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JSHAP SPOTLIGHT

Dr Meghann Pierdon

University of Pennsylvania School of Veterinary Medicine

Dr Meghann Pierdon earned a BS ('01) from Wellesley College, a VMD ('05) from the University of Pennsylvania, and is a diplomate in the American College of Animal Welfare ('18). She is currently an Assistant Professor where her work focuses on using geographic information systems (GIS) to share information with swine and poultry farmers about nonreportable diseases that are endemic, and to help farmers prepare for and prevent the introduction of foreign animal diseases. Dr Pierdon's research interests include gathering information from GIS on risk factors for disease introduction and current welfare issues such as lameness and enrichment. Dr Pierdon joined the JSHAP Editorial Board to use her welfare expertise and understanding of the industry to add perspective to the practicality and implications of welfare research.


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Find joy in your work

By the time this message reaches you, 2021 will be behind us and we will be anxiously awaiting the opportunity to gather at the 2022 AASV Annual Meeting in Indianapolis, Indiana. The program looks great. My congratulations to Dr Mike Senn and the AASV Planning Committee as they have done an outstanding job in assembling talented speakers on a diverse array of topics. I certainly hope you can join us! Please take a moment to thank our sponsors. We greatly appreciate their support and do not forget to assist the AASV Foundation. They do so much on our behalf.

The past couple of years have been fraught with challenges that you do not need me to reiterate. I am also not going to talk to you about work-life balance, because I am the worlds' worst at it. What I can share is how I find joy in my everyday work life.

What I love about being a swine production veterinarian is the diversity. No two days are the same. We have such a wide range of responsibilities. There are farms to visit, diagnostic samples to submit, results to interpret, interventions to communicate, data to enter, and trends to monitor. We have budgets, vaccine schedules, medication protocols, prescriptions, and Veterinary Feed Directives to update. We are constantly teaching and training people either in a formal setting, small group, or one-on-one as we walk through a farm. It is the wide range of responsibilities and challenges that fuel us and keep us interested. Some of our day-to-day responsibilities are tasks we complete out of necessity, and others bring us joy. When I get down, I actively seek joy in my work, and sometimes it just finds me.

We are doing an off-site breeding project as part of a herd health upgrade. We move weaned sows to a farm that has sat empty for a while. It is old school, no automatic feed system, the boars are walked on a harness, and all records are handwritten and sent in for computer entry. It is a temporary project so rather than staffing the farm, we are rotating four sow farm managers to work in pairs each day. I volunteered to help on the weekends to give them some time off. I quickly learned that I am not as young as I once was and do not have near the stamina or physical strength of my youth. After the boars drug me around the barn a couple of times, we decided to block off the aisle and move them with a herding board. One young boar is so much fun to watch. I named him Elvis, because when he enters the building, the ladies go wild. He struts up and down the aisle a couple of times, then settles down and literally must stop and chat with every sow. He makes them all feel special. He is quite the boar and helped remind me how very much I love animals. Just watching him put a smile on my face. These four farm managers have been with us a decade or more. They have seen each other at staff meetings but had never worked together. We will all be glad when the project is complete and we get back to our routines, but we have all enjoyed it too. Everyone gets along, there is no employee drama, no audits, no weekly safety training, and not much mechanical maintenance requirements. We have all enjoyed the opportunity to get more time in the barn working with animals and enjoyed getting to know each other and transitioning from coworkers to friends.

"When I get down, I actively seek joy in my work, and sometimes it just finds me."

I encourage you to take a day to do what brings you joy at work. Go visit your healthiest, best performing pigs, spend an afternoon in the farrowing house or breeding barn with your favorite client, or give a presentation on your favorite topic. Take a moment to devote time to whatever puts a smile on your face and energizes you.

I hope you more seasoned practitioners are providing extra encouragement to our newer members of the swine veterinarian profession. Please let them know that our industry, like many others, has its ups and downs. Events of the past couple of years are not normal. Help them find their niche, that part of their job that puts a smile on their face.

We could have some rough roads ahead, but we will work together, use science to guide us, and come up with solutions for the betterment of the pig. That is our legacy. Go find the fun in your job and take a moment to remember why you chose this profession.

Mary Battrell, DVM
AASV President

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I am still a pig vet

A couple of events happened over the last few weeks that caused me to ponder my professional identity. The first was attending the inaugural AASV Early Career Conference. The Early Career Committee has been very active since their inception a couple of years ago. There is obviously a lot of interest among recent graduates in learning more about practice, finances, and life management. Just looking at the agenda for the conference made me harken back to my early days in practice more than 30 years ago. I wish I had had the opportunity (or foresight) then to take advantage of some of the tools offered during the conference. Just being surrounded by all those recent graduates made me think about how much my professional career had changed from what I had imagined when I entered veterinary school. Even following graduation, my career ambitions and direction have changed a number of times. I have been a practitioner, technical services representative, swine industry legislative advocate, communicator, and association executive director. Sort of a nontraditional veterinary career path. I prefer to think of it less as an indication that I cannot hold a job and more as evidence of my willingness to take advantage of opportunities.

The second event was when an AASV member currently using their veterinary training in a nontraditional role mentioned that they were now being introduced as someone who "used to be a real veterinarian" or "used to be a pig vet." I have had this same or similar experience myself. It made me think about how I perceive myself from a professional standpoint. It occurred to me that when I introduce myself in a professional group setting, without even thinking, I almost always say, "I am a swine veterinarian and the Executive Director of AASV." I have found, however, that this can sometimes be misconstrued depending on the situation. Awhile back on an airplane, I had a lady ask me what I did for a living. When I responded that I was a swine veterinarian, she perked up immediately and said, "Oh, I love those birds! Why do they change from black to white?" I don't know if it was our noisy surroundings or my southern accent that caused the misunderstanding, but I digress.

I have found that our veterinary training and experience opens a wealth of opportunities for us to explore. I would guess it is not uncommon for veterinarians to retire doing something entirely different from what they thought they would do when they applied to veterinary school. I have had the good fortune to watch many of you over the years change focus and direction as you have progressed through your careers. I hope each one of those changes has been educational and a growth experience.

It is interesting that we are often professionally identified with the job we currently hold rather than the credentials we earned. There are a few occurrences in your life that are, in fact, life changing. For me, one of those was achieving a doctorate in veterinary medicine. A DVM is something I will always be.

Earning my DVM gave me the opportunity to become a swine vet. Although I have been employed in a number of roles, I am still a pig vet at heart. That is where my passion lies and what drives my professional endeavors. Professionally, I still identify first and foremost as a veterinarian and, in particular, a swine vet. It is that training and experience that has afforded me the opportunity to do the things I have done. This profession has allowed me to work with some really great veterinarians and swine farmers. Swine veterinary medicine has taken me all over the country and the world to visit places I would have never experienced without that DVM behind my name.

"I have found that our veterinary training and experience opens a wealth of opportunities for us to explore."

So, whether you are just starting your career or you are exploring a new professional path, do not lose sight of the fact that you will always be a veterinarian. And feel free to remind folks if they fail to see the significance of that accomplishment.

Harry Snelson, DVM
Executive Director

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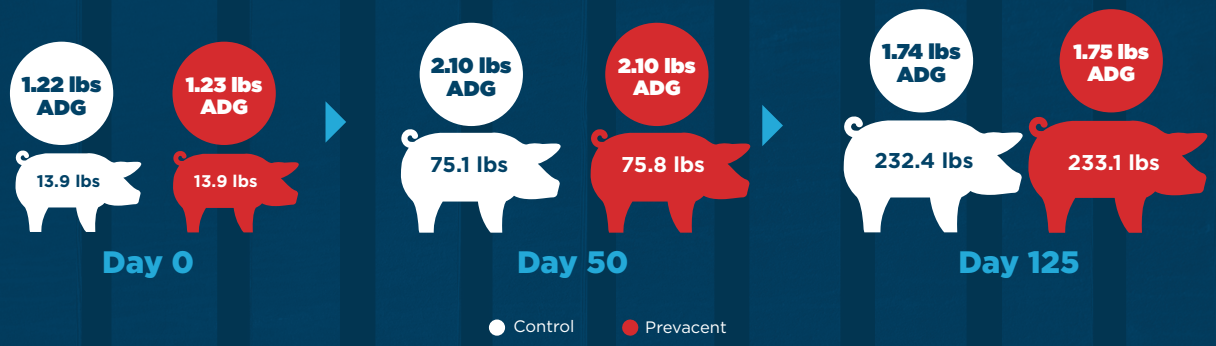

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[1]Yeske PE, Betlach A, Evelsizer RW, et al. Evaluation of shedding and effect on pig performance of Prevacent PRRS vaccine in commercial conditions. AASV Annual Meeting. 2021:203.

New year, new ideas, new knowledge

Welcome to 2022 and to the January-February issue of JSHAP. I hope you find the information in this issue interesting and informative. We have a robust line-up of manuscripts planned for the early issues of the journal. In fact, the year is already filling up with outstanding manuscripts to inform swine health and production and will bring new ideas and knowledge to our readership. As always, the journal's success remains possible due to the continued support of authors, reviewers, the editorial board, the AASV Industry Support Council, the staff in the AASV office, and the journal staff. Thank you for your hard work.

I introduced the topic of a digital object identifier (DOI) in my May-June 2020 message.[1] I can update you to say that the journal is now moving forward with the implementation of the DOIs in 2022. You will notice a change in the citation box of each manuscript to include the DOI for the publication. As a reminder, a DOI is a digital fingerprint for an electronic object (ie, our published manuscripts) and will provide a more permanent and reliable digital link to an object in comparison to a URL. The other benefit of a DOI is the ease to accurately link an object with other digital information such as citations, article corrections or retractions, and supplementary materials, to name a few. Even though the journal has been available online since 2007, the introduction of DOIs to our publications will increase accessibility. The process of implementing DOIs for past and future publications will take some time but the process has begun. Our Webmaster, David Brown, Graphic Designer, Tina Smith, and Associate Editor, Sherrie Webb, will be busy implementing this process in the coming months.

As I write this message, I can see out my window an early, but significant, winter season snowfall is happening. It has reminded me to put my snow tires on my truck and car but also reminded me to say, "send us some winter scene swine farm photos for the journal front cover." As you know, we publish a photo of a commercial swine barn or pigs on the front cover of each issue and the journal encourages our readers to submit photos. Tina Smith, our graphic artist, is always keen to receive some nice cold winter photos (all seasons in fact!) for our stock supply. For me, this time of year usually means taking my mittens off to get a good shot. But it is so worth the effort and appreciated by the journal staff. Our winter photo supply is lean, and so this winter I encourage you to stop and appreciate the scenery, take some pictures, and consider sending them to the journal.

"Even though the journal has been available online since 2007, the introduction of DOIs to our publications will increase accessibility."

I hope you enjoy this issue.

Terri O'Sullivan, DVM, PhD
Executive Editor

Reference

*1. O'Sullivan T. Digital object identifiers [Editorial]. *J Swine Health Prod*. 2020;28(3):117.

* Non-refereed reference.

Gilt rearing impacts on sow performance and longevity – a review

Jaroslava Belkova, PhD; Miroslav Rozkot, PhD

Summary

Lifetime performance and longevity are very important parameters of profitability in sow breeding. Opportunity to improve lifetime performance and longevity may be found in the rearing period and preparation of gilts for their future reproductive role. With the aim to prevent premature culling, it is possible to influence body condition, limb condition, mammary gland development, and proper function of the reproductive tract through nutrition, technology, and rearing strategies. Nutrition plays a very important role, as it can affect all the basic requirements for achieving satisfactory gilt performance. Selecting the most effective rearing strategy can be difficult because there are many factors affecting performance and longevity. The aim of this literature review is to provide up-to-date information on how sow longevity and performance can be influenced through choice of gilt rearing strategies and the important area of nutrition.

Keywords: swine, gilt, nutrition, performance, longevity

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Resumen - Impacto de la cría de primerizas en la producción y la longevidad de la cerda - una revisión

La producción de por vida y la longevidad son parámetros muy importantes de rentabilidad en la cría de las reproductoras. La oportunidad de mejorar el rendimiento y la longevidad de por vida se puede encontrar en el período de cría y en la preparación de las primerizas para su futura función reproductora. Con el objetivo de prevenir el desecho prematuro, es posible influir en la condición corporal, la condición de las patas, el desarrollo de la glándula mamaria, y el funcionamiento adecuado del tracto reproductivo a través de estrategias de nutrición, tecnología, y crianza. La nutrición juega un papel muy importante, ya que puede afectar a todos los requisitos básicos para lograr un desempeño satisfactorio de las primerizas. La selección de la estrategia de cría más eficaz puede resultar difícil porque hay muchos factores que afectan la producción y la longevidad. El objetivo de esta revisión bibliográfica es proporcionar información actualizada sobre cómo se puede influir en la longevidad y la producción de las cerdas mediante la elección de estrategias de cría de las primerizas, y la importante área de la nutrición.

Résumé - Impact de l'élevage des cochettes sur les performances et la longévité des truies - une revue

Les performances à vie et la longévité sont des paramètres très importants de la rentabilité de l'élevage des truies. La période d'élevage et la préparation des cochettes pour leur futur rôle reproducteur peuvent permettre d'améliorer les performances à vie et la longévité. Dans le but de prévenir l'abattage prématuré, il est possible d'influencer l'état corporel, l'état des membres, le développement de la glande mammaire, et le bon fonctionnement de l'appareil reproducteur grâce à la nutrition, la technologie, et les stratégies d'élevage. La nutrition joue un rôle très important car elle peut affecter toutes les exigences de base pour obtenir des performances satisfaisantes des cochettes. La sélection de la stratégie d'élevage la plus efficace peut être difficile car de nombreux facteurs affectent les performances et la longévité. L'objectif de cette recension de la littérature est de fournir des informations à jour sur la façon dont la longévité et la performance des truies peuvent être influencées par le choix des stratégies d'élevage des cochettes et le domaine important de la nutrition.

In addition to litter size and weight, longevity is a crucial indicator of sow herd profitability. Therefore, it is important to create optimal conditions for sows in the individual phases of their reproductive cycles. Even as producers can choose gilts in optimal physical condition, with a sufficient number of teats, and place them into a near-optimal environment, this still is no guarantee of achieving breeding success and longevity. It is important to begin giving special attention to gilts much earlier as they are being reared before inclusion into the breeding herd to ensure appropriate body development and onset of reproductive functions.

Longevity is associated with the level of culled sows. Although yearly replacement of 40% of sows is considered economically advisable, it varies within a wide range (62% for some US farms in 2019)[1] and depends upon the conditions and management of each herd. Even higher yearly replacement levels can be economically acceptable if breeding herd females are sufficiently productive, however, animal welfare and long-term economic viability may be concerns when replacement levels are above 50%.

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

Belkova J, Rozkot M. Gilt rearing impacts on sow performance and longevity – a review. *J Swine Health Prod*. 2022;30(1):10-16.

In a 2018 summary for the United States, PigCHAMP reported a mean culling rate of 45.06%.[2] The total culling rate included voluntary and involuntary culling. For voluntary culling, Mote et al[3] recommended obtaining at least three litters from each sow to return the investment in the sow. Selecting sows that can remain in the breeding herd for a longer time is beneficial for reproductive performance. The authors assume that the main reasons for culling do not change substantially over time, and this has been documented by publications over the years. Friendship et al[4] cited reproductive disorders (43%), limb problems (12%), and low performance (7%) among the most frequent causes for culling. Stupka et al[5] reported the most frequent causes for culling from farms to be reproductive issues (44%), musculoskeletal issues (19%), and other reasons such as milk production, health condition, and age (28%). Hadaš et al[6] performed an evaluation according to parity order and found the highest levels of culling were reached after the first and second parities, with 22% or 21% of sows culled from the sow herd, respectively, with reproductive failures (34%), musculoskeletal disorders (27%), and poor performance (18%) being the most frequent causes of culling. Poor mammary gland condition and health condition each represented less than 10% of the cases.[6] The percentage of sows culled and reason for culling are listed in Table 1. These reasons for culling indicate the areas that present room for improvement during the rearing and preparation of gilts. However, high level of involuntary culling can also be an indicator of poor staff skill or poor sow welfare.

Birth weight

Selection for improved prolificacy has resulted in larger litter sizes and thereby increased the proportion of low birth weight (LBW) piglets.[10] It is documented that LBW piglets have poorer grow-finish performance and carcass quality.[11-14] Birth weight also has a relationship with subsequent reproductive performance in gilts. Almeida et al[10] investigated the effects of birth weight on reproductive tract and ovarian follicle development in 150-day-old gilts. Twenty-eight female pigs of different birth weight ranges (high birth weight [HBW]: 1.8-2.2 kg; LBW: 0.8-1.2 kg) from higher-parity commercial sows were reared until 150 days of age. Their body weights (BW) were recorded at weaning, end of nursery, and end of grower–finisher phases. The gilts with LBW showed significantly lower BW and slower average daily gain during all phases of production compared to those in the HBW group ($P < .01$). Most biometrical measurements of the reproductive tract were similar between the experimental groups except vaginal length and the gonadosomatic index (relative ovarian weight) were affected by birth weight class ($P < .05$). The LBW females also showed fewer medium size (3-5 mm; $P < .01$) ovarian follicles, tended to have fewer pre-antral follicles ($P < .07$), and more atretic follicles per ovarian cortex area ($P < .05$). Therefore, in addition to affecting postnatal growth performance, birth weight influenced vaginal length and the follicular dynamics, which may impair the reproductive performance of replacement gilts.

Similarly, Vallet et al[15] found that total uterine length was positively associated with birth weights. Their results indicate that colostrum consumption, birth weights, preweaning growth rate, number weaned, and parity were associated with gilt development traits during later life.

Knauer[16] found that greater piglet birth weight was related to the proportion of gilts farrowing a litter. Greater piglet preweaning growth was related to the proportion of gilts that farrowed a litter and lifetime reproductive throughput. Hence, management strategies that improve colostrum production, milk production, and preweaning piglet growth should enhance subsequent lifetime productivity. Increased weaning age by 1 day added to a gilt's subsequent reproduction by 0.185 piglets/year, and gilts that were crossfostered were 2.45% less likely to farrow a litter.[15]

Mineral nutrition

It is well understood that nutrition plays an integral role in the development of a gilt. Gilts are to be bred rather than fattened so diets designed for finisher pigs may not meet the physiological needs of the replacement gilt.[17] Replacement gilts in the grower–finisher phase should receive specifically designed diets. Modern maternal line genotypes are more sensitive to nutritional management because their appetites are lower and they have exceptional lean growth potential.[18] Today's gilts are therefore more susceptible to deficiencies in nutrition, environment, and management.

To achieve better rearing performance in sows and improved growth of their pigs requires an adequate mineral supply, including trace elements. Foundation and skeletal development, birth weights, milk yield, and growth can be negatively influenced when minerals do not meet the animal's needs. Sow requirements for calcium (Ca), phosphorus (P), sodium, and chlorine, as well as zinc, iodine, and selenium are not met by feeding natural plant feeds, and so it is necessary that these be supplemented.[19]

One of the primary goals of replacement gilt nutrition is to increase mineral stores by maximizing bone mineralization. Finisher pig diets may not supply

Table 1: The percentage of sows culled and reason for culling

	Hadaš et al[6]	Engblom et al[7]	Balogh et al[8]	Wang et al[9]
Reproductive failure	34.0	26.9	47.0	34.65
Feet and leg problems	27.0	8.6	25.0	10.53
Poor performance	18.0	9.5	NA	5.0
Udder problems	8.0	18.1	NA	6.71
Old age	1.0	18.7	7.0	1.56
Other	10.0	NA	5.0	2.26

NA = not available

the correct balance of minerals to satisfy the nutritional requirements for reproductive performance and for cartilage and bone formation and integrity.[20,21] It is generally recommended that Ca and P be provided at levels greater than typically found in the grower–finisher diets in order to prevent females from experiencing locomotion problems later on due to excessive depletion of mineral stores during lactation periods.[22] Johnston[23] states that increasing bone mineralization has been shown to boost longevity of sows.

