota; and Brooke Smith, University of Illinois

\$200 scholarships: Gabrielle Fry, Purdue University; Taylor Homann, University of Minnesota; Katie Kehl, Kansas State University; Elizabeth Noblett, North Carolina State University; Emily Nogay, University of Pennsylvania; Shelby Perkins, University of Missouri; Justin Schumacher, University of Pennsylvania; Rachel Stika, Iowa State University; and Jonathan Tubbs, Auburn University.

In addition to the poster competition awards, each student poster participant received a \$250 travel stipend from Zoetis and the AASV.



Jordan Buchan, University of Guelph, winner of the top prize of \$500 for best poster.



The \$400 poster competition winners (left to right): Jacob Baker, Iowa State University; and Amanda Anderson, Iowa State University.



The \$300 poster competition winners: Andrew Noel, Iowa State University. Not pictured: David Pillman, University of Minnesota; and Brooke Smith, University of Illinois.



SAVE THE DATE

The 2020 Annual Meeting will be held March 7-10 at the Hyatt Regency Atlanta in Atlanta, Georgia.



The \$200 poster competition winners (left to right): Emily Nogay, University of Pennsylvania; Rachel Stika, Iowa State University; Elizabeth Noblett, North Carolina State University; Katie Kehl, Kansas State University; Justin Schumacher, University of Pennsylvania; Taylor Homann, University of Minnesota; Gabrielle Fry, Purdue University; and Shelby Perkins, University of Minnesota. Not pictured: Jonathan Tubbs, Auburn University.

AASV Committees meet

Fourteen issue-based committees met during the 2019 AASV Annual Meeting. The AASV Board of Directors establishes committees to address specific issues associated with swine veterinary medicine and provide recommendations for actions to the AASV leadership. The AASV committees are an integral part of the leadership structure within AASV, and they also serve as a great way for members to participate in developing positions for the association, learn about particular issues, and meet other members. During 2018, more than 250 AASV members volunteered to serve on at least one committee, with many serving on multiple committees, providing expertise and valuable experience focused on swine health, public health, animal well-being, and production.

The following are some key highlights from the committee meetings:

- The **Pig Welfare Committee** reviewed and reaffirmed the position statement on raising pigs without antibiotics. They also plan to propose alternative language for AASV Board consideration encouraging marketing programs to collaborate with AASV when

making antibiotic-use related standards. The committee agreed to form a sub-committee to seek funding for boar euthanasia research and requested that AASV staff dedicate time to compile depopulation information. The committee discussed several other topics including changes to the Common Swine Industry Audit, African swine fever preparation, multiple transport movements of culled sows and boars, and the pain mitigation assessment protocol project.

- Discussion of the **Nutrition Committee** centered around African swine fever and testing feed or feed ingredients. Many pigs are fed by companies with hazard analysis and critical control point plans or foreign animal disease mitigation plans, but committee members expressed concerns about smaller herds or higher risk herds. The Nutrition Committee will work with the Communications Committee and Committee on Transboundary and Emerging Diseases to develop bulleted talking points about foreign animal disease prevention and feed to distribute to AASV members.

- The **Boar Stud Committee** discussed several items pertaining to the *Health, Hygiene and Sanitation Guidelines for Boar Studs Providing Semen to the Domestic Market*, referred to here as the *Guidelines*. The committee established a sub-committee to review antimicrobial use in semen extenders, with the goal of updating the *Guidelines*. They plan to review *Guideline 1.4.2* to include lethargy as an early indicator of disease. Members continued to discuss issues around cull boar transportation and euthanasia. The committee plans to continue to monitor any new information that may become available about Senecavirus A, porcine circovirus 3 (PCV3), pestivirus, and African swine fever. The committee intends to hold a boar stud pre-conference seminar at the 2021 AASV annual meeting.

- During the well-attended **Committee on Transboundary and Emerging Diseases** meeting, members and newcomers participated in depopulation, feed risk, and PCV3 roundtables. They listened to updates from the Swine Health Information Center, the US Department of Agriculture (USDA), and the National Pork Producers Council (NPPC). They also heard presentations about the Secure Pork Supply plan and the business continuity database and dashboard (AgView). During the next year, the committee plans to review and provide new recommendations about *Mycoplasma hyopneumoniae* herd classification. A priority of the committee is to keep members updated about available testing options and provide resources for African swine fever.

- The **AASV Porcine Reproductive and Respiratory Syndrome (PRRS) Task Force** is requesting funding to support a second sub-committee meeting to continue review and revision of the AASV Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) Herd Classification document. Revision was identified as a priority during 2018, and results of the first sub-committee review were presented during the 2019 meeting. Although significant advances were made, the task force emphasized the need to continue working on the guidelines to prepare a formal document for industry. The committee also discussed

how to advance member knowledge of PRRSV and better use the Morrison Swine Health Monitoring Project to show regional status.