In gilt development diets, a minimum digestible Ca:P ratio of 1:1 is needed, and it varies depending on the P level. For example, it may be 1.25:1 if P meets the recommendations for 50 to 80 kg of live weight.[24] Also, Ca recommendations to maximize bone mineralization are greater than for growth (less than 1.35:1 if the concentration of P is at the requirement).[25] Even though growing gilts are generally provided *ad libitum* access to feed, the rapid growth rates in current genetic lines and high incidence of leg problems can lead to lameness. Lameness disorders account for 22.5% of sow cullings,[26] and lameness is one of the most important causes of reduced longevity and poor welfare in replacement gilts. The problem is exacerbated by inappropriate housing and diet during the rearing period.[27] Attempts to improve skeletal integrity by reducing growth rate through energy restriction have not been successful.[28] The application of management tools that are consistent with physiological processes is therefore required to reduce lameness issues.

A P deficiency can cause growth rate and bone mineralization to be suboptimal, albeit without effects on osteochondrosis (OCD).[29] Osteochondrosis is a frequent cause of lameness and consequently a reason for culling young sows. Genetic selection could be used to reduce the prevalence of OCD, although this may be difficult initially because the growth potential of lean tissue is genetically associated with OCD.[29] Other factors that could influence OCD progression are not well known. Heritability estimates of OCD score were similar for both Landrace and Yorkshire breeds, averaging about 0.21, in a genetic study by Yazdi et al.[30] The correlations between breeding values for longevity and OCD were low (on average 0.07, adjusted for genetic trends) but nevertheless significant ($P < .01$) and in a favorable direction, as greater OCD was associated with greater risk of being culled.

Fabà et al[31] supplemented the basic diet of growing gilts with organic microminerals (copper, manganese, and zinc at 10, 20, and 50 mg/kg, respectively) and observed this to enhance bone strength and bone density. Another diet with additional methionine (at a 102% methionine:lysine ratio) increased the proportion of highly dense bone (as measured by Hounsfield values). The combination of these two dietary treatments reduced OCD lesion scores compared to the basal diet.

Quinn et al[17] reported improved locomotion scores, higher bone mineral density, and lower cartilage lesion scores in gilts fed a restricted diet formulated for fat rather than lean deposition (with higher energy content and lower lysine content than a finisher diet) and with increased levels of copper, zinc, and manganese. Hartnett et al[27] used manganese, zinc, and copper at 206%, 122%, and 179%, respectively, of National Research Council recommendations for gestating and lactating sows. The benefits of supplementing these minerals could lead to potential improvements in the lifetime performance of replacement gilts and the longevity of sows. There is clear indication that replacement gilts can benefit in terms of limb health and their overall welfare from being reared in female-only pens (as gilts reared with intact male finisher pigs are exposed to high levels of sexual mounting and aggression, which may cause physical damage) and a mineral-supplemented diet.[29]

Although nutritional deficiencies reduce bone quality and can influence OCD, inconsistent research findings in this area raise questions as to the potential of nutritional supplements. These dietary measures can potentially act to prevent OCD or reverse early stages of OCD, but they cannot be used to heal advanced stages of OCD. More research is needed to understand OCD pathogenesis and progression, and the interactions with growth rate, genetics, and management.

Mammary gland development

Another important factor for strong breeding performance and longevity is sufficient milk production. Improvements in sow milk yields through the years mostly have been achieved via nutrition and management because a recent study demonstrated that 21 years of genetic selection (from 1977 to 1998) increased piglet birth weight but had no effect on sow milk yield.[32] Therefore, it is necessary to devise management strategies that optimize milk yields, and one possible way is to influence mammary gland development. The number of mammary cells present at the onset of lactation has a major impact on potential sow milk yield.[33] Several studies have shown that gilt nutrition in the periods of rapid mammary accretion occurring during prepuberty, gestation, and lactation can affect mammary development.[34] Various nutritional treatments can bring about a 27% to 52% increase in mammary tissue weight. A study where a 20% feed restriction was imposed in the prepubertal period showed that mammary parenchymal mass decreased by 26.3%.[35] *Ad libitum* feeding during the prepubertal period increased mammary parenchymal weight by 36% to 52%. It was clearly established that feed restriction from 90 days of age (but not before 90 days) until puberty had detrimental effects on mammary development in pigs.[36]

According to Farmer et al,[37] gilts that were obese (36 mm backfat) or too lean (12-15 mm backfat) in late gestation had less-developed mammary tissue. Gilts of similar BW at mating were fed different amounts of feed throughout gestation (1.30, 1.58, or 1.82 times maintenance requirements) to achieve three levels of backfat thickness (BF) on day 109 of gestation, namely, 12 to 15 mm (lean), 17 to 19 mm (medium), and 21 to 26 mm (fat). Parenchymal tissue mass was significantly reduced in lean gilts, with 1059, 1370, and 1444 g, respectively, for lean, medium, and fat gilts. These findings demonstrate that, within this range of body conditions, being too thin at the end of gestation is detrimental for mammary development, whereas medium or fat body conditions had no negative impact. Underfeeding should be avoided to ensure maximal amount of parenchymal tissue mass. Overfeeding energy in late gestation also seems to be detrimental. An experiment was carried out to study the effect of protein intake during the growing–finishing period on mammary development in gilts.[35] Reducing dietary crude protein from 18.7% to 14.4% from 90 days of age until puberty did not affect mammogenesis. Neither the amount of parenchymal tissue nor the composition of mammary parenchyma was altered. This suggests that total feed intake is more important than protein intake to ensure proper mammary development of growing gilts.

Even though research has been conducted to evaluate the nutritional control of mammogenesis in pigs, it is evident that much

remains to be learned before the best nutritional strategy to enhance mammary development can be formulated. Feeding certain plant extracts with estrogenic or hyperprolactinaemic properties may also prove beneficial in stimulating mammary development within specific physiological periods.[34] An attempt was made to stimulate mammary development in gilts by providing a dietary source of estrogen. When 2.3 g/day of the phytoestrogen genistein was added to a standard soybean meal-based diet of growing gilts from 90 to 183 days of age, there was a 44% increase in mammary parenchymal cells at the end of the treatment period.[38] Genistein is an isoflavone found in legumes, especially soybeans.[39] In another study, Farmer et al[40] used the plant extract silymarin (from *Silybum marianum*, generally known as milk thistle). Four grams of silymarin was fed twice daily to gilts from 90 to 110 days of gestation, at which time animals were slaughtered to collect their mammary glands. Even though feeding silymarin led to a 51.8% increase in circulating prolactin concentrations 4 days after the onset of treatment, this increase was transient and was not large enough to elicit beneficial effects on mammary development.[40]

Feed mycotoxins can impact mammary gland and reproductive tract development most likely through their estrogen-like activities. Stephan et al[41] found mycotoxins were passed via milk from sows to piglets on the basis of zearalenone/α-zearalenol-concentration in piglet bile and a tendency towards lower uterus weight among piglets having zearalenone-influence during gestation and lactation.

The number of teats is an important criterion for replacement gilts. According to Drickamer et al,[42] the number of pig teats is significantly influenced by genetics, principally from the dam's side. The proportion of males in a litter appears to be related to the anogenital distance of the gilt littermates, possibly as a result of an intrauterine position effect. A greater number of teats on the dam and a lower proportion of males in the litter were associated with a greater number of teats on the gilt.

Nutrient concentrations and feeding strategy

Compared to typical finishing pig diets, replacement gilt diets should contain higher concentrations of vitamins A and E, calcium, phosphorus, selenium, chromium, and zinc because highly prolific gilts reach puberty with limited reserves of protein and body fat and they continue to grow during their first gestation.[18] A vitamin premix should contain elevated levels of fat-soluble vitamins A, D, E, and K, as well as water-soluble vitamins choline, biotin, and folic acid, whose levels are relatively low or absent in typical finishing diets.

Energy and amino acid density of diets for each phase of growth will depend on lean growth potential of the gilt and voluntary feed intake. Replacement gilts are typically provided *ad libitum* access to a diet lower in energy, protein, or both than those diets fed to slaughter pigs to avoid excessive body fat.[43] This also allows for slightly slower growth, which limits mature body size thereby preventing feet and leg problems and excessive fat gain. Long et al[44] reported that sows fed a high energy, high protein diet *ad libitum* from 120 to 180 days of age had significantly poorer longevity through four parities than did gilts fed a high energy, low protein diet *ad libitum* or a restricted-fed high protein diet (35% vs 56% and 55%, respectively). Similarly, Hoge and Bates[45] found that slower growing gilts had a lower risk of being culled in their study.

Feeding modern high-lean gilts *ad libitum* is most practical for most production systems, particularly when gilts are housed in groups. Limit feeding may be more appropriate for low- and medium-lean maternal gilts. Limit feeding involves providing replacement gilts *ad libitum* access to a diet until a month or two before breeding. The *ad libitum* diets are similar to grow–finish diets, allowing maximum expression of the animal's genetic potential for growth rate and backfat. Feed intake is then restricted to approximately 85% to 90% of *ad libitum* until 10 to 14 days before mating. When restricting the diet, energy should be restricted but not amino acids, vitamins, or minerals. Therefore, concentrations of these nutrients need to be adjusted upwards in the diets accordingly.[43] Facility design may make it difficult for producers to feed a restricted diet to replacement females. When gilts are housed and fed in groups, it is difficult to ensure the correct amount of feed is ingested on an individual basis because all gilts do not consume feed at the same rate. Unless producers have individual stalls or an electronic feeding system available for potential breeding herd replacement females, it will be difficult to implement a restricted feeding program.[46] Feeding a high-fiber diet that is lower in energy concentration is an alternative that allows for a daily feed intake closer to *ad libitum* levels. The effects of increased consumption time, gut fill, and satiety may partially alleviate competition and variability in individual feed intake in group feeding situations, but it also may present challenges related to feed delivery systems and manure handling. The dietary fiber content is significant because of satiety, proper digestion, and effect on intestinal microflora, and it affects sow longevity too. Koketsu et al[47] found evidence that adding fiber to gestation diets may improve sow longevity.

BF and body condition

Backfat thickness is important in gilts and primiparous sows, as it is related to sow longevity. Some authors suggest that the ideal BF range of gilts would be between 16 and 20 mm, although this range may vary and is clearly influenced by sow genetics. Flisar et al[48] found that gilts with thicker backfat had smaller litters in the first three parities. Sows with 10 mm thicker backfat farrowed more litters (0.41 on average) per lifetime and were culled 50 days later.

Farmer et al[49] found it beneficial for primiparous sows to have greater BF (ie, 20 to 26 mm) at the end of gestation to achieve optimal mammary development and greater litter body weight gain in the subsequent lactation. The results indicate that greater BF in late gestation of primiparous sows tends to increase litter weight gain due to higher milk production possibly related to better development and preparation of the mammary glands. Given the improvement in piglet weight gain was modest (8.5%), fatter sows lost more BF for the same piglet live weight, and that the strongest correlation between BF and those parameters measured in the udder occurred with nonparenchymal tissue, it is recommended to keep primiparous sows at the end of gestation in a BF range between 15 and 26 mm.[50]

The primary goal in the final part of rearing is to encourage early expression of pubertal estrus and successfully mate gilts while they continue to grow towards their mature body size. Various strategies are possible. The specific approach may vary from farm to farm depending upon genetics and management practices. Although severe protein restrictions or imbalanced intake of essential amino acids have been demonstrated to delay the onset of puberty, moderate protein

restriction during the rearing period does not appear to influence age at first estrus in gilts. Older literature indicates that selected replacement gilts should be limit fed energy from 100 to 104 kg of BW or until 2 weeks prior to mating so they will not become too fat. Nevertheless, Foxcroft et al,[51] Williams et al,[52] and Gill[53] presented evidence that fatness is not an issue with modern lean maternal line genotype females, which deposit and mobilize lean tissue with little impact on fat tissue deposits. Development of ultra-lean genotypes has had negative effects on longevity and lifetime productivity of replacement gilts. This has led to a need for enhancing and conserving fatness in gilts by feeding a low protein diet (11.3% crude protein, 0.45% lysine, 13.0 MJ digestible energy/kg) before and during pregnancy to restrict lean gain and increase fat deposition.[53] In medium- or low-lean genotypes, gilts will tend to consume more energy than is needed to achieve ideal body condition, thus becoming too fat. Therefore, limit feeding is advised with those genotypes after selection has occurred.

Gill[54] found that increases in fatness achieved by diet during rearing are transient. Any residual effects had disappeared by the time the first litter was weaned. The potential protective benefits to sow longevity from feeding a low protein diet during gilt rearing probably result from long-term reduction in sow BW and, in turn, reduced risk of foot and leg injury. A more holistic approach would be to consider how to improve the overall welfare and fitness of gilts and sows.

Management

Management of the gilt up to when the first litter is weaned has a major influence on lifetime productivity and, consequently, weaning capacity. Size of the first litter has a strong correlation with subsequent litter sizes,[55] so achieving a large first litter can be a good indicator of more piglets born and weaned in a sow's lifetime. Correct management during gilt rearing will positively influence longevity, thereby increasing litters per sow lifetime, which is a key factor in maximizing weaning capacity. The current criteria for selecting replacement gilts for breeding are excellently described in the review by Malopolska et al.[56]

Conclusion

Nutrition during gilt rearing plays an important role as it can affect growth rate, optimal body condition, early heat onset, reproductive tract and mammary gland development, and good limb condition. It is important to focus on welfare and fitness and to create good environmental conditions from the time of a gilt's birth and continue all through rearing. As reproductive failures are the most common cause of culling, it would be appropriate to further investigate the effect of nutrition and feeding strategy on the development and functionality of the reproductive tract during rearing and its relationship to the lifetime performance of the sow. Due to the increased number of piglets born per litter, it is also appropriate to focus on a nutritional strategy that enhances mammary development to achieve increased milk production during lactation.

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Conflict of interest

None reported.

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Understanding the role of feed manufacturing and delivery within a series of porcine deltacoronavirus investigations

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Summary

Two feed mills and three breed-to-wean facilities were investigated after being diagnosed with porcine deltacoronavirus (PDCoV) with initial suspicion that feed manufacture and delivery processes were involved in disease transmission. Both feed mills were audited, and environmental samples collected in areas that were deemed high risk for virus contamination. All breed-to-wean facilities had PDCoV detected as would be expected, while the only positive samples for enteric coronaviruses associated with feed mills were feed delivery trucks. These results indicate that feed delivery surfaces can help spread virus during an ongoing disease outbreak and must be considered when determining the outbreak origin.

Keywords: swine, epidemiology, feed safety, porcine deltacoronavirus

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Resumen - Comprensión del rol de la fabricación y entrega de alimento balanceado durante una serie de investigaciones sobre deltacoronavirus porcino

Se investigaron dos fábricas de alimento y tres instalaciones de gestación a destete después de ser diagnosticadas con deltacoronavirus porcino (PDCoV) y con la sospecha inicial de que los procesos de fabricación y entrega de alimento estaban implicados en la transmisión de la enfermedad. Ambas fábricas de alimento fueron auditadas y se recolectaron muestras ambientales en las áreas consideradas de alto riesgo de contaminación del virus. Todas las instalaciones, como era de esperar, desde la gestación hasta el destete fueron positivas al PDCoV, mientras que las únicas muestras positivas a coronavirus entérico asociados con las fábricas de alimento fueron los camiones de reparto de alimento. Estos resultados indican que las superficies de distribución de alimento pueden ayudar a propagar el virus durante un brote activo de la enfermedad y deben tomarse en cuenta al determinar el origen del brote.

Résumé - Comprendre le rôle de la fabrication et de la livraison d'aliments pour animaux dans une série d'enquêtes sur le deltacoronavirus porcin

Deux usines d'aliments pour animaux et trois installations de type accouplement-sevrage ont fait l'objet d'une enquête après avoir reçu un diagnostic de deltacoronavirus porcin (PDCoV) avec la suspicion initiale que les processus de fabrication et de livraison des aliments étaient impliqués dans la transmission de la maladie. Les deux meuneries ont été auditées et des échantillons environnementaux ont été prélevés dans des zones jugées à haut risque de contamination virale. Comme on pouvait s'y attendre, le PDCoV fut détecté dans toutes les installations de type accouplement-sevrage, tandis que les seuls échantillons positifs pour les coronavirus entériques associés aux meuneries étaient des camions de livraison d'aliments. Ces résultats indiquent que les surfaces de distribution des aliments peuvent aider à propager le virus lors d'une épidémie en cours et doivent être prises en compte lors de la détermination de l'origine de l'épidémie.

The swine industry has made advancements in biosecurity practices since the introduction of porcine epidemic diarrhea virus (PEDV) and porcine deltacoronavirus (PDCoV) in 2013 and 2014. Both diseases spread quickly through US swine production systems due to naïve herd status and fomites playing a large role in disseminating these viruses. Both PEDV and PDCoV rely on fecal-oral transmission; therefore, these viruses can be prevented if fecal contamination is limited.[1] The US swine industry quickly applied this concept to our animal transportation system and how workers and veterinarians enter and exit facilities. Practices adopted during this time, such as truck washing, disinfection, and heat treating or the usage of shoe covers, are now considered normal day-to-day practices for swine production settings.

Within the last decade, feed safety became heavily emphasized once it was hypothesized that a contaminated batch of feed ingredients imported from Asia was responsible for bringing PEDV and PDCoV to the United States.[2] Prior to realizing that feed can serve as a vector for virus transmission, feed safety concerns primarily focused on controlling *Salmonella*, other bacteria, and mycotoxins in feed mills. Since then, scientists

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

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have proven that PEDV-contaminated feed can cause clinical disease and once in the feed mill environment, impractical methods such as wet cleaning and disinfection are required to successfully remove PEDV from the feed mill.[3,4] Most feed safety research has focused on PEDV, but this research opened the door to the idea that a feed mill could serve as a transmission source of any virus. Currently, feed safety has a focus on bioexclusion of endemic pathogens as well as prevention of potential foreign animal disease introduction through feed and feed ingredients. The industry has also begun to further understand the epidemiological role the feed delivery supply chain has on feed mills and production sites. Taking what is known about fomites, such as people and trucks, feed safety research is working to understand the interaction between the feed mill and these moving pieces. Therefore, the authors conducted an investigation where multiple isolated facilities were diagnosed with PDCoV. The goals were to 1) understand if the feed mill was the origin of disease and 2) determine if trucks or people, either coming from the infected farms or coming from the feed mills, served as vectors to spread this virus.

Case description

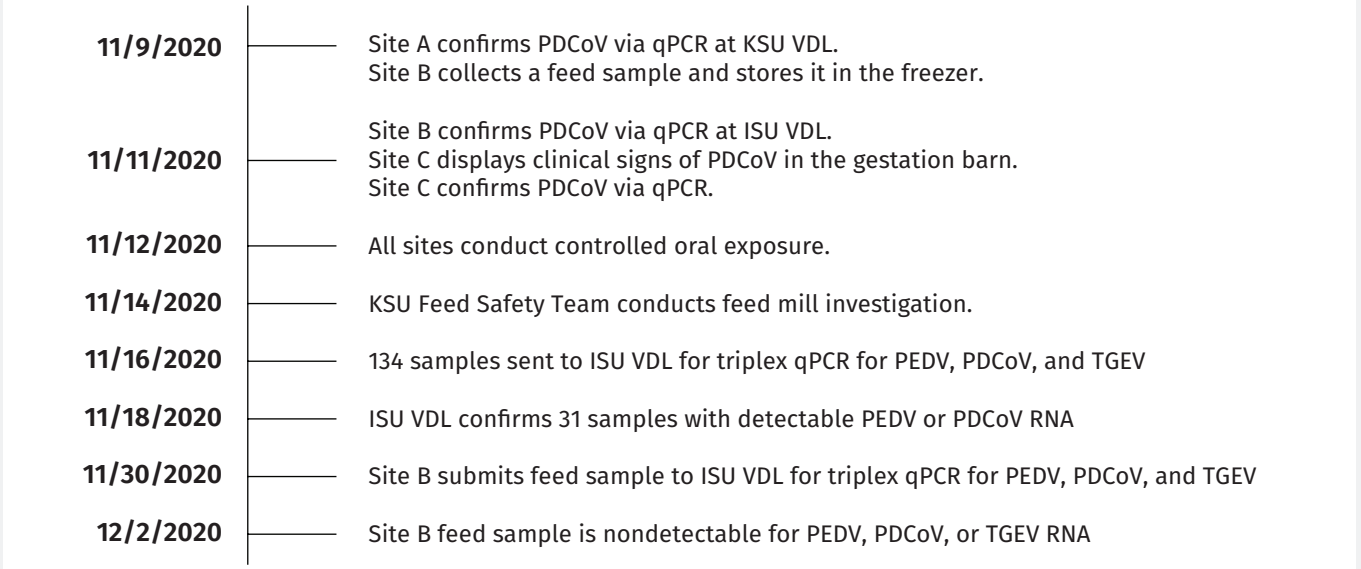
Herd histories

Three swine breed-to-wean herds, designated as sites A, B, and C, were diagnosed with PDCoV within one week in November 2020, with reports of initial clinical signs in the gestation area of the respective facilities (Figure 1). All 3 sites were in the Midwest United States and operate in accordance with Pork Quality Assurance Plus guidelines. All diagnostic samples confirming clinical disease within the production sites were collected under standard veterinary oversight procedures. All environmental swabs were collected from surfaces with no animal contact and environmental sampling personnel did not enter the production facilities. Site A and B were operated by the same production system, whereas site C did not share any management oversight with the other two sites. Workers for site A reported clinical signs of PDCoV in the gestation barn on November 9, 2020, and the diagnosis of PDCoV was confirmed that afternoon via polymerase chain reaction (qPCR) from samples sent to Kansas State University Veterinary Diagnostic Laboratory (KSU VDL). Workers from site B reported clinical signs on November 9, 2020, and the diagnosis confirmed by Iowa State University Veterinary Diagnostic Laboratory (ISU VDL) on November 11, 2020. Veterinarians from site B instructed workers to collect 1 feed sample from the gestation barn after confirmation of clinical signs of PDCoV. The sample was placed in the freezer and submitted to ISU VDL on November 30, 2020. Workers from site C reported 60 animals with scours in the gestation barn on November 11, 2020. Site C receives gilts from sites A and B, but gilts are raised in offsite gilt development units (GDU) and the timeline of animal deliveries did not indicate an epidemiological link between site C and sites A and B. A clinical diagnosis of PDCoV for site C was confirmed by laboratory evaluation the evening of November 11, 2020. Once PDCoV was diagnosed, all sites conducted controlled oral exposure with infected fecal material.

Feed mill histories

Feed mill 1 supplies site C and 12 to 15 other sow farms and only makes swine diets. Prior to the outbreak on site C, this feed mill monitored high risk areas such as boot soles, foot pedals, reclaim trucks, and office space every week. When clinical signs were first observed in gestation, the company reviewed their diets and determined that wheat middlings was the only ingredient unique to the gestation diet. Environmental samples were collected from all major ingredient bins, as it was believed that samples of accumulated dust would be

Figure 1: Timeline of events for feed mill investigation. Sites A, B, and C are three breed-to-wean facilities located in the Midwest. PDCoV = porcine deltacoronavirus; qPCR = polymerase chain reaction; KSU VDL = Kansas State University Veterinary Diagnostic Laboratory; ISU VDL = Iowa State University Veterinary Diagnostic Laboratory; PEDV = porcine epidemic diarrhea virus; TGEV = transmissible gastroenteritis virus.



more representative over a longer period compared to subsamples of feed or feed ingredients. The mill investigated the transport and handling of the wheat middlings and determined that the trucks used for transportation were not used for any other purpose, such as transporting ingredients other than wheat coproducts.

Feed mill 2 supplied feed to sites A and B and supplied the same gestation feed to 3 other sites that also were infected with PDCoV but were not part of this investigation. Our investigation was focused on understanding the potential link between feed manufacture and delivery with acute outbreaks, so these additional three sites were excluded from this investigation because a significant amount of time had elapsed since clinical signs were noted at the farms. Feed delivery records reported that feed mill 2 delivered diets to site A and B from November 9-12, 2020, but what type of diet, how much, and what bin diets were delivered to are not recorded. Prior to this investigation, this feed mill had collected and submitted 7 environmental samples to the KSU VDL following initial clinical signs at a farm and suspicion of a potential link to the feed mill. All 7 samples were free of detectable PDCoV RNA and a link between the feed mill and farm outbreak was not found.

Feed mill and production site investigations

Investigations of the production sites and feed mill locations took place on November 14, 2020; approximately one week after observing clinical signs and confirming clinical diagnosis within production sites. Samples from sites A, B, and C focused on feed contact and nonfeed contact surfaces outside of the barn. Environmental sampling was limited to feed bins of gestation, lactation, and GDU barns and areas of high foot traffic or potential for high viral load. No feed samples or environmental samples were collected interior to the entry shower because all sites conducted controlled oral exposure once confirming PDCoV on site, so environmental samples would knowingly test positive for PDCoV. Site A had 12 sampled locations including feed bins, entry benches, and barn exhaust fans. Site B had 22 sampled locations including feed bins, spilled feed under feed bins, and areas of high foot traffic like barn entries, visitor log sign in, and areas around the crossover benches before the entry shower. Site C had 13 sampled locations including feed bins, netting surrounding exhaust fans near feed bins, and fan exhaust shrouds. Feed mill sampling locations included high-risk ingredients like porcine derived ingredients, areas of high foot or vehicle traffic (receiving and load out bay and warehouse floor), feed trucks going from farm to feed mill, and bulk feed bins. Feed delivery surfaces were those within the feed delivery trucks including dashboards, foot mats, truck steps, and driver seats. Feed mill 1 had 42 samples and feed mill 2 had 44 samples.

In addition to sampling the feed mills, audits were conducted using the Kansas State University Swine Feed Mill Biosecurity Audit template (**https://www.asi.k-state.edu/research-and-extension/swine/biosecurity%20audit.doc**). The audit evaluated the biosecurity practices within the feed mill and the feed delivery system and was completed by one member of the research team by systematically proceeding through the audit document. Feed mill 1 was well kept and clean. Employees had a good understanding of biosecurity and good feed mill practices. Feed delivery trucks were required one night down time between sites and washed once deliveries were finished. However, to prepare for the upcoming holiday season, the warehouse was more crowded than normal resulting in occasional spillage and bag ripping. If spillage occurred, these ingredients are swept up and discarded in the garbage. Feed mill 2 was generally clean and well kept; the receiving pit was covered, warehouse was swept and well maintained, and the mill only manufactured swine diets. When talking with the feed delivery driver, washing trucks and sanitizing wheels and wheel wells were done as biosecurity practices when delivering to various phases of swine production systems. However, there was a porcine-based ingredient on location (choice-white grease) and this facility only had one mixer, so all diets went through the same equipment. Truck drivers were allowed to walk through the warehouse without shoe covers and feed trucks were allowed to haul diet ingredients and complete diets in the same trailer. Both the choice-white grease and no clear standard operating procedures (SOPs) for truck drivers had the potential to introduce PDCoV, PEDV, or other diseases within the feed mill and unintentionally contaminate other production sites and animals.

Environmental sampling was performed using one of two methods depending upon accessibility of sampling locations. The first method utilized a premoistened 10-cm square cotton gauze surgical sponge as previously described.[5] This method was used when sample areas were easily accessible and the selected area could be swabbed by hand. The second method used premoistened paint roller covers (Marathon 22.9 cm × 0.95 cm nylon/polyester paint roller cover; Purdy North America) and a paint roller extension set (152 cm fiberglass paint roller frame utility pole; Mr. LongArm, Inc) as previously described.[3] The second method was used when sampling was particularly challenging, for example, inside of feed bins. Samples were placed on ice and transported back to Manhattan, Kansas. Before submitting to the lab, surgical gauze environmental swabs had 20 mL of phosphate buffered solution (PBS) added to the conical tube and manually agitated while paint rollers were squeezed inside the transportation plastic bag (Ziploc one-gallon size freezer bags; S.C. Johnson & Son, Inc) and the liquid was poured into a conical tube. If 20 mL could not be extracted from the roller, approximately 20 mL of PBS was added onto the roller and wrung out a second time. Samples were stored at -20°C until shipped to the ISU VDL. All samples were processed at ISU VDL for triplex qPCR for PEDV, PDCoV, and transmissible gastroenteritis virus (TGEV). Extractions from all samples were amplified using two amplification procedures. One amplification sequence used the standard ISU VDL cycle threshold (Ct) cutoff value of 36 and retained sample extractions were amplified using a Ct cutoff value of 45.

For the first round of qPCR analysis, 17 of 133 samples (12.8%) had detectable PEDV or PDCoV RNA with a Ct cutoff value of 36 (Table 1). Site A had 4 environmental swabs with detectable PDCoV RNA taken from the fans outside the gestation and farrowing barns and on the clean and dirty side of the entrance bench (Table 2). Site B had 6 environmental swabs with detectable PDCoV RNA taken from a feed bin outside the GDU, spilled feed outside the bin, footpath to the barn entrance, beneath shoes on the entrance floor, clean side of the entrance bench, and outside the barn entrance. Site C had 5 environmental swabs with detectable PDCoV RNA taken from exhaust fan netting around 4 different feed bins and a gestation barn fan shroud. Feed mill 2

Table 1: Number of environmental swabs positive for viral RNA collected from live animal production sites and feed mills

		qPCR Ct limit					
		PDCoV		PEDV		TGEV	
Location	Zone	36	45	36	45	36	45
Site A	Feed bin - feed contact (n = 8)	0	0	0	0	0	0
	Surfaces exterior facility (n = 2)	2	2	0	0	0	0
	Personnel entry (n = 2)	2	2	0	0	0	0
Site B	Feed bin - feed contact (n = 13)	1	6	0	0	0	0
	Feed sample (n = 1)	0	0	0	0	0	0
	Feed spills exterior facility (n = 3)	1	3	0	0	0	0
	Personnel entry (n = 6)	4	6	0	0	0	0
Site C	Feed bin - feed contact (n = 6)	0	0	0	0	0	0
	Surfaces exterior facility (n = 7)	5	7	0	0	0	0
Mill 1	Feed contact surface (n = 26)	0	0	0	0	0	0
	Non-feed contact surface (n = 10)	0	0	0	0	0	0
	Transient surface (n = 6)	0	2	0	0	0	0
Mill 2	Feed contact surface (n = 29)	0	0	0	0	0	0
	Non-feed contact surface (n = 8)	0	0	0	0	0	0
	Transient surface (n = 7)	0	0	2	2	0	0

qPCR = polymerase chain reaction; Ct = cycle threshold; PDCoV = porcine deltacoronavirus; PEDV = porcine epidemic diarrhea virus; TGEV = transmissible gastroenteritis virus.

had 2 environmental swabs with detectable PEDV RNA taken from the feed truck pedals and floor and feed truck steering wheel and dashboard. Feed mill 1 had no samples with detectable PEDV, PDCoV, or TGEV RNA.

For the second round of qPCR analysis, 30 of 133 samples (22.5%) had detectable PEDV or PDCoV RNA with a Ct cutoff value of 45. Site A had no additional environmental swabs with detectable PDCoV RNA. Site B had 9 additional environmental swabs with detectable PDCoV RNA taken from 4 GDU feed bins, spilled feed by another GDU bin, spilled feed under a lactation feed bin, nursery piglet feed bin, and the floor by the visitor entry and showers. Site C had 2 additional environmental swabs with detectable PDCoV RNA taken from 2 more gestation bin fan shrouds. Feed mill 1 had 2 environmental swabs with detectable PDCoV RNA taken from the feed truck steps and inside the feed truck cab. Feed mill 2 had no additional environmental swabs with detectable PEDV RNA. The site B feed sample submitted on November 30, 2020 was confirmed nondetectable for PEDV, TGEV, and PDCoV on December 2, 2020 at both cutoff values.

Discussion

For this investigation, nonfeed contact surfaces were the majority of surfaces contaminated with PDCoV and PEDV. Since sites A, B, and C conducted controlled oral exposure once clinical signs appeared, PDCoV quickly dispersed through the environment and could be found on all surfaces including exhaust fans, exhaust fan netting, and fan shrouds. Research done with PEDV has found that once introduced, nucleic acids for the virus can be found throughout the environment.[6] Investigations like this should consider whether locations have used controlled oral exposure as a disease management strategy because environmental sampling will be of lesser value due to the nature of controlled oral exposure. Interestingly, the only surfaces associated with the feed mill that had detectable RNA for porcine enteric viruses were from the feed delivery system. These surfaces are freely movable, or transient in nature, and able to travel from one farm to the next which is probably how these surfaces became contaminated with virus. Others have found that surfaces associated with the feed supply chain contributed to the spread of African swine fever virus (ASFV) while feed contact surfaces were negative for ASFV.[7] Another study found that contaminated personal protective equipment and people can contribute to the spread of PEDV.[8] These findings highlight the importance of preventing pathogen introduction into the feed mill and the feed to eliminate potential transmission. An important, but not unexpected, takeaway message from the current investigation was that contamination with PDCoV can be found outside of clinically affected farms and that this contamination can be detected in high traffic areas for personnel and trucks. This highlights the need to implement or revisit biosecurity protocols for employees and truck drivers. While these protocols may be labor or cost intensive, it is pivotal that all people and vehicles moving in and out of the supply chain understand the importance of following and maintaining good biosecurity to control the spread of disease.

Another finding of this investigation is that neither feed mill had detectable quantities of enteric coronaviruses in environmental samples. When conducting

Table 2: Summary of qPCR Ct values for positive samples from live animal production sites and feed mills

		qPCR Ct limit					
		PDCoV		PEDV		TGEV	
Location	Sampling location	36	45	36	45	36	45
Site A	Farrowing exhaust fan	31.7	31.1	ND	ND	ND	ND
	Gestation exhaust fan	29.3	28.6	ND	ND	ND	ND
	Dirty side of entrance bench	29.5	29.1	ND	ND	ND	ND
	Clean side of entrance bench	35.5	36.0	ND	ND	ND	ND
Site B	GDU Bin 1	ND	38.8	ND	ND	ND	ND
	Spilled feed under GDU bins	35.7	36.2	ND	ND	ND	ND
	GDU Bin 2	33.0	32.6	ND	ND	ND	ND
	GDU Bin 3	ND	38.0	ND	ND	ND	ND
	GDU Bin 4	ND	36.9	ND	ND	ND	ND
	GDU Bin 5	ND	37.8	ND	ND	ND	ND
	Spilled feed under gestation bins	ND	38.7	ND	ND	ND	ND
	Spilled feed under lactation bins	ND	38.9	ND	ND	ND	ND
	Nursery holding room feed bin	ND	36.4	ND	ND	ND	ND
	Foot path exterior to facility	33.4	33.0	ND	ND	ND	ND
	Beneath shoe on floor	29.1	28.7	ND	ND	ND	ND
	Clean side of bench	35.2	34.7	ND	ND	ND	ND
	Floor by visitor log	ND	39.1	ND	ND	ND	ND
	Floor by showers	ND	39.0	ND	ND	ND	ND
	Outside near entry door	30.5	30.3	ND	ND	ND	ND
Site C	Netting by gestation bin 1	34.7	34.3	ND	ND	ND	ND
	Netting by gestation bin 2	30.9	30.2	ND	ND	ND	ND
	Netting by gestation bin 3	32.0	31.5	ND	ND	ND	ND
	Netting by gestation bin 4	34.7	33.6	ND	ND	ND	ND
	Fan shroud 1	ND	37.5	ND	ND	ND	ND
	Fan shroud 2	29.9	29.3	ND	ND	ND	ND
	Fan shroud 3	ND	35.7	ND	ND	ND	ND
Mill 1	Feed truck - steps	ND	37.3	ND	ND	ND	ND
	Feed truck - steering wheel, pedals, floor mat	ND	37.1	ND	ND	ND	ND
Mill 2	Feed truck - floor and pedals	ND	ND	33.4	33.2	ND	ND
	Feed truck - steering wheel and dashboard	ND	ND	35.6	35.0	ND	ND

qPCR = polymerase chain reaction; Ct = cycle threshold; PDCoV = porcine deltacoronavirus; PEDV = porcine epidemic diarrhea virus; TGEV = transmissible gastroenteritis virus; ND = no genetic material detected; GDU = gilt development unit.

disease outbreak investigations, particularly those incorporating environmental sampling, collection of appropriate samples in a timely manner is critical to allow for the greatest epidemiological value. Sample collection in the current investigation took place within 48 hours of notification of the desire to conduct sampling by the involved parties. When using environmental sampling to aid in a diagnostic investigation, the sooner the samples can be collected the lower likelihood of secondary epidemiological links causing confounding. A list of sampling locations was generated based on previous feed investigation experience to maximize the likelihood of detecting contamination if present. In this investigation, authors felt our response was timely to collect meaningful diagnostic information. When conducting investigations such as the one described in this manuscript, it is very important that personnel collecting samples are appropriately trained and collect samples in an aseptic manner.

Even though no swine enteric viruses were detected in either feed mill, there are multiple preventative strategies both feed mills could implement to mitigate the risk of feed delivery trucks potentially serving as vectors for disease that should remain out of the feed mill. Feed mitigants, like commercially available formaldehyde or medium chain fatty acids, can be expensive but reduce viral contamination in the feed.[9,10] Another solution to help reduce introduction of pathogens into a mill would be to implement truck and visitor SOPs to improve biosecurity within the feed mill. These moving pieces within the feed mill will always be present, but additional training will help to reduce the likelihood of introducing a health hazard into the feed mill.[11] During this investigation, authors would have liked more detailed record keeping and so recommend that all feed deliveries have detailed records. Feed delivery records were obtained from feed mill 2 to further investigate the presence of PDCoV inside the feed bins at site B but there were not sufficient details within the records to make a definitive link between the feed and outbreak of PDCoV. The records showed supply date and trip location but did not provide details on type of diet transported or what bin was filled. Since there were not enough details present in the delivery records, a link between the PDCoV outbreak and presence of PDCoV RNA in the feed bin can only be speculated. The records did show that feed was unloaded into the bins during a time when PDCoV was intentionally spread through a farm. It is possible these bins were in front of exhaust fans and the bins were unintentionally contaminated with PDCoV from exhaust air. Because the feed sample and feed mill surfaces from feed mill 2 had no detectable RNA for PEDV, PDCoV, or TGEV, a link could not be made between the feed mill and PDCoV farm outbreak. Had there been more information available from the feed records, a possible link between the outbreak and feed mill could have been identified.

Lastly, site B had the largest portion of environmental samples testing positive for PDCoV using a Ct value of 36 and 45. When the Ct cutoff was 36, only 6 of 22 samples were positive but 9 additional samples were positive when the Ct cutoff value was increased to 45. The laboratory performing the analysis, matrix of the sample, and viral load of the sample must all be considered when interpreting diagnostic sample results.[12] There are differences between diagnostic laboratories regarding primers and threshold limit values. Current molecular based diagnostic techniques are not validated for environmental swabs or feed/ingredient samples and consequently care must be taken when interpreting diagnostic results. In this investigation, using a Ct limit of 45 cycles resulted in a greater number of positive samples. Given where these samples were collected, it was logical there would be virus present, albeit at a low level. Thus, increasing the Ct limit from 36 to 45 within this investigation likely increased the sensitivity of detecting environmental contamination with PDCoV. While increasing the Ct cutoff value to 45 increased the sensitivity of the test results, this practice also may increase the rate of false-positive results. The purpose of this investigation was to identify areas of contamination and make biosecurity recommendations based on results. When interpreted appropriately, having a greater diagnostic sensitivity can help identify areas of concern and the consequences of false positives are outweighed by the value of increased sensitivity in this situation. Individuals must be cautious when interpreting results near the limit of detection for diagnostic assays, but if used appropriately, increasing the Ct limit as demonstrated in the current report can add value to diagnostic investigations using environmental swabs and feed/ingredient matrices.

To further understand the possible connection between the farms with clinical disease, genetic comparison of viruses through sequencing could be a useful tool. However, this was not possible in the current investigation. Additionally, a limitation of the qPCR assay used in the current experiment is that no information is provided regarding the ability for the identified genetic material to be infectious. The assay simply detects a specific sequence of RNA and provides no information regarding potential infectivity. Additional work is necessary to further understand the infectivity characteristics of environmental swabs in diagnostic investigations, but when results are interpreted appropriately qPCR can serve as a rapid, cost-effective diagnostic tool that can provide useful information.

In conclusion, this diagnostic investigation did not find evidence within the feed supply chain indicating feed or feed delivery was associated with outbreaks of PDCoV. Due to the nature of timing, it is believed that the contamination identified at the infected sites was due to the intentional exposure through controlled oral exposure. Furthermore, it is not known what the specific mechanism of transmission was to these farms, although other routes must be considered such as personnel and other possible fomites such as incoming supplies. The goal of this investigation was to evaluate the likelihood of a link between feed manufacturing and delivery with the outbreak of clinical disease, so greater investigation into potential routes of entry were not explored. This investigation highlights the importance of biosecurity during controlled oral exposure because viral contamination can be detected outside of the farm perimeter and common events such as feed delivery may serve as a mechanism for transfer of viral contamination back to the feed mill or to other farms. The current investigation emphasizes the importance of biosecurity in the feed supply chain at both the feed manufacturing and delivery stages, with particular focus needing to be directed towards personnel movement.