- The **Influenza Committee** intends to continue with their 2018 proposed survey of the membership to gain a better understanding of AASV member knowledge and concerns about zoonotic influenza risk at fairs and exhibitions. The committee would like to hold an influenza A virus pre-conference seminar every 2 to 3 years, beginning in 2020 or 2021. They expressed continued support for the influenza A virus of swine (IAV-S) surveillance program and raising awareness about the zoonotic potential of influenza.
- The **Pork Safety Committee** supports AASV, the National Pork Board (NPB), and NPPC development and use of an on-farm testing decision matrix following human illness associated with pork products. The committee discussed and recommended that AASV support continued toxoplasmosis research at the USDA Agriculture Research Service Animal Parasitic Diseases Laboratory.
- The **Pharmaceutical Issues Committee** reaffirmed the position statement on raising pigs without antibiotics. They discussed updates to the *Prevention of Diseases Using Antibiotics* flyer. With the Swine Medicine Education Center (SMEC), the committee intends to develop a swine antibiotic database of drug summaries to be made available to AASV members. The committee also plans to increase AASV member awareness of proposed state or local antibiotic legislation and provide talking points for AASV members to use with local elected officials.
- At the request of NPB, the **Human Health and Safety Committee** will review NPB needle safety videos. The committee will continue to support zoonotic influenza awareness among members and plans to work with the Membership Committee and the Communications Committee to address mental health and wellness among AASV members. They discussed a pre-conference seminar or short video vignettes to be shown during the annual meeting.
- The **Membership Committee**, composed of the immediate 20 past-presidents, strongly supported efforts initiated by the Human Health and Safety Committee to address mental health and provide wellness resources for AASV members.
- The **Communications Committee** is requesting to revise and broaden their mission statement to include statements on inward and outward facing communication, social media, and member resources for public interaction. With the AASV photo library complete, the committee plans to improve accessibility and usability to all AASV members. The committee discussed potential updates to the AASV website. The committee also would like to provide members with talking points to use in response to social media posts and recommended a media training pre-conference seminar for AASV members.
- The **Student Recruitment Committee** is requesting funding from the AASV Board to continue hosting, along with SMEC and the Iowa State University College of Veterinary Medicine AASV Student Chapter, the Swine Medicine Talks series. The Swine Medicine Talks are a three-part live-streamed lecture series with expert speakers representing a wide range of topics. The committee requested data about program success from SMEC. The committee plans to develop PowerPoint slides briefly describing AASV and its value to student membership. These slides will be available for members to use in any student presentation. The committee also discussed a pre-conference seminar for young graduates that would include topics on student debt, buying into a practice, contract negotiations, insurance, and leadership.
- During their meeting at the faculty breakfast, the **Collegiate Activities Committee** decided to add two questions to the student abstract submission process, including date of data collection and enrollment in a dual-degree program. The committee will continue to encourage faculty involvement in AASV.
- The **Operation Main Street (OMS) Committee** discussed the growing demand for veterinarians as speakers as OMS expands its reach further into high-level influencer audiences such as human health professionals (nurses and schools of medicine), dietitians, food service, and grocer associations. The OMS committee will continue to encourage veterinarians to become trained OMS speakers to help fill the demand for veterinary presenters coast-to-coast. Specifically, the OMS committee would like to encourage veterinarians who are 3 to 5 years post-graduation to participate. Key messages for this year will be sustainable farming and emerging trends in agriculture that reduce environmental impact. Furthermore, the presentations will emphasize veterinarians as key drivers in food safety. A virtual farm tour by live stream will be combined with several select OMS presentations.

The committees are a critical part of the AASV leadership, and we appreciate the efforts of the volunteer members. If you are interested in learning more about the committee activities, visit the committee web pages on the AASV web site (www.aasv.org/members/only/committee/). Contact the committee chair or the AASV office to join a committee.

AM Report continued on page 167



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AASV proceedings and videos online

Even if you weren't able to attend the AASV Annual Meeting in Orlando, you can still benefit from the many excellent presentations delivered at the meeting. The conference proceedings, including the pre-conference seminar booklets, are available for all AASV members to download at www.aasv.org/library/proceedings/, or look under the "Resources" menu tab on the AASV Web site for "AASV Meeting Proceedings." All you need is your AASV member username and password with 2019 dues-paid status.

On the web site you will find

- The "big book" containing all the papers for the regular meeting sessions in a single PDF file with a hyperlinked table of contents,

- Seminar booklets—a PDF file for each seminar, and
- Individual papers for each presentation in the Swine Information Library (www.aasv.org/library/swineinfo/).

Members can also access the conference videos at www.aasv.org/members/only/video. Along with the Golden Anniversary video, you can view the Veterinarian's Oath video, seminar and session introduction videos, and recordings of the general session and the Vaccinology and Immunology breakout session presentations.

If you have forgotten your AASV username or password, select the "Reset Password" link in the upper right of the AASV website to receive them by email. Need to pay your 2019 AASV membership dues? Go to ecom.aasv.org/membership. Please allow a few days for your membership record to be updated.

Photos are courtesy of Tina Smith.

Thank you, AASV Annual Meeting sponsors!

Members of AASV attending the annual meeting make a substantial investment in the form of registration fees, travel, lodging, meals, and potential loss of income while away from work. However, the cost of attendance would be even greater – or the quality of the meeting experience reduced – if it were not for the financial support provided by corporate sponsors for refreshments, meals, social activities, as well as scholarships and travel stipends for veterinary students. The AASV extends its sincere appreciation for the sponsorship of meeting events by the following companies:

- Boehringer Ingelheim Vetmedica, Inc (AASV Luncheon)
- CEVA Animal Health (Refreshment Break Sponsor)
- DSM Nutritional Products (Exercise Class)
- Elanco Animal Health (AASV Foundation Veterinary Student Scholarships, Social Media Center)
- Hog Slat (Refreshment Break Co-sponsor)
- Merck Animal Health (AASV Awards Reception, Student Swine Trivia Event, Student Reception, AASV Foundation Veterinary Student Scholarships)
- Newport Laboratories (Veterinary Student Travel Stipends, Veterinary Student Poster Scholarships)
- Quality Technology International (Refreshment Break Sponsor)
- Stuart Products (Praise Breakfast)
- Zoetis (Welcome Reception, AASV Student Seminar and Student Poster Session, AASV Foundation Top Student Presenter Scholarship)

The AASV is also grateful to the 97 companies and organizations that provided support through their participation in the 2019 Technical Tables exhibit.

Thank you all!



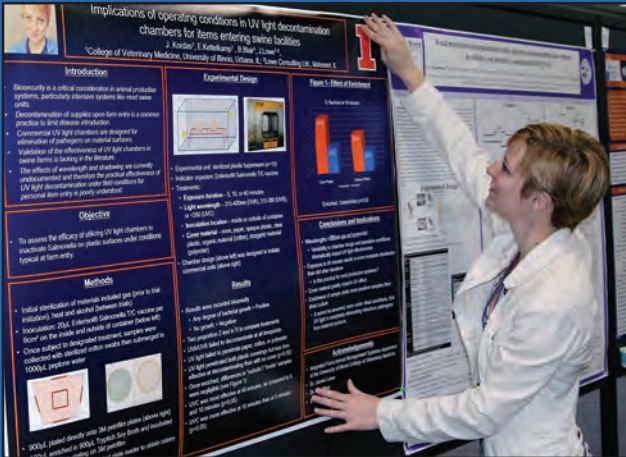
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FOUNDATION NEWS

Three research projects funded in 2019

Dr Paul Ruen, chairman of the AASV Foundation, announced the selection of 3 research proposals for funding during the foundation's annual luncheon on March 10th in Orlando, Florida. The foundation granted a total of \$60,000 to support efforts by researchers at Iowa State University, University of Minnesota, and Kansas State University.

A \$30,000 grant was awarded to help Dr Locke Karkiker and co-investigators at Iowa State University answer the question, "Does knowledge of testing procedures or the format of culture and susceptibility reports from veterinary diagnostic laboratories influence antimicrobial selection decisions?" The two objectives of the study are to determine if training on how laboratory susceptibility results are generated changes antimicrobial selection and to determine if the format and context of antimicrobial susceptibility reports changes antimicrobial selection. Results of the study will be disseminated through veterinary continuing education for veterinarians, peer-reviewed publication, and updated professional curriculum. Data from this study may support further studies aimed at influencing behaviors that could impact antimicrobial resistance.

Dr Fabio Vannucci and co-investigators at the University of Minnesota were awarded \$19,700 to fund the project, "Development of a diagnostic platform for *in situ* detection and subtyping of PRRSV within histological lesions." The goals of the project are to develop and validate a novel RNA-*in situ* hybridization (RNA-ISH) for *in situ* detection and genotyping of porcine reproductive and respiratory syndrome virus (PRRSV) strains in lung lesions, to evaluate the analytical performance and agreement between PRRSV open reading frame 5 sequences detected by RNA-ISH in lung lesions and by classical sequencing obtained from tissue homogenate, and to differentiate wild-type PRRSV from vaccine strain in lung tissues of animals naturally infected during outbreak scenarios. The



AASV Foundation Chairman Dr Ruen (left) with Drs Vannucci, Coetzee, and Karkiker, whose research proposals were selected for funding by the foundation.

research will offer a rapid diagnostic tool to genetically characterize PRRSV strain in association with histopathological lesions.

The foundation granted \$10,300 to Dr Hans Coetzee from Kansas State University to partially fund the proposal, "Evaluating the plasma pharmacokinetics, efficacy and tissue residues of oral firocoxib following transmammary delivery from sows to piglets." He and co-investigators will describe the pharmacokinetics and bioavailability of oral firocoxib in sows, develop and validate a drug regimen for transmammary delivery of oral firocoxib from sows to piglets at processing, and describe the tissue residue concentrations of firocoxib in sows and piglets following oral administration. This research will optimize the dose, duration, and frequency of administration of oral firocoxib in sows for transmammary delivery to piglets prior to processing so that this can be safely and effectively implemented on swine production systems.

Dr Teddi Wolff chaired the scientific subcommittee responsible for reviewing and scoring the proposals received for consideration, and she joins the foundation in thanking Drs Rick Swalla, Robyn Fleck, Matt Ackerman, Luc Dufresne, and Clayton Johnson for their participation on this important subcommittee. Each proposal submitted was given careful consideration.

An overview of past and current projects funded by the foundation is available at www.aasv.org/foundation/research.htm. The foundation will issue its next call for research proposals in the fall of 2019.