Implications

Under the conditions of this report:

- People and transportation vehicles can serve as fomites for pathogens.
- No evidence of contamination within the feed mills for PDCoV was detected.

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Conflict of interest

None reported.

Disclaimer

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Three cases of *Actinobacillus suis* in eastern North Carolina

Emily Mahan-Riggs, DVM

Summary

This case study describes sudden deaths of pigs in a North Carolina production system at three different finishing facilities between June 2019 and February 2020. The cases involved 3- to 6-month-old pigs of the same genetics but from different sow farm flows. Pigs at all three sites had gross lesions that included firm, deep red to purple lungs. Based on laboratory results from tissue samples, all cases were diagnosed with *Actinobacillus suis*. Treatments and the significance of this disease in swine are discussed.

Keywords: swine, *Actinobacillus suis*, bronchopneumonia

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Resumen - Tres casos de *Actinobacillus suis* en el este de Carolina del Norte

Este estudio de caso describe muertes repentinas de cerdos en un sistema de producción de Carolina del Norte en tres diferentes instalaciones de engorda entre junio de 2019 y febrero de 2020. Los casos incluyeron cerdos de 3 a 6 meses de la misma genética, pero de diferentes flujos de granjas de hembras. Los cerdos en los tres sitios tenían lesiones macroscópicas que incluían pulmones firmes, de color rojo intenso a púrpura. Según los resultados de laboratorio de las muestras de tejido, todos los casos fueron diagnosticados con *Actinobacillus suis*. En este estudio se discuten los tratamientos y la importancia de esta enfermedad en cerdos.

Résumé - Trois cas d'infection par *Actinobacillus suis* dans l'est de la Caroline du Nord

Cette étude de cas décrit des morts subites de porcs dans un système de production en Caroline du Nord dans trois installations d'engraissement différentes entre juin 2019 et février 2020. Les cas concernaient des porcs âgés de 3 à 6 mois de la même génétique mais provenant de différents flux d'élevage de truies. Les porcs des trois sites présentaient des lésions macroscopiques qui incluaient des poumons fermes, rouge foncé à violet. Sur la base des résultats de laboratoire d'échantillons de tissus, tous les cas ont été diagnostiqués avec la présence d'*Actinobacillus suis*. Les traitements et l'importance de cette maladie chez le porc sont discutés.

First reported in 1962, *Actinobacillus suis* infection was a neonatal or recently weaned pig disease in high-health or start-up herds.[1-10] However, disease incidence increased in the 1980s and early 1990s with the implementation of management practices that decreased pig exposure to endemic pathogens.[2,4,11] Now, the disease is increasingly reported in grow-finish pigs from commercial farms with a normal parity structure.[1,3,5,9] Due to its similarities to *Actinobacillus pleuropneumoniae* (APP) infection, it may be underdiagnosed in the field; therefore, prevalence is thought to be underreported.[1-3,6,7,9-11] From 2018 to 2020, 7 cases of *A suis* infection were diagnosed in a large commercial hog production system in eastern North Carolina. Three of these cases are described and discussed herein.

Case description

Case 1

The first case occurred in June 2019 at a 4-barn finishing site that shared a premises, driveway, and management with another 2-barn finishing site. The barns were partially slatted and naturally ventilated, 1224-head capacity buildings (4896 total head) with solid block penning. The barn placement populations were 1305 pigs in barn 1, 1326 in barn 2, 1313 in barn 3, and 1299 in barn 4 with a total of 5243 pigs at the site. The pigs at this site were from a porcine reproductive and respiratory syndrome (PRRS) stable and PRRS modified-live virus (MLV) vaccinated flow. Three days prior to the veterinarian's visit, pigs were observed to be in good health. However, pigs began coughing, losing weight, and developed watery diarrhea. These symptoms did not affect all the pigs at the same time, but there were at least 5% to 10% of them losing weight or with diarrhea, which fit the criteria for treatment according to company protocol. The pigs were prescribed a 3-day course of water-soluble gentamicin to combat the diarrhea. On the day prior to the veterinarian's visit and sample collection, 5 pigs had died. In barn 2, the weekly total mortality was 17. In that barn, most of the mortalities occurred in the end pen, which had the feed drop motor. Due to the association with the feed drop motor, stray voltage had already been checked and ruled out as the cause of death. At the time of the veterinarian's visit, the pigs were 21 to 24 weeks of age and had been at the finisher site for 11 to 14 weeks. During the veterinarian's walk-through, one pig was found dead in this pen with red froth coming from the

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nose. Samples of tonsil, lung, heart, multiple lymph nodes, liver, spleen, kidney, intestine, and colon were taken within an hour of death. During the necropsy, red froth was found in the trachea, and the lungs were deep red to purple (Figure 1). Normal lung tissue was difficult to find. The spleen and lymph nodes were enlarged as well. While it is best practice to sample tissues from at least two pigs, only one pig was found dead during the visit. No additional pigs were euthanized. Oral fluids from pigs in all 4 barns (four tubes) were also collected. All samples were sent to the Iowa State University Veterinary Diagnostic Laboratory (ISU VDL). Histopathology, culture, and polymerase chain reactions (PCRs) were completed on the tissues for PRRS, influenza A virus (IAV), and *Mycoplasma hyopneumoniae,* and PCR was completed on oral fluids for IAV.

The histopathology showed signs of acute, severe fibrinopurulent bronchopneumonia, which is highly suggestive of an *Actinobacillus* infection. As is typically observed in an *Actinobacillus* infection, the alveoli were filled with large numbers of neutrophils, rare hemorrhage, clusters of basophilic bacteria, and abundant proteinaceous fluid (Figure 2). Oat cells (white blood cells, in this case neutrophils, with streaming chromatin) were also observed (Figure 3). In addition, fibrin and neutrophils markedly expanded the interlobular septa and lymphatics. Differentiation between APP and *A suis,* however, is difficult based on lesions alone, so a bacterial culture was requested. Bacterial culture of the lung tissue confirmed an *A suis* infection. All PCR testing for the other previously mentioned pathogens were negative. *Streptococcus suis* was also cultured from the lung and *Salmonella typhimurium* was cultured from the intestine. The *A suis* that was cultured was susceptible to ampicillin, ceftiofur, enrofloxacin, florfenicol, gentamicin, spectinomycin, tiamulin, tilmicosin, and trimethoprim/sulfamethoxazole.

The treatments for the pigs in these barns were determined based on the amount of time prior to selling them to market. Barn 1 was the oldest and least affected, so it did not receive any treatment. However, 14 pigs in that barn died in the last 3 weeks prior to marketing with a total mortality of 51 (3.91%). Barn 2 was the most affected, but pigs were to be sold within 3 weeks. Ceftiofur hydrochloride (Excenel RTU EZ; Zoetis) was given to pigs in the most affected pens in this barn (8 mL to 122 pigs and 5 mL to 52 pigs) for 3 consecutive days according to the label. There were 25 more pigs that died in the remaining weeks in barn 2, and the total mortality was 74 (5.58%). According to the barn records, no medications were given to barn 3 even though there were 6 weeks left in that barn prior to marketing. During those 6 weeks, 21 more pigs died for a total of 73 (5.56%). Barn 4 had the youngest pigs on the site with 8 weeks left in the barn. Tiamulin (Denagard; Elanco) was administered at the respiratory level in this barn, and only 22 more pigs died. The total mortality for this barn was 54 (4.16%). The mean mortality across all 4 barns during this case was 4.81%. Compared to the annual mean mortality in 2018 (4.99%) and 2019 (5.55%), mortalities were 0.18% and 0.74% less than the historical mean mortality, respectively, for this site during this case (Table 1).

Figure 1: Affected pig lung. Lung is not collapsed, dark red to purple, moderately firm, with multifocal moderate fibrin on the pleural surface and multifocal hemorrhages on the pleura.

Clinical presentation of *A suis* and APP infection in pigs are very similar. However, APP infected pigs usually recover once treated, but the probability of relapse is high due to carrier pigs remaining in the population.[7] Due to the inability to discern between the two *Actinobacillus* species and the possibility of having new cases, the production personnel were advised to quickly sell the healthy pigs at this site to try to minimize the site's mortality. The

Figure 2: Serofibrinosuppurative bronchopneumonia with serofibrinous effusion, dense aggregates of neutrophils, and congestion of alveolar capillaries with multifocal hemorrhage. Photo and description courtesy of Dr Greg Stevenson. (Written communication with Greg Stevenson, DVM, PhD, Iowa State University Veterinary Diagnostic Laboratory, July 5, 2019.)

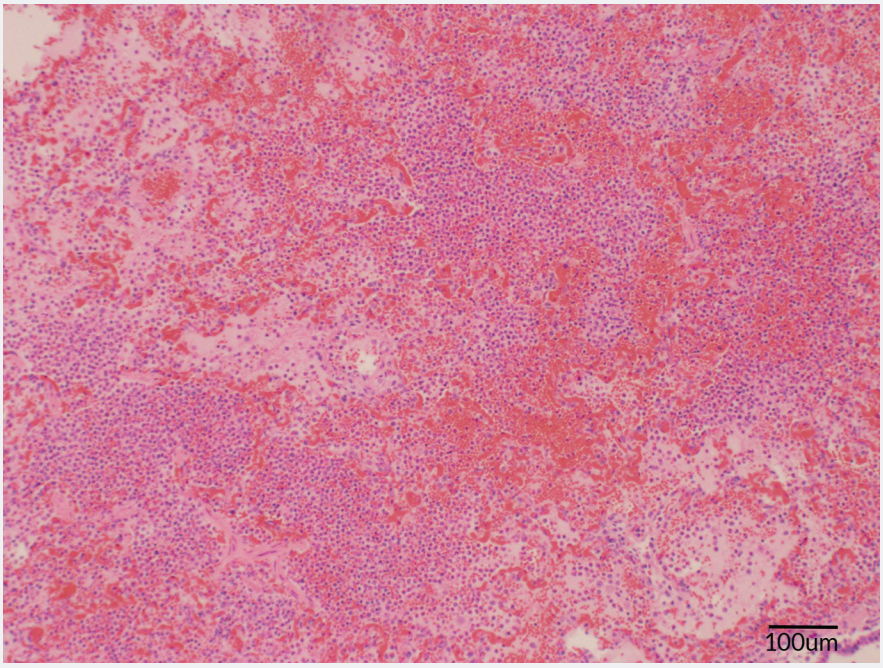
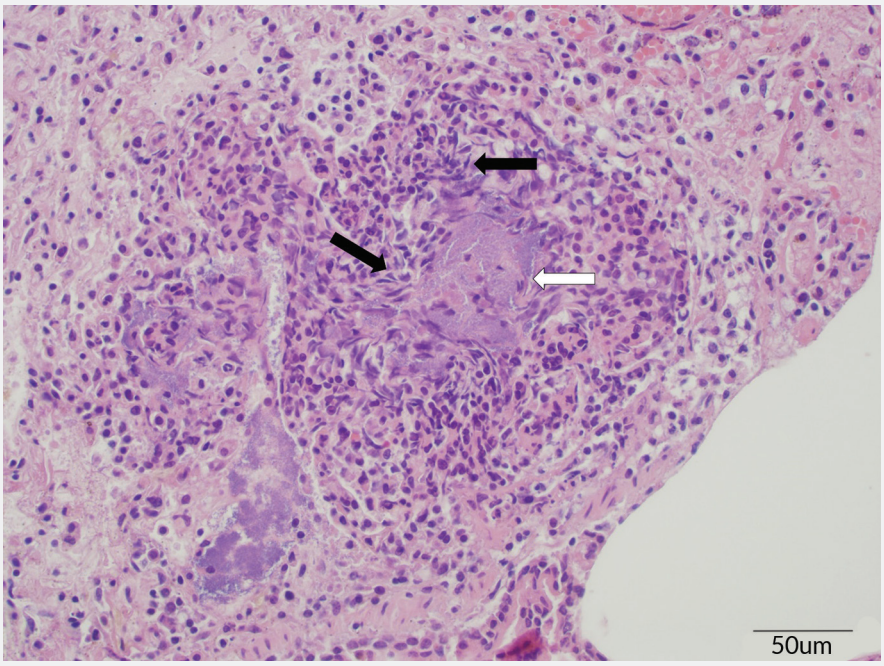


Figure 3: Focal *Actinobacillus suis* fibrinonecrotic pneumonia. A colony of *A suis* bacteria (white arrow) is surrounded by infiltrating leukocytes; many are degenerate and streaming "oat cells" (black arrows) due to secreted bacterial leukotoxins. Photo and description courtesy of Dr Greg Stevenson. (Written communication with Greg Stevenson, DVM, PhD, Iowa State University Veterinary Diagnostic Laboratory, January 22, 2021)



first-in-last-out (FILO) age is a production metric that tracks the number of days between when the first pig arrived at the site and when the last pig was removed from the site. The FILO age for this site during this case was 136.5 days. The FILO age for this flow of pigs was 129.83 days in 2018 and 134.61 days in 2019. The differences between the FILO age in this case and the historical means were 1.89 and 6.67 more days, respectively (Table 1). The older FILO age in this case was likely due to these pigs being placed into the finisher earlier than normal.

Case 2

The next case occurred the beginning of July 2019. The finishing facility had three, 1160-head capacity barns (3480 total capacity) that were naturally ventilated and fully slatted with metal penning. The barn placement populations were 1225 in barn 1, 1221 in barn 2, and 1247 in barn 3 for a total of 3693 pigs on the site. The flow of pigs at this site was from a previously PRRS-naïve multiplier that broke with PRRS the beginning of April 2019. The timing of the PRRS break on the sow farm meant that the pigs at this finisher were still from a high-health sow farm at weaning. This high-health status is often associated with high morbidity and mortality with an *A suis* infection due to the lack of immunity.[2,10] The finishing farm staff noticed an increase in mortality 2 weeks before the veterinarian was called to the farm. At that time, the farm administered tiamulin (Denagard; Elanco) at the respiratory level, and the pigs seemed to recover. Then, another increase in mortality started the day before samples were taken. At the time of the veterinarian's visit, the pigs were 21 weeks of age and had been in the finisher for 11 weeks. A hacking cough affected at least 75% of the pigs in the barns; clear nasal discharge was also observed in these pigs. Those that died were seemingly normal, healthy pigs that died suddenly with bloody discharge from the nose.

Tissues including tonsil, lung, heart, multiple lymph nodes, liver, spleen, kidney, intestine, and colon were taken from 2 pigs soon after death. No oral fluids were collected. During the necropsies, blood was found in the trachea and lungs of both pigs. An enlarged spleen and multiple enlarged lymph nodes were also observed. Samples were sent to the ISU VDL where histopathology, culture, and PRRS and IAV PCRs were completed. Similar to Case 1, the histopathology showed lesions highly suggestive of an

Table 1: Number of pigs at risk, mortality, and first-in-last-out (FILO) age in the cases described

Case No.	Barn/Room	Pigs placed, No.	At-risk population, No.*	Mortality, No. (%)	Mortality, mean, %	2018 mortality		2019 mortality		FILO age, d	FILO age, mean, d	2018 FILO age, d		2019 FILO age, d	
						Mean, %	Difference, %†	Mean, %	Difference, %†			Mean	Difference†	Mean	Difference†
1	1	1305	1268	51 (3.91)						138					
	2	1326	1277	74 (5.58)	4.81	4.99	-0.18	5.55	-0.74	139	136.50	129.83	1.89	134.61	6.67
	3	1313	1260	73 (5.56)						132					
	4	1299	1267	54 (4.16)						137					
2	1	1225	1197	45 (3.67)						117					
	2	1221	1166	76 (6.22)	5.12	2.30	2.82	3.84	1.28	117	117.00	126.02	-9.02	126.50	-9.50
	3	1247	1197	68 (5.45)						117					
3	1	1238	1197	72 (5.82)						115					
	2	1238	1207	83 (6.70)	6.67	4.40	2.27	5.26	1.41	117	114.00	129.87	-15.87	126.16	-12.16
	3	1283	1240	103 (8.02)						112					
	4	1248	1223	76 (6.09)						112					

* The at-risk population is the number of pigs on site at the time of the veterinarian's visit.

† Difference between the case mean and the historical mean for 2018 and 2019.

Actinobacillus infection. The blood vessel endothelium was swollen, and serous or serofibrinous fluid that contained occasional aggregates of bacteria expanded the adventitia. Interlobular septa and alveoli were distended by serous or serofibrinous effusion. Most alveoli were filled with dense aggregates of neutrophils and fewer macrophages. There were lesions of acute serofibrinosuppurative bronchopneumonia with intralesional short rod-shaped bacteria (Figures 4 and 5). Acute necrotizing bronchitis and bronchointerstitial pneumonia were also observed. *Actinobacillus suis* was cultured from the lung, and influenza A(H1N2) virus was identified by PCR. The PRRS PCR was negative, and *S suis* was also cultured. The *A suis* that was cultured was susceptible to ampicillin, ceftiofur, enrofloxacin, florfenicol, gentamicin, neomycin, sulfadimethoxine, tiamulin, tilmicosin, and trimethoprim/sulfamethoxazole.

All 3 barns at this site were treated by administering tiamulin (Denagard) at the respiratory level and injecting the pigs in the most affected pens. Ninety-five pigs in barn 1, 67 pigs in barn 2, and 36 pigs in barn 3 were injected with 5 mL of ceftiofur hydrochloride (Excenel RTU EZ) for 3 consecutive days according to the product label. This seemed to halt the high mortality that was seen the week of the veterinarian's visit. Only 7 pigs died in the remaining six weeks in barn 1 with a total mortality of 45 (3.67%). Barn 2 had 14 more dead pigs after the *A suis* diagnosis for a total mortality of 76 (6.22%). There were 10 more pigs that died in the last 6 weeks in barn 3 with a total mortality of 68 (5.45%). The mean mortality across all barns was 5.12%. This is an increase of 2.82% from the 2018 annual mean mortality (2.30%) and an increase of 1.28% from the 2019 annual mean mortality (3.84%) for this flow (Table 1). According to Dufresne,[3] finishing mortality can increase by 1% to 2% in a barn of pigs with an *A suis* diagnosis as is seen in this case.

The marketing of these pigs was handled similarly to Case 1 to try to limit excessive mortality. Production personnel worked diligently to quickly sell the healthy pigs. The FILO age for this site during this case was 117 days. The FILO age of this flow of pigs was 126.02 days in 2018 and 126.5 days in 2019. The differences between this case and the historical means were 9.02 and 9.5 fewer days, respectively (Table 1).

Figure 4: The epithelium of the bronchiole is thin, irregular, and attenuated, typical of influenza. Blood vessels are congested. The adventitia of the artery in the lower left is distended by serous effusion (edema fluid). Some alveoli contain dense aggregates of bacteria. Photo and description courtesy of Dr Greg Stevenson. (Written communication with Greg Stevenson, DVM, PhD, Iowa State University Veterinary Diagnostic Laboratory, July 5, 2019.)