Foundation honors Henry with prestigious Heritage Award

Dr Steven Henry received the American Association of Swine Veterinarians Foundation's Heritage Award during the AASV's 50th Annual Meeting in Orlando, Florida. Dr Paul Ruen, AASV Foundation chair, presented the award to Dr Henry during the AASV Awards Reception on March 11th. He becomes only the fifth recipient of the award, which recognizes individuals who have lifelong outstanding achievements in swine veterinary medicine. It is only awarded on an as-needed basis (not necessarily annually) when a deserving individual has been nominated and selected. Awardees have demonstrated their eligibility through their membership in the AASV, service to the AASV, and service to the North American swine industry.

Henry received his doctor of veterinary medicine from Kansas State University's College of Veterinary Medicine in 1972. After graduation, he practiced in Illinois as a general practitioner before returning to Kansas in 1976, where he practiced with his partners at Abilene Animal Hospital, PA, retiring in 2017.

For more than 45 years, Dr Henry has specialized in health management and diseases of swine. With an expertise in disease prevention and diagnosis in optimizing swine herd productivity, he has consulted in North and South America, Asia, and Australia. He shares his knowledge of swine health by presenting continuing education courses for veterinarians and students at Kansas State University. He has an extensive publication history in professional and industry publications and has authored veterinary book chapters.

A Diplomate of the American Board of Veterinary Practitioners in Swine Health Management, Henry received the first Allen

D. Leman Science in Practice award, was recognized as AASV's 1981 Swine Practitioner of the Year, and received the Howard Dunne Memorial award in 2002. He was also recognized by Iowa State University with the Science with Practice Award in 2014. Dr Henry was honored as a Distinguished Veterinary Alumnus by Kansas State University in 2002.

Dr Henry has been involved in various AASV committees, represented AASV in the American Veterinary Medical Association's (AVMA) House of Delegates, and served AASV as president in 1982. Henry has served on the US Food and Drug Administration Center for Veterinary Medicine's Advisory Committee and the AVMA's Council on Biologic and Therapeutic Agents.

Dr Henry was also a pork producer and has served on numerous committees for the National Pork Producers Council and the National Pork Board.

When asked to reflect on his career as a swine veterinarian and his involvement with AASV, Dr Henry replied, "I am so proud of the AASV and what it continues to accomplish! To be recognized by my peers with this honor is most humbling. Just the opportunity to spend my career in this wonderful industry, to be a part of the progress in advancing the health of pigs was reward enough. Of course, recognition makes it all the more special."

He elaborated, "The AASV, begun as a small specialty species group of the AVMA, rapidly shed this cocoon to include experts from many diverse fields. With core missions of science, education, collaboration, and communication, the AASV advanced the careers of all of us. Now members are leaders in the world swine industry, providing expertise on



Dr Steve Henry, recipient of the AASV Foundation Heritage Award.

health and production challenges. Because members so willingly share and collaborate, the capability to actually eliminate diseases and pathogens from herds is now an accepted standard of care. Swine medical care has evolved from 'attend to these sick pigs and clean up the mess' to elimination of the pathogen so there won't be another mess. It takes strong, visionary leaders to accomplish such big leaps. And the AASV organization and members have done just that! What a wonderful place to have as my 'veterinary home' for an entire career. Being recognized for having fun with pigs and people for these many years is special beyond words."

Henry and his wife Vangie enjoy time on their farm with their children, grandchildren, and great-grandchildren. A cellist, Henry plays with the Salina Symphony Orchestra and enjoys the time spent in various ensembles.

Past presidents rise to the challenge

During August 2017, then AASV Foundation Chairman Dr John Waddell initiated the Past Presidents' Challenge to help the foundation achieve its \$2 million goal by the 2019 AASV 50th Anniversary Annual Meeting. Dr Waddell challenged each of his fellow past presidents to recruit at least 3 new Leman, Heritage, or Legacy donors. To count toward the goal, the donors could have been members who had yet to support the foundation at any level, or those wanting to increase their support from Leman to Heritage or from Heritage to Legacy.

Past presidents accepted this challenge. Fourteen past presidents earned points in the competition by encouraging new endowment contributions. The point system was based on the amount of the donation; the establishment of a Legacy Fund (\$50,000) was worth 50 points, a new Heritage Fellow (\$5000) generated 5 points, and a new Leman Fellow (\$1000) was worth 1 point in the competition.

The Past Presidents' Challenge winner was Dr Joe Connor with 59 points; he will receive

complimentary registration and suite lodging for the 2020 Annual Meeting in Atlanta. Runners-up were Tim Loula (56 points) and Bob Morrison (52 points). Lisa Tokach solicited five new or level-up donors, Joe Connor solicited four, and Tim Loula, Bob Morrison, and Paul Ruen each had three.

The Leman, Heritage, and Legacy contributions provide the basis for a perpetual source of income for foundation programs, including scholarships, swine externship grants, travel stipends for veterinary students, research grants, and more.

Chelsea Stewart receives inaugural student debt relief scholarship

Dr Chelsea Stewart, a 2016 graduate of Iowa State University's College of Veterinary Medicine and continuous AASV member since joining as a student in 2013, received the newly established AASV Member Student Debt Relief Scholarship in Orlando, Florida, on March 11th.

The purpose of the \$5000 scholarship is to help relieve the student debt of recent veterinary graduates engaged in swine practice who still have significant debt burden. Qualified applicants must have been engaged in private practice with at least 50% of their time

devoted to swine, providing on-farm service directly to independent pork producers.