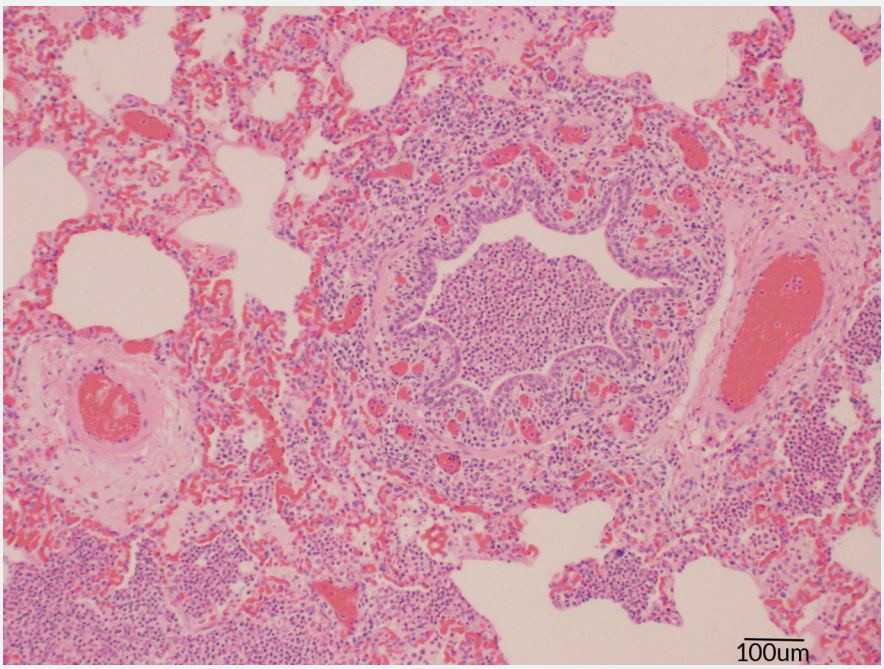
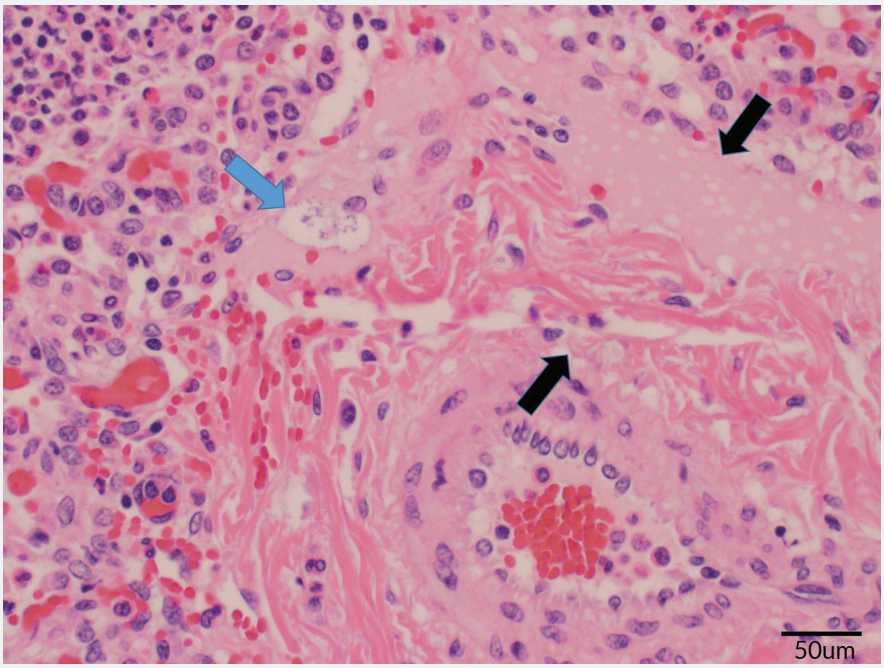


Figure 5: Artery (lower right) has swollen endothelium, and adventitia is distended by edema fluid (between black arrows). Short rod-shaped bacteria are in a vacuole amid the edema fluid (blue arrow). Dense aggregates of neutrophils fill alveoli. Photo and description courtesy of Dr Greg Stevenson. (Written communication with Greg Stevenson, DVM, PhD, Iowa State University Veterinary Diagnostic Laboratory, July 5, 2019.)



Case 3

The third case occurred the beginning of February 2020 at a 4-room, 2-barn site. Each of the 4 rooms had a capacity of 1250 pigs (5000 total capacity), and each room was naturally ventilated and partially slatted with solid block penning. The room placement populations were 1238 in room 1, 1238 in room 2, 1283 in room 3, and 1248 in room 4 for a total of 5007 pigs at the site. The flow of pigs at this farm were from a PRRS stable and PRRS MLV vaccinated flow. The older pigs at this site seemed normal and healthy but began dying suddenly the week prior to the veterinarian's visit. This flow of pigs previously had a clinical case of erysipelas, so tylvalosin tartrate (Aivlosin; Pharmgate) was administered via water assuming erysipelas was again the problem despite not seeing diamond skin lesions. The medication was ineffective, and younger pigs started dying suddenly just a few days prior to the veterinarian's visit. Some of the pens in the rooms had higher mortality than others, but the farm owner did not observe bloody discharge from the nose or mouth of dead pigs.

At the time of the veterinarian's visit, the pigs on the site ranged from 13 to 15 weeks of age and had been in the finisher for 4 to 6 weeks. Two pigs died during the veterinarian's walk-through and were chosen for necropsy and tissue collection. The lungs were adhered to the thoracic wall and were firm, heavy, and purple (Figure 1). There was also fibrin coating the heart. Like the first two cases, samples from the tonsil, lung, heart, multiple lymph nodes, liver, spleen, kidney, intestine, and colon were collected and sent to the ISU VDL where histopathology, culture, and PRRS, IAV, *Mycoplasma hyorhinis*, *M hyopneumoniae*, and *Glasserella parasuis* (GPS) PCRs were completed. Microscopic lesions in the lungs included areas of parenchymal necrosis that were surrounded by fibrin, degenerated leukocytes, foci of hemorrhage, numerous degenerated neutrophils, macrophages, and occasional aggregates of streaming leukocytes (oat cells). A thick layer of fibrinous exudate also covered the pleura of the lung. In the heart, the pericardium was thickened and expanded by layers of granulation tissue (tissue formed in the process of healing). A fibrinous exudate covered the surface with scattered aggregates of lymphoplasmacytic infiltrates that multifocally extended into the myocardium. The mesothelial cells lining the pericardial surface were plumped and hypertrophied.

Again, these lesions were consistent with an *Actinobacillus* infection. *Actinobacillus suis* was cultured from the lung and septicemic sites (liver and spleen). No other bacteria were cultured, and all PCRs were negative. The *A suis* that was cultured was susceptible to ampicillin, ceftiofur, enrofloxacin, florfenicol, gentamicin, neomycin, penicillin, tiamulin, tilmicosin, and trimethoprim/sulfamethoxazole.

Both tiamulin (Denagard) at the respiratory level and ceftiofur hydrochloride (Excenel RTU EZ) were recommended for this site to be used similarly to Cases 1 and 2. The pigs remained at this site for 11 weeks after the veterinarian's visit. Thirty pigs from room 1 died in the remaining weeks before marketing for a total of 72 (5.82%). Room 2 had 52 more pigs that died for a total mortality of 83 (6.70%). Room 3 had the worst mortality with a total of 103 pigs (8.02%), with 44 of those pigs dying in the last weeks. Room 4 lost 43 pigs in the remaining weeks for a total of 76 dead (6.09%). The mean mortality across all 4 rooms was 6.67%. Compared to historical annual mean mortality from 2018 (4.40%) and 2019 (5.26%), the mortality in this case was 2.27% and 1.41% more, respectively (Table 1). Again, finishing mortality is expected to increase by 1% to 2% with an *A suis* diagnosis.[3]

As was done in the other two cases described here, the healthy pigs were sold as quickly as possible to try to minimize mortality losses. The mean FILO age for this site during this case was 114 days. The 2018 historical mean FILO age was 129.87 days in 2018 and 126.16 days in 2019. These historical FILO age means were 15.87 and 12.16 days greater, respectively, than the mean FILO age for the pigs in this case (Table 1).

Discussion

Actinobacillus suis is a gram-negative, aerobic or facultative anaerobic, nonmotile, nicotramide adenine dinucleotide (NAD)-independent coccobacillus bacterium of the Pasteurellaceae family.[1-3,6-10,12-14] It is a ubiquitous opportunistic pathogen and early colonizer of the tonsils and nasal cavity of healthy pigs.[2,3,5,7-12,15-18] It can also be found in the vaginal mucosa of sows.[2,3,8-10,12] *Actinobacillus suis* is believed to pass from sows to piglets.[1,3,18] It is also transmitted by aerosol or nose-to-nose contact.[3,5] It is likely that the bacteria can invade through skin and mucous membrane abrasions as well.[9,10] However, this bacterium is susceptible to most disinfectants, can be killed if kept at 60°C for 15 minutes, and will die in clinical specimens after a few days.[9,10]

Actinobacillus suis can be found in any age of pig but now most commonly occurs in early to middle finishing pigs.[1,3,7-9,11,12,17] Stressful situations, such as transportation, concurrent diseases, crowding, poor ventilation, environmental extremes (excessive heat or frigid temperatures in the barns), among others, are risk factors associated with the incidence of clinical disease.[1-3,5] Decreased immunity to *A suis* due to being offspring of high-health animals, along with a concurrent influenza A(H1N2) virus infection, may have contributed to the *A suis* diagnosis in Case 2. In Case 3, the previous erysipelas diagnosis may have played a role in finding *A suis*. Other possible contributing risk factors for these cases are only speculations and therefore not mentioned here.

After the inciting stressful situation, *A suis* invades through the upper respiratory tract and spreads systemically through the bloodstream.[2] This can cause a variety of clinical signs, but often only sudden death is observed.[2,7,11] *Actinobacillus suis* usually infects 10% or fewer of the pigs in the population, and it can be easily isolated from the pigs that die from the disease.[1,4] Recently deceased pigs are therefore the best to necropsy especially in cases where sudden death is the only clinical sign like the cases described here.[2,7,11] Petechial to ecchymotic hemorrhages can be observed in lung, kidney, liver, spleen, skin, and intestinal tissue samples.[2,4,7,9,10] *Actinobacillus suis* can also produce fibrin similar to GPS and *S suis*.[2,7,9,10,19,20]

There are three different forms of disease caused by *A suis*: an acute fulminant septicemic form, a respiratory form, and an acute septicemic form.[3,7,11] The acute fulminant septicemic form of *A suis* usually occurs in younger grow-finish pigs.[3,4,7,11,17] Pigs with this form of the disease may have no other clinical signs other than death, and gross lesions are characterized by randomly scattered hemorrhages in multiple organs.[4,7,11] Differentials for septicemia with similar lesions in younger grow-finish pigs include GPS, *S suis*, erysipelas, *Escherichia coli*, and *Salmonella*.[1,2,4,7-10] However, due to hemorrhages often seen in the lungs, APP should still be on the differential list.[9] This form of the disease was seen in Case 3.

The respiratory form mainly affects grow-finish pigs.[3,4,7,11] Even in this form, sudden death is often the only clinical sign observed.[3,7] Gross lesions include hemorrhages on multiple organs, but these are most often seen on the serosal surface of the lungs.[3,7] The differentials should include APP because the gross and histologic lesions in the lungs of pigs with *A suis* infections are indistinguishable from those of APP infections.[1-3,6-11,18] Other differentials include GPS and erysipelas.[9] This form of the disease was seen in Cases 1 and 2.

The acute septicemic form occurs in older growing pigs and adults.[7] Skin lesions similar in appearance to erysipelas, abortions, metritis, fever, and anorexia can be observed in this form.[2,3,7,9,11,16] Again, hemorrhages in multiple organs and fibrin can be seen during necropsy.[3,7] Differentials should include APP, GPS, and erysipelas.[3,7-9,11]

Pulmonary lesions caused by APP and *A suis* are often indistinguishable.[9] Therefore, both bacteria should be differentials when the clinical signs and gross lesions described here are seen. The primary reason the lesions of these two diseases are almost identical is due to the production of toxins.[9] The toxins produced by *A suis* are ApxI and ApxII, both of which are also produced by APP.[2,7,9,11,12,15-18] However, *A suis* is less virulent than APP because *A suis* is believed to produce fewer of these toxins than APP.[2,4,7]

Bacterial culture is the gold-standard test for *A suis* diagnosis.[2,6-10] *Actinobacillus suis* grows well on blood agar plates, and it can be found in both the lungs and systemic sites.[2,3,6,9,10,18] *Actinobacillus suis* was cultured from the lungs in Cases 1 and 2 and from the lung, spleen, and liver in Case 3.

An *A suis* PCR was not done for these three cases. While no PCR test has been validated for *A suis,* some laboratories may offer this test. An *A suis* enzyme-linked immunosorbent assay has also not been validated. However, an experimental antibody test for *A suis* is being used at the University of Montreal.[16] While still experimental, Lapointe et al[16] points out that this test may be useful in making decisions regarding the use of autogenous vaccines but should not be used diagnostically.

To decrease mortality in suspected *A suis* outbreaks, it is necessary to start treatment as soon as possible, prior to receiving sample results back from the

lab. The inability to clinically distinguish between APP and *A suis* guided the veterinarian's choice of antibiotics used for the 3 cases.[1-3,6-11] For *A suis*, there are multiple choices for water-administered antibiotics including tiamulin, chlortetracycline, sulfadimethaxine, oxytetracycline, gentamicin, neomicin, clindamycin, and penicillin.[1,7] These can be used with varying efficacy according to laboratory minimum inhibitory concentrations, though none are labeled for *A suis*.[1] While both chlortetracycline and tiamulin are labeled for APP, reports of chlortetracycline resistance may make tiamulin the only water-administered antibiotic on this list that is effective for APP.[7] Ceftiofur and gentamicin are injectable antibiotics that are effective against both APP and *A suis*.[7] However, of the two, only ceftiofur is labeled for APP and neither are labeled for *A suis*.

Currently, there are no effective commercial vaccines available for *A suis*. The production of a vaccine could help lower the chances of devasting disease by increasing humoral immunity and stabilizing antibodies.[16] Lapointe et al[16] described an autogenous vaccine that was produced using two field isolates of the bacteria. Protocols for autogenous vaccine use varies depending on the age of disease onset.[16] Vaccination of sows is warranted for repeated disease seen in piglets, but pigs should be vaccinated if the disease repeatedly occurs in finishing.[16] The author did not pursue the production of an autogenous vaccine due to the sporadic nature of disease seen across multiple flows.

Implications

Under the conditions of this case study:

- Bacterial culture was a valuable diagnostic test for cases of *A suis* infection.
- Treatment that targets both APP and *A suis* infections should be considered.

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Conflict of interest

None reported.

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Modification of a standard dump trailer into a mobile carbon dioxide depopulation unit for swine

Brent J. Pepin, DVM, MS; Todd Williams, DVM; Carissa Odland, DVM; Taylor Spronk, DVM; Joel Nerem, DVM

Summary

Carbon dioxide (CO_2) is an American Veterinary Medical Association approved swine euthanasia method. A limitation for the use of CO_2 during depopulation events, such as a foreign animal disease diagnosis, is the ability to apply the method to finisher and adult pigs. The common euthanasia methods in finishing and adult swine require individual animal handling and restraint, increasing human safety risk in large-scale depopulation events. This project validates the modification of a standard dump trailer into a mobile CO_2 depopulation unit. The success of the method was verified with subdermal implants for monitoring heart rate, activity, and body temperature.

Keywords: swine, carbon dioxide, depopulation, trailer, implant

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Resumen - Modificación de un camión de volteo estándar en una unidad móvil de dióxido de carbono para la despoblación de cerdos

El dióxido de carbono (CO_2) es un método de eutanasia porcina aprobado por la Asociación Americana de Medicina Veterinaria. Una limitación para el uso de CO_2 durante los programas de despoblación, por ejemplo, debido al diagnóstico de una enfermedad exótica, es la capacidad de emplear el método en cerdos de engorda y adultos. Los métodos comunes de eutanasia en cerdos de engorda y adultos requieren el manejo y sujeción individual de los animales, lo que aumenta el riesgo para la seguridad humana en programas de despoblación de gran escala. Este proyecto valida la modificación de un camión estándar en una unidad móvil de despoblación usando CO_2. El éxito del método se verificó con implantes subdérmicos para monitorear la frecuencia cardíaca, la actividad y la temperatura corporal.

Résumé - Transformation d'une benne basculante standard en une unité mobile de dépeuplement au dioxyde de carbone pour les porcs

Le dioxyde de carbone (CO_2) est une méthode d'euthanasie porcine approuvée par l'American Veterinary Medical Association. Une limitation de l'utilisation du CO_2 lors d'événements de dépeuplement, comme un diagnostic de maladie animale exotique, est la possibilité d'appliquer la méthode aux porcs de finition et aux porcs adultes. Les méthodes d'euthanasie courantes chez les porcs à l'engraissement et les porcs adultes nécessitent une manipulation et une contention individuelles des animaux, ce qui augmente le risque pour la sécurité humaine lors d'événements de dépopulation à grande échelle. Ce projet valide la transformation d'une benne basculante standard en unité mobile de dépeuplement au CO_2. Le succès de la méthode a été vérifié avec des implants sous-cutanés pour surveiller la fréquence cardiaque, l'activité et la température corporelle.

The current methods for on-farm euthanasia of late finishing age (4-6 months of age) or adult swine rely on individual animal handling and restraint.[1,2] Individual animal handling is problematic for large-scale depopulation due to the physical and emotional stress on personnel, leading to increased hazardous situations.[3] As in a foreign animal disease outbreak, an efficient euthanasia method that accounts for animal and human welfare is needed in a depopulation event. The American Veterinary Medical Association (AVMA) defines depopulation as the "rapid destruction of a population of animals in response to urgent circumstances with as much consideration given to the welfare of the animals as practicable."[4]

Carbon dioxide (CO_2) inhalation is an AVMA approved euthanasia method for individual swine but requires special equipment.[5] For appropriate use of CO_2 in a depopulation event for multiple animals at once, a mobile method for application to adult swine is needed. An advantage CO_2 inhalation has over other inhalant gases is its nonflammable properties and easy reversal if accidental human exposure occurs.[6,7] Previous studies on the modeling of dump trucks for the CO_2 depopulation of pigs show that it can be operational if design specifications are met.[3,8] Required specifications include an airtight seal at the bottom and sides, an impermeable top cover, a vent to allow displaced oxygen to escape, and CO_2 to be introduced at a 20% volume/minute rate.[1,3,6] The further advantage of the dump trailer is for pigs to be depopulated outside of the barn and carcasses to be efficiently transported to a designated location for disposal. This depopulation of pigs outside the barn prevents the need to physically

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

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remove each carcass from the building, thus increasing worker safety, caretaker well-being, and depopulation process efficiency.[1]

The development of specifications and modifications to a standard dump trailer that the swine industry can replicate would provide an easily constructed and readily accessible option when depopulation events arise. This project provides the modifications made to a standard 2.4 m wide × 12 m long × 1.02 m tall vertical hydraulic dump trailer to produce a mobile CO_2 depopulation apparatus. This project also confirms the success of the CO_2 trailer on finisher pigs and adult swine.

Animal care and use

Animals were used under the guidelines and approval of the Pipestone Research Institutional Animal Care and Use Committee protocol ID No. 2020-009.

Materials and methods

Animals

A total of 160 pigs (mean weight = 82 kg) and 42 sows (mean weight = 198 kg) were used in this study. Finishing age pigs were divided into two trailer-load groups (80 pigs each). Eight finisher pigs were sedated for surgical implant installation with a cocktail of tiletamine, butorphanol, and xylazine. The subcutaneous implant monitors (DST centri-HRT ACT; Star-Oddi) measured the animal's heart rate (beats per minute [bpm] derived from electrocardiogram [ECG]), activity (external acceleration > 1 standard gravity), and body temperature. The external acceleration from the activity was measured by a calculation on the external acceleration of the *g*-force above the standard gravity from a 3-axis accelerometer. Implants were installed over the xiphoid process of the sternum. Animals were implanted 48 hours before CO_2 administration to attain baseline information after the sedatives were cleared from the body. Implant readings were taken every 30 minutes until the day of CO_2 administration when readings were then taken every 15 seconds. The implanted finishing age pigs were assigned by convenience into two different loads for CO_2 exposure. Immediately after the CO_2 administration, the pigs were visually inspected for any signs of breathing or movement. If breathing or movement was observed, CO_2 administration would be repeated for an additional complete cycle. Pigs were also visually inspected for any signs of movement or breathing while carcasses were emptied onto the ground. If breathing or movement was observed at this stage, the captive bolt euthanasia method was applied immediately. Following captive bolt administration, the animal was confirmed dead by lack of corneal reflex when touching the eye and the cessation of breathing under the observation of a licensed veterinarian.

Trailer

A 2.4 m wide × 12 m long × 1.02 m tall standard frameless, open-top, hydraulic lift, double-axle dump trailer was modified to handle CO_2 gas input. A vertical sliding door was installed on the rear of the trailer to be flush with the barn's chute and be able to open or close as needed for loading pigs (Figure 1). A ceiling was built inside the trailer at the height of 1 m to limit the area needed to be filled with CO_2 and ensure animals could not lift their heads above the CO_2 gas. The ceiling was made from aluminum material and was hinged with liftable panels down the center to provide an alleyway for people to walk upright with a sorting board to aid in loading the trailer (Figure 2). The aluminum ceiling was welded into place with an overlapping lip on one side of the liftable panels to prevent a gap formation (Figure 2). Duct tape (Gorilla Tape; Gorilla Glue, Inc) was placed over the trailer liftable ceiling panel seams to ensure an airtight seal before CO_2 inflow began.

A swing gate hinged near the top of the installed ceiling that could be lowered and locked was installed at the halfway point of the trailer length (Figure 3). This gate could be locked after the front half of the trailer was loaded with animals so they could not run back off the trailer while the back half was filled. Animals were loaded onto the trailer using a sorting board with the same methods used and level of difficulty experienced when loading pigs onto a livestock trailer for transport. After the trailer was fully loaded, the hinged swing gate was unlocked, and the CO_2 filling began. The gate could swing open during the dumping process.

Four 1.25-inch ball valve ports were installed into the lower sidewall on one side of the trailer. On the opposite side, four ball valve ports were installed high on the trailer but below the ceiling (Figure 4). The lower ports allowed for CO_2 input, while the higher ports allowed oxygenated air to escape as CO_2 gas filled from the bottom. Plastic piping was added onto the end of the oxygen escape ports to ensure any escaped CO_2 would flow towards the ground and not into an area where people may walk (Figure 4).

CO_2 administration

The transfer of CO_2 from high-pressure to low-pressure tanks for flowing into the trailer was based on previously published work.[1] During this project, the ambient outside temperature was 23°C. The 1000-gallon low-pressure repurposed tanks (former propane tanks) were filled from a high-pressure CO_2 vertical gas-liquid (VGL) cylinder through a non-electric ambient air approximately 2500 standard cubic feet per hour vaporizer (Thermax; Chart Industries). The repurposed low-pressure tanks were refurbished with new fittings, gauges, and pressure relief valves for safety. The VGL cylinder and vaporizer were transported in a separate enclosed trailer and two 1000-gallon tanks on an open trailer (Figure 5). The CO_2 flowed into the trailer through the four CO_2 ports by hoses connected to a 1000-gallon low-pressure tank (4 hoses/tank). Each 1000-gallon tank was filled with enough CO_2 to fill the dump trailer up to the installed ceiling (120 psi). A regulated valve allows a flow of 20 to 24 psi/minute for 5 minutes for the tank feeding into the trailer. After the 5-minute fill time, all valves (oxygen and CO_2) were closed, and the trailer was held sealed for 10 minutes (15 minutes total time from CO_2 start to end of holding time). After holding time, ceiling panels were opened, and animals were inspected for any signs of breathing or movement. If no breathing or movement signs were observed, the carcasses were removed from the trailer by gravity via the trailer's hydraulic lift system (Figure 6). Carcasses were examined for any signs of breathing or movement during and immediately after the truck emptying process, moving carcasses around as necessary for proper visualization of all animals.

Results

Implant results

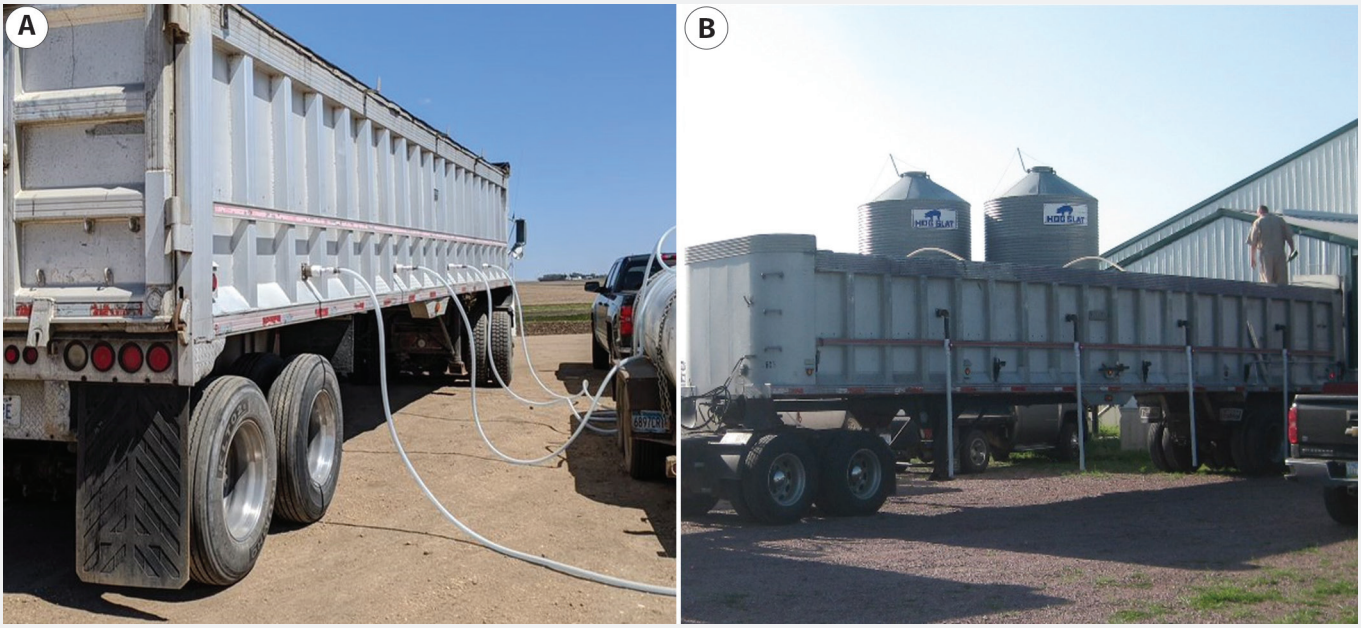
One pig did not recover from sedation for implant placement, allowing for readings from only 7 of the 8 pigs. A substitute pig was added to keep the finisher pig numbers the same but did not have an implant placed. The ECG images from

Figure 1: Rear of the trailer with a vertical sliding door installed for loading pigs. A) The vertical sliding door open and trailer backed up to barn chute for loading pigs. B) The trailer with the closed vertical sliding door (arrow).

Figure 2: Installed ceiling in the trailer with hinged center. A) The ceiling decreased the area needed to be filled with CO_2 and prevented pigs from raising their heads above the gas. B) The hinged center provided a space for people to walk while loading pigs onto the trailer that could be closed later. C) The overlapping lip on one side of the liftable hinged panels prevented the formation of a gap.

Figure 3: Top hinged swing gate installed at the halfway point of the trailer. The swing gate can be lowered after filling the front half of the trailer to allow greater ease in loading pigs in the back half.

Figure 4: Ball valve ports to let CO_2 in and oxygen out. A) The valves attached to the hoses to move CO_2 into the trailer. B) The valves that allow the oxygen to escape on the opposite side of the trailer.



the individually implanted pigs showed no regular sinus rhythms at the end of the holding time. Figure 7 demonstrates the decrease in heart rate and activity readings throughout the CO_2 exposure and holding process. Figure 7 also shows heart rate and activity measurements at 22 minutes before starting the CO_2 inflow into the trailer, which would encompass the time to load the pigs onto the trailer. Body temperature readings from the implanted pigs ranged from 39.5°C to 40.7°C with a mean body temperature of 40.1°C from the time the CO_2 inflow was started to the end of the holding time. All implanted pigs experienced an increase in body temperature over the CO_2 inflow and holding time.

Animals

Of the 160 finisher pigs (2 trailer loads of 80 pigs each) in this study, one pig in group 1 was observed to begin breathing after the trailer was emptied. This pig did not show any signs of positional self-righting behavior or respond to being physically touched. This animal was euthanized immediately by a captive bolt device. The cessation of life for all 42 sows (1 trailer load) was successful after the CO_2 holding time was completed.

Discussion

The filling of CO_2 and the displacement of oxygen are necessary for the trailer unit to work. The heavier molecular weight of CO_2 allows the displacement of the oxygenated air out of the higher release valves on the trailer.[7] The ability to close the oxygen release valves also helped minimize CO_2 loss through them once the trailer filled based on the flow rate. The one pig from group 1 that began breathing again after the hold time was completed demonstrated the importance of a near airtight container. That pig was located next to the vertical sliding door which did not seal completely and allowed oxygenated air to leak in. The vertical door was ensured to be slid down completely into place and flush with the truck's frame for all remaining groups. Depending on how other sliding doors in the field are constructed, sealing the outside door seam with duct tape may be helpful. The sows used in this project were tall enough to push on the trailer's ceiling when they raised their heads. The weight of the ceiling and duct tape covering the panel seams were sufficient to still attain proper CO_2 exposure without leaking in oxygen. If the trailer is used frequently on adult animals, a higher ceiling may be beneficial to better accommodate their size. Further use of the unit in the field outside of the current study has been 100% successful on approximately 700 finisher swine and 3000 nursery pigs (20-30 days of age).

The implant monitor results for activity and heart rate were limited to 7 finisher animals in this project and not completed in the sows. As seen in Figure 7, recorded activity levels flattened out, and recorded heart rates reached 0 bpm in the implanted pigs. At the end of the holding time, images of the implant ECG readings revealed an absence of normal sinus rhythm in the individual pigs. The lack of sinus rhythm in brain death is supported in the human literature by the documented progressive loss or depression of sinus activity in the terminal stages of brain death.[9] As expected, Figure 7 shows the heart electrical activity, measured as bpm, continuing after death occurs due to the heart's sinoatrial node activity even after brain death may have occured.[9,10]

A spike in activity in the second group can be attributed to the dump trailer's movement to the designated unloading location at that time. In the first group, the dump trailer was left stationary before moving to the selected unloading location. The accelerometer measurements of pig activity allow for an objective way to monitor the general animal activity without subjective human observation. This objective ability to monitor was helpful in this study where the physical observations could not be performed during the CO_2 exposure process. Group 1 showed greater spikes in activity readings than group 2, but the activity readings flattened out in both groups before the end of the holding time. Spikes in activity levels were visually comparable for both groups before the start of CO_2, with activity readings flattening out just prior to the end of the

Figure 5: The tanks and non-electric vaporizer used for CO_2 delivery. A) The 1000-gallon low-pressure tanks that flowed CO_2 into the trailer. B) The non-electric vaporizer and C) vertical gas-liquid tank carried on an enclosed trailer and used to fill the low-pressure tanks.

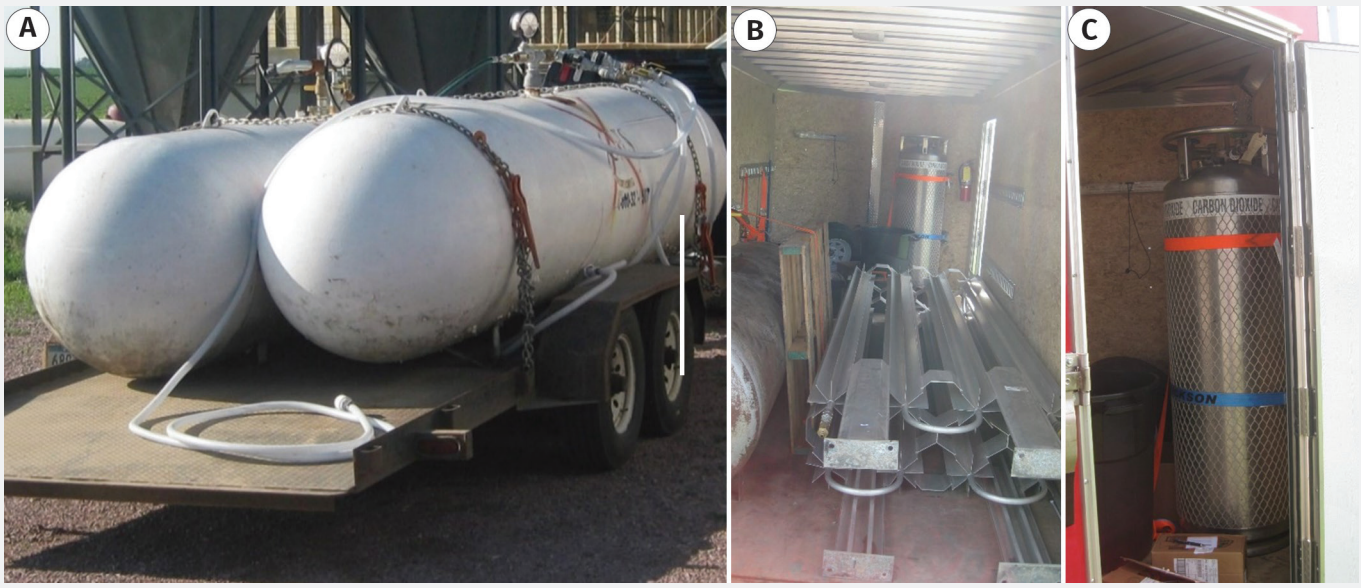


Figure 6: Hydraulic dump trailer in a raised position for easy emptying of carcasses. The trailer can be moved to place carcasses in a designated location.

holding time and did not resume afterward. This reduction of activity provides confidence that the CO_2 inhalation was influencing the pigs. Heart rate in both groups remained above 100 bpm until after the CO_2 exposure cycle was complete, staying comparable to the period of readings taken before CO_2 inflow was started. The spikes in activity and visually typical heart rates between CO_2 fill and end of holding time compared to the pre-exposure suggest the pigs may have been able to recover if exposed to oxygenated air during this time (Figure 7). This observation supports the importance of maintaining the recommended 15 minutes for CO_2 exposure (5 minutes of CO_2 fill with a 10-minute hold).[1,3,6] The ability for animals to recover if not adequately exposed to the complete CO_2 cycle is supported by the 1 pig in the current study that was able to resume breathing when oxygenated air was allowed to leak through the improperly closed sliding door.

Body temperatures did show a slight rise throughout the CO_2 inflow and holding procedure. This increase in temperature is possibly due to the ambient temperature inside the trailer. The trailer internal ambient temperature could rise due to the lack of air movement coupled with animal movement until sedation from the CO_2 inhalation and pig respiration until death. The shortcomings of this study include the lack of a CO_2 monitor inside the trailer to confirm gas concentration. Another shortcoming is the lack of ambient temperature measurement from inside the trailer during the CO_2 fill and holding time.

The transfer of CO_2 from the high-pressure VGL to the low-pressure tanks is the greatest time-limiting step of the process. The non-electric vaporizer (heat exchanging device) greatly hastened this gas transfer rate, saving time. The vaporizer helps fill the low-pressure tanks with CO_2 from VGL cylinders in approximately 30 minutes at 23°C ambient environmental temperature. Without the vaporizer, the flow is kept slow to decrease the loss of CO_2 to dry ice formation.[1,7] The vaporizer utilized in the current study would require supplemental heat in colder temperatures to provide the same flow rate into the low-pressure tanks. In case supplemental heat was needed, the vaporizer was hauled on an enclosed trailer that could be heated if necessary. Other vaporizer models may allow for CO_2 transfer under more extreme temperature conditions outside the ambient temperatures explored in this study.

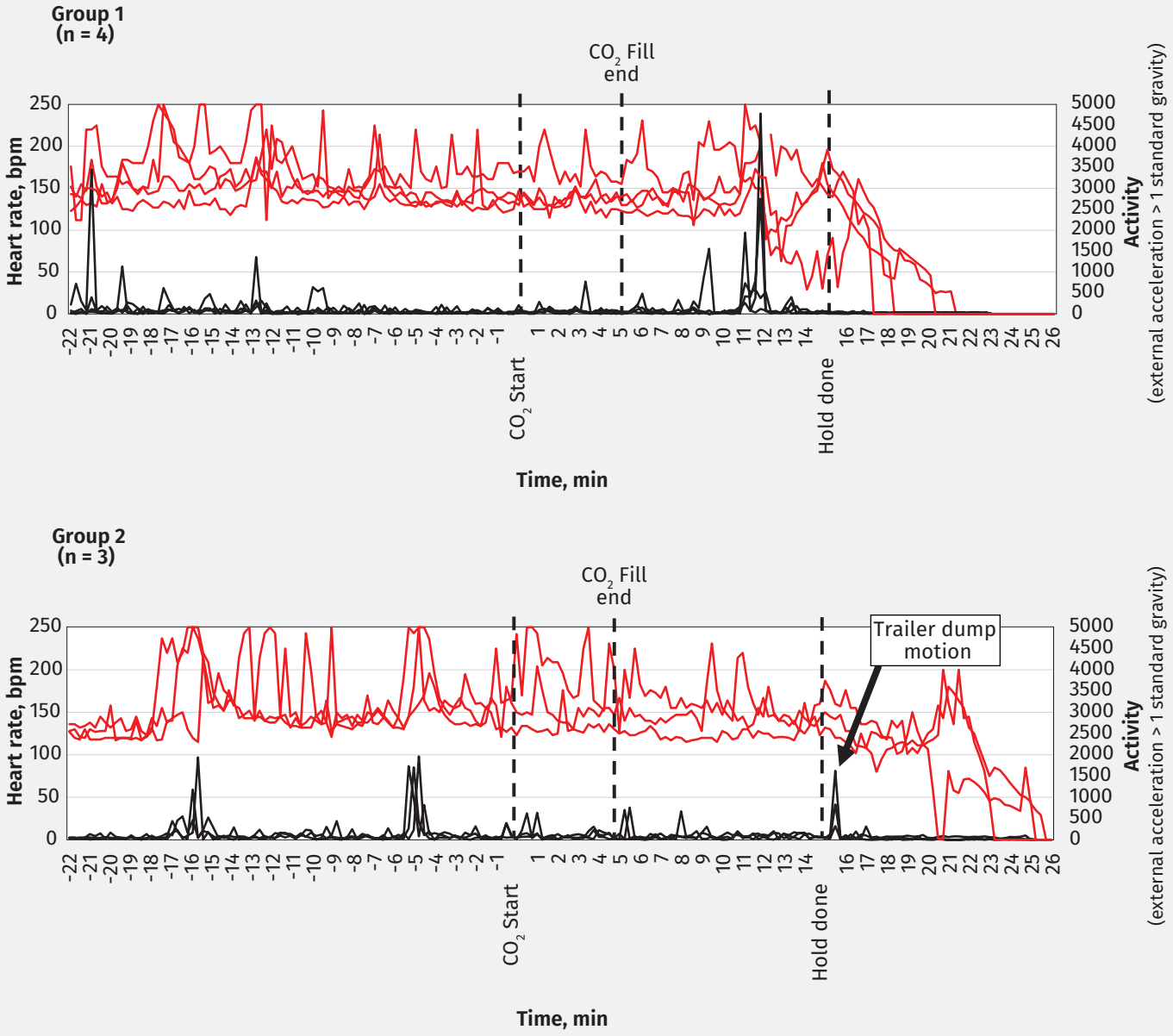
The trailer modifications for use as a portable CO_2 unit provided a success rate of 99.5% (201 of 202 pigs) of finisher pigs and sows depopulated. This unit provides a viable tool for the industry for application in a foreign animal disease outbreak where a depopulation event is required. Greater efficiencies in the process may be found with further research into other in-field options.

Implications

Under the conditions of this study:

- A standard dump trailer can be modified into a mobile CO_2 depopulation unit.
- Minimizing potential air leaks is essential for CO_2 depopulation success.

Figure 7: Heart rate and activity readings over time from the start of CO_2 flow into the trailer in two groups of pigs. Red lines represent heart rate (beats per minute) and black lines represent activity measurement (external acceleration > 1 standard gravity). Start time of CO_2 flow, end of CO_2 fill, and completed holding times (15 minutes from the start of CO_2 flow) marked in the figure. In group 2, motion from the truck movement was picked up by the implant monitors.



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Conflict of interest

None reported.