After graduation, Dr Stewart joined the Sheldon Veterinary Medical Center in Sheldon, Iowa, where she spends at least 65% of her time providing veterinary support to independent pork producers, including farrow-to-finish farms with 10 to 2500 sows and various sized wean-to-finish farms. Providing outstanding service, Stewart performs herd health visits, postmortem analysis, diagnostic services, and follow up care and communication.

Dr Stewart credits her involvement with AASV as a student to her success as a swine veterinarian. Relationships made during AASV student networking events fostered interest in swine medicine and mentorship with colleagues. She hopes to keep engaging students and promoting swine medicine.

The new scholarship was initiated with a generous \$110,000 contribution to the foundation by the Conrad Schmidt and Family Endowment. Dr Schmidt, a charter member of AASV, explained, "Together, Judy and I noticed that many new DVM graduates interested in swine medicine begin their professional life with heavy educational debt obligations. As a long-time AASV member and animal industry supporter, it was our desire to help AASV members who have dedicated their professional skills to swine herd health and production. We hope that this endowment will grow over time to assist in reducing the educational debt load of AASV members as they begin their professional journeys."

When asked to comment about receiving the scholarship, Dr Stewart replied, "I am incredibly honored to have received this inaugural student debt relief scholarship. The idea of helping new graduates who are actively paying off their debt burden is fantastic, and I am so thankful to have been the recipient of this scholarship."



Dr Conrad and Mrs Judy Schmidt with Dr Chelsea Stewart, the first recipient of the AASV Member Student Debt Relief Scholarship.

Foundation endowment reaches its \$2 million big hairy audacious goal

The American Association of Swine Veterinarians Foundation (AASVF) successfully reached its goal of achieving total assets of \$2 million by the 2019 celebration of AASV's 50th anniversary, while at the same time maintaining its ongoing commitment to fund research, scholarships, externships, tuition grants, and other programs and activities that benefit the profession of swine veterinary medicine.

During the recent AASV Foundation Luncheon in Orlando, Florida, Foundation Chairman Dr Paul Ruen announced the establishment of two new Legacy Funds. The Legacy Fund represents the highest level of the foundation's triad of endowed giving programs (Leman, Heritage, and Legacy), with a minimum \$50,000 contribution required to establish a named endowment.

A generous \$110,000 donation from the Dr Conrad Schmidt and Family Endowment initiated a new AASV member student debt relief scholarship. Dr Joe and Callie Connor

designated their Legacy Fund's proceeds to be used for research, education, and long-range issues.

Dr Ruen also announced five new Heritage Fellows:

- Dr Jim and Carol Dick,
- Drs William and Brigit Hollis,
- Dr Aaron and Roberta Lower,
- Dr David and Carol Reeves, and
- Dr Paul and Susan Ruen.

If you are ready to lend your support and help build the endowment to ensure future support of the swine veterinary profession, visit www.aasv.org/foundation or contact the foundation by phone, 515-465-5255, or email, aasv@aasv.org.

AASV Foundation endowed giving programs

Leman

Named for the late industry leader and former AASV president Dr Allen D. Leman,

this giving program confers the title of Leman Fellow upon those who make a contribution of \$1000 or more to the foundation endowment.

Heritage

The Heritage Fellow program recognizes contributions of \$5000 or more. In addition to monetary donations, other giving options such as life insurance policies, estate bequests, and retirement plan assets may be used.

Legacy

A donor, multiple donors, or a veterinary practice may establish and name a Legacy Fund with a gift of \$50,000 or more. The fund may be named after the donor or another individual or group. The donor designates which of three foundation mission categories the fund's proceeds will support: 1) research, 2) education, or 3) long-range issues.

Foundation announces recipient of Hogg Scholarship

Dr Erin Lowe was named the 2019 recipient of the American Association of Swine Veterinarians Foundation Hogg Scholarship. Mary Lou Hogg presented the scholarship during the American Association of Swine Veterinarian's 50th Annual Meeting in Orlando, Florida.

Established in 2008, the scholarship is named for Dr Alex Hogg who was a leader in swine medicine and pursued a master's degree in veterinary pathology after 20 years in a mixed-animal practice. The scholarship is awarded annually to an AASV member who has been accepted into a qualified graduate program to further his or her education after years as a swine practitioner.

Dr Lowe earned her doctor of veterinary medicine with highest honors in 2004 from the University of Illinois. She completed the Executive Veterinary Program in Swine Health Management at the University of Illinois in 2009. Since graduating, Dr Lowe has been involved with the pork industry as a veterinarian, production manager, and a technical services veterinarian. She is currently the associate director of field services and data integration with Boehringer Ingelheim Animal Health. She has an interest in



Mary Lou Hogg congratulates Dr Erin Lowe for being awarded the Alex Hogg Memorial Scholarship.

improving business and health outcomes by increasing accessibility and usability of data. Recognizing the changing knowledge and skills required of a swine veterinarian, and a desire to better serve the industry through

strategic thinking and data management, Dr Lowe has been accepted into the Master of Science-Information Management program in the iSchool at the University of Illinois.

Auction raises \$80,000

The 2019 American Association of Swine Veterinarians Foundation (AASVF) held its annual fundraising auction on March 11th during the 50th AASV Annual Meeting in Orlando, Florida. This year's auction raised \$80,000!

The funds raised during the auction support foundation programs, including student travel stipends, research projects, scholarships, student externships, awards, support for veterinarians pursuing board certification in the American College of Animal Welfare, and other opportunities to enhance the personal and professional aspects of swine veterinary medicine.

Auctioneer Dr Shamus Brown called the auction assisted by Wes Johnson, who generously lent his capable clerking services. The spirited live auction raised \$38,000 in addition to the \$18,930 collected during the silent auction and \$23,070 in cash donations. All bidding in the silent auction was paperless; bids were submitted electronically via ClickBid Mobile Bidding.

The foundation thanks all those who participated in the auction by bidding on or donating items, as well as those who served on the auction committee chaired by Dr Butch Baker. Visit www.aasv.org/foundation/2019/auctionlist.php to view auction results.



Special thanks go to bid-takers Butch Baker, Joey Burkgren, Tom Burkgren, Jeff Harker, Howard Hill, Dave Madsen, David Reeves, and John Waddell, who watched and encouraged bidders. The auction was a success because of the behind-the-scenes and front-end help from Miranda Ayers, Joey Burkgren, Abbey Canon, Sue Kimpston, Kay Kimpston-Burkgren, David and Karen

Menz, Karen Richardson, Lee and Sue Schulteis, Tina Smith, Harry Snelson, and Sherrie Webb.

An extra-special thanks goes out to Lee Schulteis and David Menz for driving the truck and trailer containing all the auction items and meeting materials from Perry, Iowa, to Orlando and back again.

Foundation news continued on page 177

And the winners are...

Thank you to ALL who made a contribution or placed a bid on items in the live and silent auctions.

Thanks to your generosity, the auction raised \$80,000 for the AASV Foundation!

We are pleased to recognize the winning bidders who purchased one or more items at the auction:

Kent Adams	Tara Donovan	Randy Jones	Michelle Michalak	Kent Schwartz
Roberta Alvarez	RC Ebert	Dianna Jordan	Bill Minton	Steve Sornsen
Matt Anderson	Jeff Feder	Kerry Keffaber	Eric Moore	Bill Starke
Paul Armbrecht	Mark FitzSimmons	Marcus Kehrl	David Nolan	Rick Tubbs
Aurora Pharmaceutical	Christa Goodell	Jason Kelly	Russ Nugent	Liz Wagstrom
John Baker	Jeff Harker	Joel Burkgren	Chris Olsen	Tom Wetzell
Corinne Bromfield	Perry Harms	Paul Knoernschild	Tom Petznick	Kristen White
Shamus Brown	Peggy Anne Hawkins	John Kolb	Phibro Animal Health	Warren and Marilyn Wilson
George Charbonneau	Jason and Sara Hocker	Chris Kuster	Michael Pierdon	Paul Yeske
Scanlon Daniels	William Hollis	Rodger Main	Alex Ramirez	
Todd Distad	Megan Inskeep	David and Karen Menz	Steve Schram	



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¹Data on file, Merck Animal Health.

²Based on label claims of product including 3 days of age and demonstrated five-month duration of immunity.



Ten veterinary students receive \$5000 scholarships

In partnership with the American Association of Swine Veterinarians Foundation (AASVF), Merck Animal Health announced the 2019 recipients of the AASVF-Merck Animal Health Veterinary Student Scholarships.

The recipients, who were each awarded a \$5000 scholarship, were:

- Kayla Castevens, North Carolina State University
- Grace Elijah, Kansas State University
- Matt Finch, Iowa State University
- Taylor Homann, University of Minnesota
- Sophie Leone, Colorado State University
- Jamie Madigan, North Carolina State University
- Elizabeth Noblett, North Carolina State University
- Shelby Perkins, University of Missouri
- Rachel Stika, Iowa State University
- Zach Talbert, University of Illinois

The scholarship program, now in its fourth year, was funded by a generous \$50,000 contribution from Merck Animal Health, assisting the foundation's mission to support the development and scholarship of students and veterinarians interested in the swine industry.



Recipients of the \$5000 AASVF-Merck Veterinary Student Scholarship (from left): Shelby Perkins, University of Missouri; Grace Elijah, Kansas State University; Rachel Stika, Iowa State University; Sophie Leone, Colorado State University; Kayla Castevens, North Carolina State University; Elizabeth Noblett, North Carolina State University; and Taylor Homann, University of Minnesota. Also pictured (from left) are Drs Jack Creel, Joe Roder, and Justin Welsh, Merck Animal Health. Scholarship recipients not pictured: Matt Finch, Iowa State University; Jamie Madigan, North Carolina State University; and Zach Talbert, University of Illinois.

Second- and third-year students enrolled in American Veterinary Medical Association-accredited or recognized colleges of veterinary medicine in the United States, Canada,

Mexico, South America, and the Caribbean Islands were eligible for the scholarship. Learn more at www.aasv.org/foundation.

Social media raises money for AASV Foundation #AASV2019

Elanco Animal Health graciously hosted a social media booth at the annual meeting to encourage all AASV members to join social media to promote the swine industry, share lessons learned, and celebrate the great achievements in swine health accomplished during the last 50 years.