Disclaimer

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Conversion tables

Weights and measures conversions

Common (US)	Metric	To convert	Multiply by
1 oz	28.35 g	oz to g	28.35
1 lb (16 oz)	0.45 kg	lb to kg	0.45
2.2 lb	1 kg	kg to lb	2.2
1 in	2.54 cm	in to cm	2.54
0.39 in	1 cm	cm to in	0.39
1 ft (12 in)	0.3 m	ft to m	0.3
3.28 ft	1 m	m to ft	3.28
1 mi	1.6 km	mi to km	1.6
0.62 mi	1 km	km to mi	0.62
1 in^2	6.45 cm^2	in^2 to cm^2	6.45
0.16 in^2	1 cm^2	cm^2 to in^2	0.16
1 ft^2	0.09 m^2	ft^2 to m^2	0.09
10.76 ft^2	1 m^2	m^2 to ft^2	10.8
1 ft^3	0.03 m^3	ft^3 to m^3	0.03
35.3 ft^3	1 m^3	m^3 to ft^3	35.3
1 gal (128 fl oz)	3.8 L	gal to L	3.8
0.26 gal	1 L	L to gal	0.26
1 qt (32 fl oz)	0.95 L	qt to L	0.95
1.06 qt	1 L	L to qt	1.06

Temperature equivalents (approx)

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

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

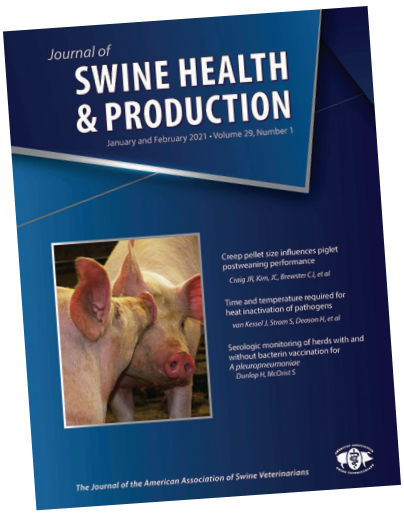
Conversion calculator available at: amamanualofstyle.com/page/si-conversion-calculator

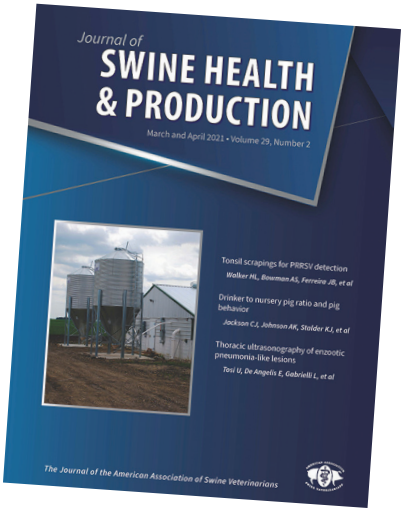
Conversion chart, kg to lb (approx)

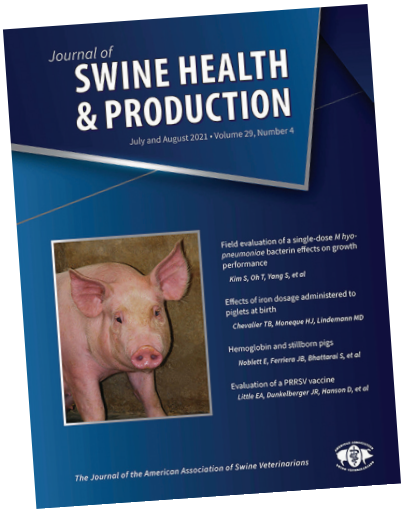
Pig size	Lb	Kg
Birth	3.3-4.4	1.5-2.0
Weaning	7.7	3.5
	11	5
	22	10
Nursery	33	15
	44	20
	55	25
	66	30
Grower	99	45
	110	50
	132	60
Finisher	198	90
	220	100
	231	105
	242	110
	253	115
Sow	300	136
	661	300
Boar	794	360
	800	363

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

Pigs of #instaham







Share your pig photos for the JSHAP cover

Submissions by readers are welcome!

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

Momentum grows for Certified Swine Sampler Collector Training Program

If you have not heard about the Certified Swine Sampler Collector (CSSC) Training Program yet, you soon will. Many state veterinarians across the Hog Belt have already adopted the program and have begun planning on how to launch the CSSC program in their respective states to get more producers trained.

"We're excited by the response that we've been getting across the country," says Pam Zaabel, DVM, Director of Swine Health with the National Pork Board. "More states and swine veterinarians are seeing the value of what the training program could mean to their response time during a foreign animal disease crisis."

The CSSC program, an industry-wide initiative jointly managed by the National Pork Board, the American Association of Swine Veterinarians, and Iowa State University, can help in a foreign animal disease response by increasing sample collection capacity by allowing the current on-farm labor force to be a critical asset in collecting samples correctly and submitting them to certified laboratories. The program also assures state and federal animal health officials that producers and caretakers have been trained prior to an outbreak through a standardized process to correctly collect, handle, and submit samples.

For USDA Category II accredited veterinarians with swine experience who wish to train individuals to become CSSCs, the first step is to contact the State Animal Health Officials in the state(s) where they plan to train or use CSSCs to confirm their eligibility to participate in the program and any additional requirements that exist. For more information and to access the training materials, go to **securepork.org/cssc**.

AgView adoption grows, new feature offers everyday utility

After more than a year since its release, AgView, the free online software platform for contact tracing of pigs, has gained acceptance by half of the nation's state veterinarians and AgView accounts continue to grow among producers of all sizes. AgView was developed by the National Pork Board, using Checkoff funding, to promote business continuity and make disease traceback and pig movement data available to state animal health officials on day one of a foreign animal disease outbreak.

"We're very pleased with how the first year of AgView adoption has gone, but we have much more to do to ensure all producers and veterinarians see the value of getting on board," says Patrick Webb, DVM, Director of Swine Health at the National Pork Board.

The newest feature of AgView is called Account Management Partner (AMP). The AMP feature allows swine veterinarians to request permission from their existing clients who are using AgView to help them prepare for an African swine fever outbreak and leverage locations, movements, and lab data to better manage/treat/prevent/track existing endemic disease threats such as porcine reproductive and respiratory syndrome, influenza, porcine circovirus, etc.

To learn more about AgView, including AMP, please visit **agview.com**. For questions, please contact Dr Patrick Webb at **pwebb@pork.org** or call 515-223-3441.

Trackable manure management strategies, can save farmers money

By using a free On-Farm Sustainability Report, courtesy of the Pork Checkoff, producers can now refine their nutrient management plan and evaluate how the report can set a baseline for their farms and bottom lines. According to the Sustainable Environmental Consultants, swine manure has an average nutrient (N, P, K) savings of $120/acre when applied at 4000 gallons/acre.

On-Farm Sustainability Reports will help producers recognize key sustainability metrics on their operations. It will help track, measure, monitor, and report the sustainability story of each operation and the US pork industry. Complete the form found at **porkcheckoff.org/sustainability** to let us know you are interested in receiving a customized report for your farm.

For more information or if you have questions, contact Dr Brett Kaysen at **bkaysen@pork.org** or 515-223-3528.

Defining Our Future

53rd AASV Annual Meeting

Howard Dunne Memorial Lecture:

Leaping into the future:
Sit down, buckle up, and hang on
Angela Baysinger

Alex Hogg Memorial Lecture:

Learning for the future
Jim Kober

February 26 – March 1, 2022
Indianapolis, Indiana

Register today!
aasv.org/annmtg

AASV Board highlights

The AASV Board of Directors and committee chairpersons met virtually on September 29th for a review of AASV committee activities. The AASV Board of Directors met virtually on September 30th to conduct official business. The following are highlights from the meetings:

- Committee leaders agreed to hold virtual committee meetings prior to the 2022 annual meeting. Schedules are posted on the committee webpages: **aasv.org/aasv/committee**. Committees will also meet in Indianapolis on Saturday, February 26th.
- The launch of the reorganized, responsive AASV website is anticipated to occur around the time of the 2022 AASV Annual Meeting.
- The Board took the following actions:
    - Approved the description for the new Outstanding Swine Academic of the Year Award: **aasv.org/aasv/academic_award**.
    - Granted a request from the PRRS Task Force for up to $10,000 in expenses related to preparing a clinical case definition based on key production indicators for each PRRSV classification status.
    - Approved revisions to the *Hygiene, and Sanitation Guidelines for Boar Studs Providing Semen to the Domestic Market* - **aasv.org/members/only/BoarStudGuidelines.pdf**.
    - Approved a request from the Collegiate Activities Committee to submit a manuscript to Journal of the American Veterinary Medical Association describing swine veterinary education.
    - Approved the Collegiate Activities Committee's request to survey US veterinary colleges about swine medicine education.
    - Approved the mission proposed for the newly established Diversity, Equity, and Inclusion Committee: To promote a socially conscious organizational culture that affirms the value of diversity, equity, and inclusion. To increase diversity, equity, and inclusion awareness among members and students through education and outreach. To make recommendations that result in a comprehensive effort to enhance diversity, equity, and inclusion within the AASV and the communities that we serve through actionable goals with defined timelines.
    - Approved the document *Recommendations for the Depopulation of Swine*.
    - Approved the Pig Welfare Committee's request to submit a letter to NPPC regarding fetal depopulation indemnification.
    - Approved proposed modifications of the AASV position statement on Anti-abuse.
- The Board approved an increase in membership dues to $280 and an increase in Annual Meeting registration fees by $30.
- Dr Harry Snelson described the continually increasing costs associated with in-person meetings, especially in the areas of food and beverage and audiovisual equipment.
- The program for the 2022 AASV Annual Meeting, *Defining our Future*, chaired by Dr Mike Senn, is available online at **aasv.org/annmtg**. Planning continues for an in-person annual meeting in Indianapolis February 26-March 1, 2022.
- Dr Angela Baysinger was nominated to run for the office of AASV Vice President.

Read the complete minutes of the Board meeting at **aasv.org/members/only/board/board_f21**.

View each committee's fall report on the committee webpages. Interested in joining a committee? Contact the AASV office by email, **aasv@aasv.org**, or phone, 515-465-5255.

AVMA Committee and Council positions open

The AASV designates representatives for several committees of the American Veterinary Medical Association. Current representatives are listed at **aasv.org/members/only/AVMAreps**. Visit **avma.org/membership/volunteering-avma/avma-volunteer-opportunities-vacancies** for more details and descriptions of each committee. Several committees have openings; please contact the AASV office (**aasv@aasv.org**; 515-465-5255) if you are interested in representing AASV.

Early Career Discussion Forum

The Early Career Discussion Forum, created by the Early Career Swine Veterinarian Committee in 2021, is a resource for early career AASV members. This space can be used for peer-to-peer support as early career veterinarians navigate their way through the first several years in swine medicine, no matter what type of career in which they find themselves. Discussions center around pig health and production, business and finance, and personal and professional growth and development.

To access the Early Career Discussion Forum, visit **early.aasv.org** to login in with your AASV email and password and get your conversations started!

First AASV Early Career Swine Veterinarian Conference held November 5

To encourage and support swine veterinarians in the early stages of their careers, AASV held the first-ever Early Career Swine Veterinarian Conference on November 5th in Ames, Iowa, in conjunction with the Iowa State University James D. McKean Swine Disease Conference.

The AASV Early Career Committee, established in 2020, planned the conference to offer a welcoming, interactive setting where early career veterinarians could socialize, collaborate, and communicate with others working in swine veterinary medicine. The half-day conference was intended for AASV members who have received their veterinary degree within the past ten years.

Dr Larry Firkins opened the conference with a discussion about leadership. By using an interactive demonstration, he described that the culture of an organization is revealed by what it does and not necessarily what it says. Dr Doug Groth reminded the audience that their retirements were right around the corner in his presentation about personal and professional finances.

The second half of the afternoon included scientific presentations. Drs Jeremy Pittman and Kurt Kuecker described unique cases encountered in swine practice. Dr Pittman encouraged veterinarians to never stop learning by reading about cases they recently diagnosed. Dr Kuecker stressed that veterinarians should always verify a process is done correctly. Dr Mike Eisenmenger emphasized that swine veterinarians must know about ventilation.

Conference recordings are available in the AASV video library: **aasv.org/members/only/video/**.

The afternoon's educational presentations were followed by an evening social gathering at a local restaurant, sponsored by Boehringer Ingelheim Animal Health and Merck Animal Health.

Dr Doug Groth, financial literacy.

Dr Jeremy Pittman, case review.

Whatcha gonna bid?

The AASV Foundation is gearing up for its annual live and silent fundraising auctions to be held in conjunction with the 2022 AASV Annual Meeting. While the silent auction will be conducted entirely online using the popular ClickBid site, the live auction will once again close out the Monday evening festivities during the meeting in Indianapolis.

It is time to take a look – a really good look – at the auction items and ask yourself, "Whatcha gonna bid?"

As you peruse the items up for bid at **aasv.org/foundation/2022/auctionlist.php**, look beyond the posted market value of each item and consider the following:

- Whatcha gonna bid to support research with direct application to what you do every day?
- Whatcha gonna bid to provide opportunities for veterinary students to gain practical, hands-on experience in swine practice?
- Whatcha gonna bid to help relieve student debt for young swine practitioners?
- Whatcha gonna bid to support scholarships for swine veterinarians pursuing an advanced degree or board certification in the American College of Animal Welfare?
- Whatcha gonna bid to provide travel stipends and scholarships for veterinary students attending the AASV Annual Meeting?
- Whatcha gonna bid to preserve the history of organized swine veterinary medicine?

When you bid in the foundation auction, you are supporting all of this and more!

Bidding on silent auction items will open in February at **https://aasvf.cbo.io.** To bid in the live auction, be present at the AASV Awards Reception in Indianapolis, or contact AASV (**aasv@aasv.org**, 515-465-5255) to make arrangements for offsite bidding.

So, whatcha gonna bid?

Early career swine practitioners invited to apply for debt relief

Applications are now being accepted for three $5000 scholarships to be awarded to early-career swine practitioners through the Dr Conrad and Judy Schmidt Family Student Debt Relief Endowment. The scholarship recipients will be announced during the 2022 AASV Annual Meeting.

The scholarships are available to AASV members who are between 2 and 5 years post graduation from veterinary school, engaged in private practice, and who carry a significant student debt burden.

The scholarship program was initiated three years ago with a $110,000 contribution to the foundation by the Conrad Schmidt and Family Endowment. Strong interest by applicants prompted the foundation board to increase the number of scholarships awarded to three, beginning in 2021.

The scholarship application form is available at **aasv.org/foundation/debtrelief.php**. Applications are due January 31, 2022. The following criteria will be used to select the scholarship recipient:

1. Joined AASV as a student enrolled in an AVMA-recognized college of veterinary medicine
2. Attended the AASV Annual Meeting as a student
3. Maintained continuous membership in AASV since graduation from veterinary school
4. Is at least 2 years and at most 5 years post graduation from veterinary school (2017, 2018, 2019 DVM/VMD graduates)
5. Has been engaged in private veterinary practice, 50% or more devoted to swine, providing on-farm service directly to independent pork producers. Veterinarians who work for production companies, pharmaceutical companies, or universities are not eligible for the scholarship.
6. Has a significant student debt burden

For more information, contact the AASV Foundation: **aasv@aasv.org, 515-465-5255.**

AASV Foundation news continued on page 47

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AASV Foundation news continued from page 45

Swine practitioners: Apply for Hogg Scholarship to pursue graduate degree

The American Association of Swine Veterinarians Foundation is now accepting applications for the prestigious Hogg Scholarship, established to honor the memory of longtime AASV member and swine industry leader Dr Alex Hogg.

The intent of the $10,000 scholarship is to assist a swine veterinarian in his or her efforts to return to school for graduate education (resulting in a master's degree or higher) in an academic field of study related to swine health and production. Fifteen swine practitioners, recognized at **aasv.org/foundation/hoggscholars.htm**, have been awarded the scholarship since it was established in 2008.

Applications for the scholarship will be accepted until January 31, 2022. The scholarship recipient will be announced Sunday, February 27 during the 2022 AASV Annual Meeting.

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

The scholarship application requirements are outlined below, and on the AASV website at **aasv.org/foundation/hoggscholarship.htm**.

Hogg Scholarship Application Requirements

An applicant for the Hogg Scholarship shall have:

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

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

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

Applications and requests for information may be addressed to:

AASV Foundation
830 26th Street
Perry, IA 50220

515-465-5255
aasv@aasv.org

AASV Foundation issues call for research proposals

As part of its mission to fund research with direct application to the profession, the American Association of Swine Veterinarians Foundation seeks research proposals for funding in 2022. Proposals are due by 12:00 PM Central Time on **January 14, 2022**, and may request a maximum of $30,000 (US$) per project. The announcement of projects selected for funding will take place during the AASV Annual Meeting on Sunday, February 27, 2022. Up to $100,000 will be awarded across three or more projects.

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

The instructions for submitting proposals are available on the AASV Foundation Web site at **aasv.org/foundation/2022/research.php**.

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

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

A summary of the research funded by the foundation over the past 15 years is available at **aasv.org/foundation/research.htm**.

For more information, or to submit a proposal:

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

AASV Foundation Mission Statement

The mission of the AASV Foundation is to empower swine veterinarians to achieve a higher level of personal and professional effectiveness by:

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

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

New swine depopulation resources

Last February, I shared with you that AASV had received funding form the US Department of Agriculture Animal and Plant Health Inspection Service through their National Animal Disease Preparedness and Response Program.[1] The objectives of the project were to gather information about experiences with swine depopulation, develop swine-specific recommendations for practical on-farm implementation of depopulation methods, and create supplemental resources to assist swine veterinarians and farmers before, during, and after a depopulation event occurs. Over the past 12 months, the depopulation subcommittee of the AASV Pig Welfare Committee has worked to accomplish these objectives.

The subcommittee began by soliciting input using a web survey and telephone interview of 24 participants. Their responses and feedback offered a wealth of information related to the setup, implementation, and efficacy of various swine depopulation methods. The subcommittee used these responses to develop the *AASV Recommendations for the Depopulation of Swine*, which defines depopulation and conditions for its use, factors that must be considered when choosing a depopulation method, and suggestions for how to prepare and care for responders before, during, and after a depopulation event. Additionally, the depopulation recommendations address procedures, labor and throughput estimates, safety considerations, seasonality impacts, carcass disposal restrictions, setup configurations, and needed resources for 12 depopulation methods. Members of AASV had the opportunity to comment on a draft version and their input was incorporated into a final version, which was adopted by the AASV Board of Directors during their Fall 2021 meeting.

"To those that responded to the survey and interview request, thank you for openly sharing your experiences and insights on this difficult topic."

Supplemental resources created to accompany the depopulation recommendations include a depopulation decision tool, depopulation method case studies, carbon dioxide calculator, recordkeeping form, and literature reference lists. The decision tool is designed to guide users through the decision-making process of when to depopulate and documenting which method they may choose to use given the farm resources and situation. The depopulation method case studies provide successful examples of depopulation method configurations. The carbon dioxide calculator allows users to input number of pigs, container sizes, and time constraints to calculate throughput and quantity of carbon dioxide needed.

Also, a resiliency debrief tool has been created in collaboration with Dr Elizabeth Strand, a licensed clinical social worker, resiliency coach, and Founding Director of Veterinary Social Work at the University of Tennessee. The tool was developed to aid veterinary professionals in monitoring and taking action to address psychological impacts of depopulation during or after the depopulation event. This tool will be beta tested in 2022 with key learnings incorporated to improve the tool where appropriate.

The *AASV Recommendations for the Depopulation of Swine* and the other supplemental resources can be found at **aasv.org/resources/welfare**. I would like to acknowledge the many people who contributed to the creation of these resources. To those that responded to the survey and interview request, thank you for openly sharing your experiences and insights on this difficult topic. Thank you to the AASV members who took the time to review the draft recommendations and offer feedback for how to improve them. Thank you to those who served on the subcommittee and worked to synthesize survey responses and scientific literature to create useful depopulation resources for veterinarians and their clients. Finally, a big thank you to our AASV summer intern, Kamryn Gitchell. Kamryn is a third-year veterinary student at the University of Tennessee and did much of the work to review and analyze the interview transcripts and helped create the resulting resources.

Reference

*1. Webb S. Sharing your experience [Editorial]. *J Swine Health Prod*. 2021;29(2):109.

* Non-refereed reference.

Sherrie Webb, MSc
Director of Swine Welfare

Journal of Swine Health and Production Author Guidelines

Journal description

The *Journal of Swine Health and Production* (JSHAP) is published bi-monthly by the American Association of Swine Veterinarians (AASV) and is freely available online. The journal accepts manuscripts for peer review that encompass the many domains of applied swine health and production, ie, the diagnosis, treatment, management, prevention and eradication of swine diseases, swine welfare and behavior, nutrition, public health, epidemiology, food safety, biosecurity, pharmaceuticals, antimicrobial use and resistance, reproduction, growth, systems flow, economics, and facility design.

Types of papers

The *Journal of Swine Health and Production* currently accepts manuscripts that meet the descriptions and formatting requirements defined in Table 1.