Along with Elanco representatives, AASV student members explained the various social media platforms to those who were unfamiliar. Large screens at the booth displayed live monitoring of real-time social media issues that pertain to the swine industry, showing how many were "talking" about pigs, pork,

animal health, and foreign animal diseases. Elanco donated \$1 for each mention of #AASV2019 on Twitter or Instagram during the meeting (up to \$2500), and raised \$676 for the foundation. Consider joining next year's #AASV2020 conversation!

Phibro Animal Health makes \$25,000 endowment match – again!

For the third year of its 4-year commitment, Phibro Animal Health is contributing \$25,000 to the AASV Foundation endowment, thanks in part to contributions by AASV members. In 2016, the company pledged to donate up to \$100,000 over 4 years by matching \$25,000 of the endowed contributions made by AASV members each year. Phibro's most recent match brings the

company's total donation to \$75,000 so far, with one year remaining in the pledge.

AASV member contributions to the Leman, Heritage, and Legacy programs are endowed and count towards the match total. If you haven't already become a Leman, Heritage, or Legacy donor, help the foundation make the most of this matching opportunity by

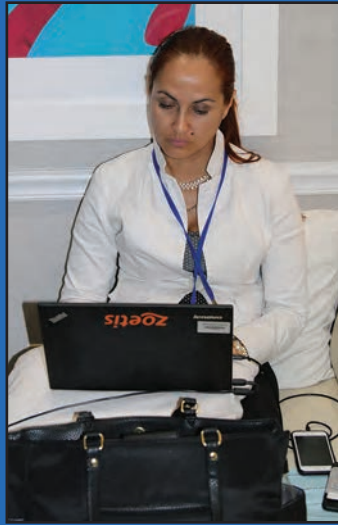
doing so in 2019. And be sure to thank Phibro Animal Health for their ongoing commitment to support swine veterinarians and the AASV Foundation!





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¹ Radke, S.L., Olsen, C.W., Ensley, S.M., (2018) Elemental impurities in injectable iron products for swine. *The Journal of Swine Health and Production*, 26(3).

² Gaddy H et al. A review of recent supplemental iron industry practices and current usage of Uniferon[®] (iron dextran complex injection, 200 mg/mL) in baby pigs. *AASV*. 2012; 167-171.

³ Haugegaard J et al. Effect of supplementing fast-growing, late-weaned piglets twice with 200 mg iron dextran intramuscularly. *The Pig Journal*. 2008; 61; 69-73.

⁴ Olsen C and Fredericks L. Impact of iron dose and hemoglobin concentration on wean-to-finish weight gain. *IPVS*. 2018; 910.

Citation. Title. *J Swine Health Prod.* 2018;26(5):000-000.

Swan song and new beginnings

I was on a plane a few years ago and the woman sitting next to me asked about my profession. I told her I was a swine veterinarian to which she responded, “Oh, I love those birds! Tell me, how do they change from black to white?” After a moment of puzzlement, it occurred to me that she thought I said “swan” veterinarian. I will attribute the misunderstanding to the engine noise rather than my Southern accent, since I do not have one. Anyway, after having the joy of writing this column 6 times a year for the last 13 years, this article will be my swan song.

I have used this column as a mechanism to try to provide a more in-depth look at our advocacy efforts on behalf of the association

regarding current issues facing swine veterinarians. The fact that I am not an expert on many of the issues has never stopped me from taking the opportunity to educate anyone who would listen, as evidenced by my 30-minute conversation with my seatmate regarding swans. I am happy to say that the AASV has the great fortune of having hired a couple of bona fide experts in the fields of animal welfare and public health—Mrs Sherrie Webb and Dr Abbey Canon, respectively. Sherrie has a master’s degree in animal science with an emphasis on stress physiology and spent 13 years as the director of animal welfare with the National Pork Board. Abbey has a doctor of veterinary medicine

degree, a master’s degree in public health, is board certified in the American College of Veterinary Preventative Medicine, and worked for the Centers for Disease Control and Prevention.

I thought I would take the opportunity with this issue to let Sherrie and Abbey introduce themselves, give a little of their background, and offer their thoughts about the impact of swine welfare and public health on the future of the swine industry. I obviously leave this column in very capable hands and look forward to turning it over to them.

Harry Snelson, DVM
Executive Director

Protecting animal welfare

The American Veterinary Medical Association revised the veterinarian’s oath in 2011 to include the protection of animal welfare and the prevention and relief of animal suffering to clearly identify animal welfare as a priority of the veterinary profession. While this addition occurred within the past 10 years, animal welfare has been at the heart of veterinary medicine for far longer. The primary focus has been within

the realm of animal health through prevention and treatment of disease, but the scope of animal welfare has expanded over the past 40 years as we learn more about complex social behaviors and how animals process information through experience and their senses.

During Dr Mary Battrell’s presentation at this year’s AASV Annual Meeting, she stated that part of her role as a veterinarian during a disease outbreak is to listen, teach, and coach. I would submit that veterinarians have a similar role for animal welfare. Veterinarians are in a key position to learn what challenges caretakers are facing when caring for their pigs and help identify areas of concern and opportunities for improvement to promote good welfare. Awareness of domestic and international animal welfare issues and good animal care practices allows veterinarians to serve as an important resource for producers as they make

decisions about daily animal care. These decisions obviously have a direct impact on the animal and its well-being but can also impact the well-being of the caretaker, the environment, the farm’s profitability, and the entire US pork industry.

After spending 13 years helping producers navigate pig welfare issues during my tenure at the National Pork Board, I was excited to shift gears and address these topics from a new perspective with a different audience, the veterinarian. My goal is to use this column to highlight timely domestic and international animal welfare topics that are of interest to swine veterinarians and the clients they serve. I invite and welcome your input on animal welfare topics of interest as well as ideas for animal welfare related resources you feel this organization should provide as a benefit to the broader AASV membership.

Sherrie Webb, MSc
Director of Swine Welfare



Healthy animals – healthy food – healthy people

My grandparents built a diversified family-farm in Iowa but retired when I was in elementary school. One generation too late, I desperately wanted to raise livestock. I helped many friends with 4-H and FFA projects and jumped into learning everything I could about animal agriculture. While studying animal science and international agriculture at Iowa State University, I took “Foods of Animal Origin,” which spurred me to investigate animal-based protein and human nutrition during two summer internships in Africa. The combination of my meat science classes and summer internships drove my career path. That was my first look at the link between healthy animals, healthy food, and healthy people. Driven by that link, my purpose in earning my DVM was never to work on individual animals; my DVM gave me the opportunity to improve human health *through* animals.

Now I know that this link is part of One Health—the concept that animal, human, and environmental health are all connected—

a buzzword with which many in the veterinary profession are familiar. But what role do we, as swine veterinarians specifically, have in One Health?

Of our 14 AASV committees, 4 are directly related to One Health or public health. Two more address One Health topics depending on what events might be occurring in swine health. Five involve personnel, the general public, and communication about top swine production issues, including One Health issues (eg, food safety, antibiotic use, and environmental impact).

The challenges human and swine health professionals simultaneously face continuously evolve, but the strong link between human and animal health and disease provides opportunities for collaboration and improved health for all. During the 50th AASV Annual Meeting, I repeatedly heard the call to work together. Cross-disciplinary collaboration, shared resources, and respect for each other’s strengths will help us accomplish our goals in the next half-century. I have always

been an advocate for the swine industry and all of animal agriculture. This has sometimes been challenging in the various human health roles I have held, but I appreciate the opportunity to represent animal health and agriculture to human health audiences, and human health to animal agriculture audiences. I strive to do what is best for both pigs and people.

As food-animal veterinarians, I am sure you do not need to be convinced why One Health is important. Everything you do impacts animal health, human health, and environmental health. You are swine veterinarians because people eat animal-based protein. The bottom line is we make safe, healthy, wholesome food for people.

I hope to use this column to continue bringing important issues to your attention and create awareness of advocacy efforts on behalf of the association regarding current issues facing swine veterinarians. We are here for the pigs, but we cannot forget that the pigs are here for the people.

Abbey Canon, DVM, MPH, DACVPM
Director of Communications



UPCOMING MEETINGS

World Pork Expo

June 5-7, 2019 (Wed-Fri)
Iowa State Fairgrounds
Des Moines, Iowa
Hosted by the National Pork Producers Council

For more information:
Web: www.worldpork.org

8th International Symposium of Emerging and Re-Emerging Pig Diseases

June 23-26, 2019 (Sun-Wed)
CasaPiedra Conference Center
Santiago, Chile

For more information:
Email: emerging2019@grupodos.cl
Web: emerging2019.com

LIII National Congress AMVEC 2019

July 23-26, 2019 (Tue-Fri)
Guadalajara, Jalisco, Mexico
Hosted by the Asociación Mexicana de Veterinarios Especialistas en Cerdos A.C.

For more information:
Tel: +52 378 705 0345
Email: administracion@amvec.com
Web: www.amvec.com/blog/amvec-1/post/expo-industrial-amed-2019-1

IXth International Conference on Boar Semen Preservation

August 11-14, 2019 (Sun-Wed)
Hunter Valley, NSW, Australia

Earlybird registration deadline: May 10

For more information:
ASN Events Pty Ltd
Head Office: 9/397 Smith Street
Fitzroy VIC 3065
Australia
Tel: +61 3 8658 9530
Fax: +61 3 8658 9531
Email: rh@asnevents.net.au
Web: www.boarsemen2019.com

Asian Pig Veterinary Society Congress 2019

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

For more information:
Amy Chang (Secretariat of APVS 2019):
802, InnoN, 66, Seongsui-ro, Seongdong-gu, Seoul
Republic of Korea
Tel: +82 2-2190-7331
Email: moon@innon.co.kr
Sue Jo (Secretariat of APVS 2019):
Tel: +82 2-2190-7327
Email: sue@innon.co.kr
Web: www.apvs2019.com

Allen D. Leman Swine Conference

September 14-17, 2019 (Sat-Tue)
Saint Paul RiverCentre
Saint Paul, Minnesota
Hosted by the University of Minnesota

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

Pig Welfare Symposium

November 13-15, 2019 (Wed-Fri)
Minneapolis Marriott City Center
Minneapolis, Minnesota
Hosted by the National Pork Board

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

American Association of Swine Veterinarians 51st Annual Meeting

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

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



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

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Photo Corner

Nursery pig at University of
Missouri Swine Teaching Center

Photo courtesy of Tina Smith

AASV Resources online at www.aasv.org