Policies and procedures

Animal care and use

For animal experiments performed in research facilities or on commercial farms, include a statement indicating that the studies were reviewed and approved by an institutional animal care and use committee or equivalent. For case reports and studies performed under field conditions, in which animals are not manipulated beyond what would be required for diagnostic purposes, it must be clear that housing was adequate and that the animals were humanely cared for. If the study is exempt from animal care and use approval (eg, use of diagnostic records), authors need to clearly state the reasons in the manuscript. Place animal care and use statements in a separate section labeled with an "Animal care and use" heading. This section should immediately precede the "Materials and methods" heading or equivalent position depending on genre.

Authorship

According to the International Committee of Medical Journal Editors, all listed authors must have participated sufficiently to take public responsibility for the work. Individuals should only be listed as authors if contributions have been made in each of the following areas[1]:

1) Conception and design, acquisition of data, or analysis and interpretation of the data,
2) Drafting the manuscript or revising it critically for important intellectual content,
3) Approval of the version of the manuscript to be published, and
4) Agreement to be accountable for all aspects for the work, ensuring questions related to accuracy and integrity are investigated and resolved.

Ethics

Authors are expected to observe high standards with respect to research and publication ethics. Fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results is considered research misconduct.[2] All cases of research misconduct will be investigated and addressed accordingly.

Conflict of interest

Authors are required to declare the presence of any personal, professional, or financial relationships that could potentially be construed as a conflict of interest for the submitted manuscript, regardless of genre. This declaration is placed just before the reference section, and provides information concerning authors who profit in some way from publication of the paper. For example, one or more of the authors may be employed by a pharmaceutical company that manufactures a drug or vaccine tested in the study reported. Other examples include consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. If there is no conflict of interest to declare, the statement under the "Conflict of interest" heading is "None reported."

Copyright transfer

When a manuscript is submitted to the JSHAP, a pre-review copyright agreement and disclosure statement must be signed by all authors. It is the responsibility of the corresponding author to secure these signatures. This form is available from the publications manager. Scan and email signed copies to Karen Richardson at **jshap@aasv.org**. When the manuscript is accepted for publication, the corresponding author will be required to transfer copyright to the AASV, with the exceptions of US government employees whose work is in the public domain and portions of manuscripts used by permission of another copyright holder. Anyone acknowledged by name in the manuscript will need to sign an acknowledgment permission form.

Prior publication

We do not republish materials previously published in refereed journals. Sections of theses and extension publications that may be of value to our readership will be considered. Prior publication of an abstract only (eg, in a proceedings book) is generally acceptable.

Permissions

If copyrighted material is used, advise the editors of this at the time of manuscript submission. Authors are responsible for securing permission to use copyrighted art or text, including the payment of fees.

Publication fees

There is no fee for publication of manuscripts in the JSHAP.

Manuscript preparation

File types

All manuscripts must be submitted as a Microsoft Word document using 1-inch margins, Times New Roman 12-point font (unless otherwise specified), and left justification with double-spacing throughout. Include continuous page and line numbers. Do not use numbered or bulleted lists in the summary or the

Table 1: Manuscript genres and formatting requirements currently accepted by the *Journal of Swine Health and Production*

		Maximum words		Maximum No.		
Genre	**Description**	**Abstract**	**Manuscript body**	**Figures and Tables**	**References**	**Other requirements***
Original Research	Reports the results of original research on topics that are within journal scope.	250	4000	As needed	35	–
Brief Communication	Documents observations made in a narrowly defined research area or a mini-review of a subject area.	50	2000	2	15	–
Case Report	Describes an unusual or interesting case.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Case Study	Describes unusual or interesting cases occurring on two or more farms.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Literature Review	Review of the published scientific literature about a specific topic area in which important advances have been made in the past five years and is of current interest.	200	5000	As needed	As needed but most references should be recent (within 5 yrs) and avoid use of non-refereed references and personal communications.	Manuscript should not exceed 30 pages including figures, tables, and references.
Production Tool	Describes a practical, state-of-the-art technique for improving an individual swine enterprise or the swine industry at large.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Diagnostic Note	Describes methods of diagnosis for swine diseases. A brief literature review may be included and use of non-refereed references and personal communications is not restricted.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Practice Tip	Describes new technological methods likely to be of use to swine practitioners.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.

Table 1: Continued

Genre	Description	Maximum words		Maximum No.		Other requirements*
		Abstract	Manuscript body	Figures and Tables	References	
Peer-reviewed Commentary	Commentary on diagnostic, research, or production techniques used in the field of swine health and production.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Letter to the Editor (LTE)	Offers comment or useful critique on materials published in the journal.	-	500	0	5	The decision to publish an LTE rests solely with the executive editor. Letters referring to a published article will be forwarded to the author of the article, and both the original letter and the response will be published in the same issue if possible. Letters to the Editor are not peer-reviewed but are subject to editorial changes.

* Page limits are for Microsoft Word documents using 1-inch margins, Times New Roman 12-point font (unless otherwise specified), and left justification with double-spacing throughout.

text. Do not include tables or figures in this file, but do include table and figure references, such as (Table 1) or (Figure 1), within the text. Software programs that automatically create endnotes, footnotes, and references should be avoided in the final submitted version of the manuscript as the embedded formatting cannot be read by the publication software.

If the manuscript includes tables, create and submit them in a second Microsoft Word document titled "Art". Multiple tables can be submitted in a single Word document.

If the manuscript includes figures (graphs or images), submit each figure in a separate file titled as the respective figure number. Graphs created in Microsoft Excel should be submitted in the original .xls file(s). A graph created in statistics software can be submitted as a .pdf file. Photographs and images need to be high resolution .jpg files. Figure caption and legend texts should be submitted in a Microsoft Word file titled "Art" (included with Tables if applicable).

Sample templates have been created for each genre to assist authors in formatting their manuscript and can be accessed at **aasv.org/shap/guidelines**.

Supplementary materials

Supplementary materials are additional materials that are not essential to the understanding of the manuscript but provide important context to the manuscript and may be submitted for online only publication. Examples of materials accepted include extended descriptions of experimental methods or statistical analysis, extended bibliographies, additional supporting tables and figures, reporting checklists, copies of surveys or questionnaires, handouts, and forms.

For supplementary materials that are too large or in a format not consistent with JSHAP publication (eg, data sheets, presentations, audio, or video), authors are encouraged to upload and publish these files to a repository, such as FigShare, and reference the DOI within the manuscript.

Supplementary materials must be formatted according to the JSHAP Author Guidelines. There is no word or page limit for supplementary materials, but they should be succinctly presented to facilitate peer review. Acceptance of supplementary materials for publication is at the discretion of the editor. All JSHAP published supplementary materials are subject to copyright.

General style

Manuscripts must be written in English and use American spelling and usage. The JSHAP uses the AMA Manual of Style for guidance on general style and form.[3] Please review the complete author guidelines and author checklist at **aasv.org/shap/guidelines** for full details on journal formatting requirements for submitted manuscripts.

Manuscript submission

Submission instructions

All submissions must be accompanied by a cover letter. The cover letter should be on official letterhead, not exceed 1 page, and include the following information:

- a statement acknowledging the manuscript is not currently under consideration for publication elsewhere,
- a statement that all co-authors have reviewed and approve the manuscript submission,
- the intended genre of the submitted manuscript,

- a brief description of how the manuscript relates to the scope of JSHAP (optional),
- suggestions for potential reviewers of the submitted manuscript (optional), and
- signature of the corresponding author.

All manuscript files should be submitted to the JSHAP publications manager via email: **jshap@aasv.org**.

Unless given alternate instructions at the time of submission, we will correspond with the corresponding author.

Questions about manuscript submission or status can be directed to the JSHAP publications manager:

Karen Richardson
Journal of Swine Health and Production
c/o American Association of Swine Veterinarians
830 26th Street
Perry, IA 50220
Tel: 519-856-2089
Email: **jshap@aasv.org**

References

1. International Committee of Medical Journal Editors. Recommendations for the conduct, reporting, editing, and publication of scholarly work in medical journals. **http://www.icmje.org/icmje-recommendations.pdf**. Updated December 2017. Accessed June 20, 2018.

2. Office of Science and Technology Policy. Federal policy on research misconduct. *Fed Regist*. 2000;65(6):76260-76264.

3. Christiansen SL, Iverson C, Flanagin A, Livingston EH, Fischer L, Manno C, Gregoline B, Frey T, Fontanarosa PB, Young RK, eds. *AMA Manual of Style: A Guide for Authors and Editors*. 11th ed. New York, New York: Oxford University Press. 2020.

JSHAP Author Guideline Checklist

Updated January 2022

Title page

- □ My manuscript is a Word document with double spacing, footer page numbers, continuous line numbers, and Times New Roman 12 pt font.
- □ I have provided a short title of 90 characters or less (including spaces).
- □ I have included the genre of publication.
- □ I have created a title that is concise, specific, and informative without using abbreviations.
- □ I have properly formatted the author byline.
  - ○ Alpha B. Charlie, degree, degree; Juliett K. Lima, degree; Mike N. Oscar, degree
  - ○ List only the highest level of degree or professional certification except if additional degree denotes a different field of study or a specialty degree, license, certification or credentials.
- □ I have properly formatted the author affiliations.
  - ○ ABC, MNO: department, college, institution, City, State or Country. (State only if in the United States)
  - ○ JKL: company, City, State or Country. (State only if in the United States)
- □ I have properly formatted the Corresponding Author information.
  - ○ Corresponding author: Dr Alpha B. Charlie, street address, City, State Zip; Tel: 555-555-5555; Email: **email@email.com**.

Summary

- □ I have included a Summary not exceeding the word limit for the genre:
  - ○ 250 words for original research including these subheadings – Objective(s), Materials and methods, Results, and Implication(s).
  - ○ 200 words for literature review. No subheadings needed.
  - ○ 100 words for case report, case study, production tool, diagnostic note, practice tip, or peer-reviewed commentary. No subheadings needed.
  - ○ 50 words for brief communication. No subheadings needed.
- □ I have defined abbreviations at the first mention of the term being abbreviated in the summary.
- □ I have only introduced abbreviations if they are used again in the summary and have used the abbreviation whenever the term is mentioned in the summary except at the beginning of a sentence.
- □ I have included "swine" as the first keyword with up to 4 additional words or phrases for a total of 5 keywords.

Manuscript body

- □ I have included the required sections for the genre of manuscript.
- □ I have defined abbreviations at the first mention of the term being abbreviated in the body of the manuscript except in titles, headings, and subheadings.
- □ I have only introduced abbreviations if they are used again in the manuscript body and have used the abbreviation whenever the term is mentioned in the manuscript body except at the beginning of a sentence or as the sole term in headings and subheadings.
- □ I have included an animal care and use statement in a separate section preceding the Materials and methods section.
- □ I have provided the manufacturer's name for all equipment and reagents used in my study.
- □ When *P* values are reported, I have capitalized and italicized the *P* and have not included a zero to the left of the decimal point. The numerical value is rounded to 2 or 3 digits to the right of the decimal point with the smallest being $P < .001$.
- □ I have included spaces around signs of operation (+, <, >, =, etc).
- □ I have used commas to separate all parts of a series (eg, green, red, and yellow).
- □ I have spelled out all units of measure unless they are accompanied by a numerical value.
- □ I have not used numbered or bulleted lists in the manuscript.
- □ I have used brackets to indicate a parenthetical expression within a parenthetical expression: ([ ]).

Implications

- □ I have included up to 3 bulleted implications, each with a maximum of 80 characters or less (including spaces). This section is exempt only for literature review and practice tip manuscripts.

Acknowledgments

- □ I have mentioned any individuals, companies, or funding sources that I would like to acknowledge.
- □ I have disclosed all conflicts of interest for this paper. If none exist, I have included the statement "None reported."
- □ I have included the JSHAP disclaimer.

References

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- □ I have provided complete page numbers in all references (eg, 120-128, not 120-8).
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- □ I have created my tables using Microsoft Word.
- □ I have included the appropriate unit of measure for each row and column.
- □ I have no missing data in my tables (eg, empty cell, hyphen, period) and used the numeral "0" to indicate the value of the data is zero or "NA" to denote not available, not analyzed, or not applicable and have defined the abbreviation accordingly in the abbreviations footnote.
- □ I have used parentheses instead of the ± symbol throughout my table (eg, "1 (3.5)" rather than 1 ± 3.5").
- □ I have used footnotes to explain data in the table using symbols in the designated order (*†‡§¶) and doubled the symbols in that order if more were needed.
- □ When appropriate, I have provided a footnote to describe the level of significance and the statistical method of analysis used.
- □ When appropriate, I have used lower case letters as superscripts to designate significant differences and have created a footnote to explain the level of significance and the statistical method used.
- □ I have defined all abbreviations used in the table in the last footnote, which does not use a footnote symbol.
- □ I have ensured the abbreviations used in the table are consistent with any abbreviations used in the manuscript.

Figures

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- □ My figure title is descriptive, brief, and followed by the legend and abbreviations. The legend includes a brief description of treatments, level of significance, *P* values, and the statistical method used. All abbreviations used in the figure are defined.
- □ I have created a separate file for each figure in the acceptable file types (ie, .xls, .pdf, or .jpg).
- □ All axes are labeled with a description followed by the unit of measure, when needed, separated by a comma.

Manuscript submission

- □ I have included my manuscript file and a separate art file with my submission.
- □ I have included a cover letter that does not exceed 1 page and includes the requested information.

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Dr Angela Baysinger

I don't know if it was his plan or simply that he needed my small hands and spindly arms, but when Dr Don Hudson guided me through helping a gilt deliver her first litter when I was six years old, he started me on my path to becoming a swine veterinarian. My entire life has been about animal agriculture – in particular, pig production. From growing up on my family's pig farm, studying animal science and veterinary medicine, serving farmers as a practicing veterinarian, supporting the animal health sector of our food system, and volunteering with many organizations; swine health, the well-being of my peers, and welfare of animals has not only been my vocation but my passion. It is my way of life.

Confucius teaches us, "If your plan is for one year, plant rice. If your plan is for ten years, plant trees. If your plan is for one hundred years, educate children." I believe we are all "children" – life-long learners.

Just as Dr Hudson and many others invested in me as a young person interested in veterinary medicine, I desire to ensure the American Association of Swine Veterinarians (AASV) invests in all of us "children" as we prepare for the future of our careers and the swine industry. As a candidate for AASV Vice President, I would be honored to apply my knowledge, skills, and experiences to the future of our organization. As an elected leader of AASV, I will work to ensure the AASV continues to be inclusive and uplifting for all members. And I look forward to working with my fellow board members, committee leaders, and professional staff as, together, we provide visionary leadership for the long-term success of AASV.

I believe my educational, professional, and volunteer experiences will allow me to fulfill this role. I earned my doctor of veterinary medicine in 1992 from the University of Missouri-Columbia College of Veterinary Medicine. After graduation, I began my professional career as an associate veterinarian at Sutton Veterinary Clinic in Sutton, Nebraska. In 1995 I began my master's degree in epidemiology at the University of Nebraska-Lincoln (UNL) and served as the interim state swine extension veterinarian. Since completing my master's degree, I have worked as a swine technical services veterinarian with ALPHARMA and Boehringer Ingelheim, a self-employed swine consultant, and a Health Assurance Veterinarian with Pig Improvement Company (PIC).

Today, many within AASV know my calling is animal welfare. My interest in focusing on animal welfare arose during my seven years as Vice President of On-farm Food Safety and Animal Welfare for Farmland Foods (Smithfield). I apply the skills and knowledge I have developed in this space in my current role as Animal Welfare Lead, North America, for all species at Merck Animal Health. In this role, I work across the food chain, retail to producer, to foster trust, promote science, and advocate for animal agriculture.

Like many swine veterinarians, I cannot sit still very long. In addition to my role at Merck Animal Health, I have completed a master's degree in international animal welfare, ethics and law at the University of Edinburgh in December 2021 and will pursue board certification in the American College of Animal Welfare. Now I am pondering what to pursue next because life-long learning is a habit that one should never give up!

Professionally, I have served as a member of the animal welfare committees for the American Veterinary Medical Association, North American Meat Institute, National Pork Board, American Association of Bovine Practitioners, and, of course, the AASV. I am also a past chair (2x), a current member of the board of directors for the Professional Animal Auditor Certification Organization, and a past member of the AASV board. I also serve on the board of the International Poultry Welfare Alliance.

My husband, Jerry, an agronomist, farmer, and small business owner, and our two sons, Isaac, a computer science major and member of the UNL Marching Band, and Sam, an enlisted member of the Nebraska Army National Guard and future UNL student, call Bruning, Nebraska home. As a family, we are active in the Hebron Nebraska Bible Church, American Legion, Legion Auxiliary, Boy Scouts of America, the National FFA Organization, and many community activities.

I am humbled to be considered and welcome the opportunity to serve AASV. Service is in my heart, and I am here for the members of AASV.

LinkedIn Profile: **www.linkedin.com/in/angela-baysinger-a8065419**

Angela Baysinger, DVM, MS, MSc

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1: Perri A et al. An investigation of iron deficiency and anemia in piglets and the effect of iron status at weaning on post-weaning performance. JSHAP. 2016;24:10–20.

2: Fredericks L et al. Evaluation of the impact of iron dosage on post- weaning weight gain, and mortality. AASV. 2018;315

3: Olsen, C. (2019) The economics of iron deficiency anemia on US swine production: An annual impact of 46-335 million US dollars. American Association of Swine Veterinarians. Orlando. Florida.

* Industry Standards for Blood Hb Levels (g/L)

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UPCOMING MEETINGS

Banff Pork Seminar

January 11 - 13, 2022 (Tue-Thu)
A Hybrid Conference
Fairmont Banff Springs
Banff, Alberta, Canada

For registration or conference inquiries:
Ashley Steeple
Tel: 780-492-3651
Email: **pork@ualberta.ca**
Web: **banffpork.ca**

2022 Pig Ski Conference

February 9 - 11, 2022 (Wed-Fri)
Copper Mountain, Colorado

For more information or to register:
Lori Yeske
Pig Group
39109 375th Ave
Saint Peter, MN 56082
Tel: 507-381-1647
Email: **pyeske@swinevetcenter.com**
Web: **pigski.com**

American Association of Swine Veterinarians 53rd Annual Meeting

February 26 - March 1, 2022 (Sat-Tue)
JW Marriott Indianapolis
Indianapolis, Indiana

For more information:
American Association of Swine Veterinarians
830 26th Street
Perry, Iowa 50220 USA
Tel: 515-465-5255
Email: **aasv@aasv.org**
Web: **aasv.org/annmtg**

Animal Agriculture Alliance Stakeholders Summit

May 11 - 12, 2022 (Wed-Thu)
Kansas City, Missouri

For more information:
Animal Agriculture Alliance
2101 Wilson Blvd, Suite 810-B
Arlington, VA 22201
Web: **animalagalliance.org/initiatives/stakeholders-summit**

World Pork Expo

June 8 - 10, 2022 (Wed-Fri)
Iowa State Fairgrounds
Des Moines, Iowa

For more information:
National Pork Producers Council
10676 Justin Drive
Urbandale, Iowa 50322
Web: **worldpork.org**

7th International Symposium on Animal Mortality Management

June 13 - 16, 2022 (Mon-Thu)
Raleigh, North Carolina
Web: **animalmortmgmt.org**

26th International Pig Veterinary Society Congress

June 21 - 24, 2022 (Tue-Fri)
A hybrid conference
Riocentro Convention and Event Center
Rio de Janeiro, Brazil

For more information:
Rua Guaicuí 26, 10º andar
Coração de Jesus
Belo Horizonte, MG 30380.380
BRAZIL
Tel: +55 31 3360 3663
Email: **ipvs2022@ipvs2022.com**
Web: **ipvs2022.com**

ZeroZincSummit 2022

June 22 - 23, 2022 (Wed-Thu)
Copenhagen, Denmark

For more information:
SEGES Danish Pig Research Centre
Axelborg, Axeltorv 3
1609 Copenhagen V
DENMARK
Web: **tilmeld.dk/zerozincsummit2022**

2022 Annual Therio Conference

July 20 - 23, 2022 (Wed-Sat)
Bellevue, Washington

Hosted by the Society for Theriogenology and the American College of Theriogenologists

For more information:
Web: **theriogenology.org**
For abstract submission (due February 1, 2022):
theriogenology.org/page/2022CallforAbstracts

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

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