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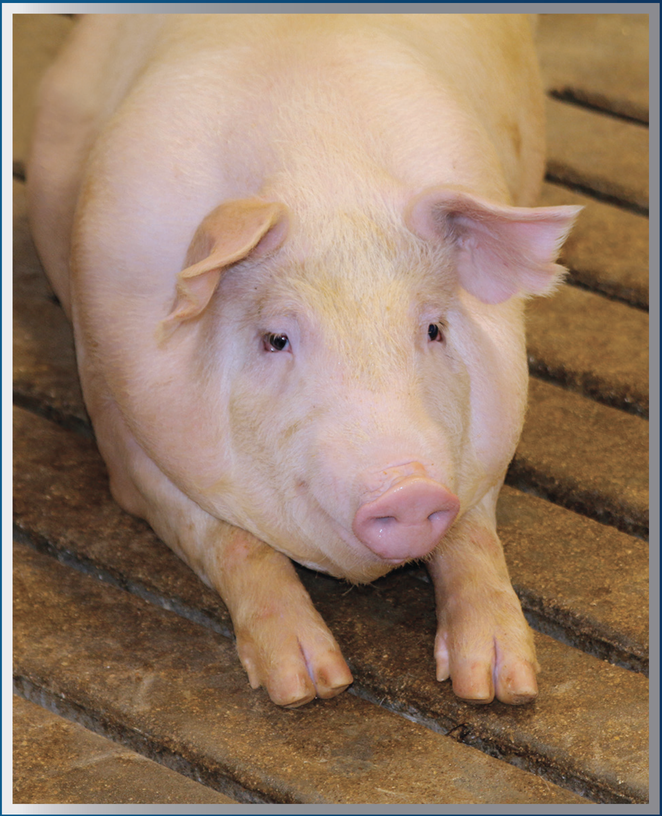

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"Amidst this turmoil, it is crucial to remember that sometimes the helpers need help too."

quoted from Advocacy in Action, page 229

NEWPORT LABORATORIES®

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Don't blink

I am going to continue taking advantage of the year 2020 for its vision analogy by considering the phrase "in the blink of an eye." I was recently reminded of this by a car accident I had that certainly seemed to happen in the blink of an eye. Thankfully, no injuries occurred mainly due to the many safety features of modern cars. But it made me think that in that blink, a lot of things changed. Many of those changes I had no control over, the car was not drivable and I was not getting to my destination on time. However, I could control my reaction and make a quick change of plans to adjust to this new normal without transportation.

Another use of the phrase in the blink of an eye is to describe the seemingly rapid passage of time. There is even a country song about it by Kenny Chesney, "Don't Blink." The time between major events in our lives, such as graduations, marriages, births, new jobs, and disasters, seems to pass rapidly. We can certainly now add global pandemic to that list of major events in our lives. Very few people who survived the 1918 influenza pandemic are still alive today. I recently learned that this disease had claimed my great-grandfather's life when my grandmother was very young. That event, that they had no control over, created a major change for my great-grandmother and her 2 children. However, she was able to control her reaction, re-married, had more children, and in the blink of an eye lived to be 100. That one blink of an eye event changed the entire lifetimes of my great-grandmother and grandmother. The other blink of an eye event that comes to mind is September 11, 2001. That event occurred nearly 20 years ago now, but it still seems like only a few years ago because it was such a dramatic event.

Which brings me to our current event of packing plant closures. Just a few months ago we were able to hold the annual AASV convention in Atlanta, the next week many businesses classified as non-essential closed or events were cancelled, but the essential food supply activities continued. We seemed to be lulled into the idea that packing plants would always stay open. Then, in the blink of an eye, over half of the federally inspected capacity was shut down. It seemed similar to the car accident and the only thing I could control were my actions following this major event. Thankfully, many producers had AASV members to help them adjust to this new normal by adjusting diets and double stocking young pigs to try and hold market pigs until they could be processed. But it was not enough, pigs would need to be removed from the supply chain before they became too big for the processing plant. Our AASV members were right there next to their clients working to control what they could and making plans to make the best of the situation.

> *"Our AASV members were right there next to their clients working to control what they could and making plans to make the best of the situation."*

Some will say the processing industry should have been more ready for this type of disease in workers. I would argue that this virus has been unpredictable in its transmission and length of asymptomatic status. This resulted in some swings and misses with intervention methods from even the most expert public health professionals. In a few years, or in the blink of an eye, we will be on to our next major life changing event. We will have moved on from this situation smarter and more prepared for the next one. Just remember, when the next major event occurs, to control what you can and don't worry excessively over what you cannot.

Don't blink or you'll miss it!

Jeff Harker, DVM
AASV President

COVID-19 and the AASV

Coronavirus disease 2019 (COVID-19) has been dominating everyone's life for months. The virus was just beginning to appear in the United States as we approached the 2019 AASV Annual Meeting in Atlanta, Georgia. We feel fortunate to have been able to hold the meeting; we may have had to cancel had it been scheduled one week later. We are very thankful to everyone who attended and the sponsors who continue to support the association. Nonetheless, due to reduced registrations, technical tables, and subsequent cancellations, the global pandemic did have a significant impact on the revenue AASV derives from the annual meeting.

Since March, the impact of the SARS-CoV-2 virus on our industry has been dramatic and unprecedented. The AASV has worked in collaboration with the National Pork Board, National Pork Producers Council, and Swine Health Information Center to engage with allied organizations such as the North American Meat Institute, North American Renderers Association, and the American Veterinary Medical Association. We have supported efforts at the local and national level to stress the importance of recognizing processing facilities as an integral part of critical infrastructure necessary to feed America. We have actively participated in daily calls with state and federal animal health officials to coordinate preparation efforts to address the marketing challenges resulting from the closure and reduced operating capacity of the nation's processing facilities as well as helping states prepare to address the need to depopulate and dispose of thousands, if not millions, of market-weight hogs. The goal of this enhanced interaction is to emphasize the concerns of swine veterinarians and pork producers to ensure every effort is being made to recognize and address those concerns.

More importantly, the AASV staff has attempted to provide access to the resources necessary to help guide our members as they work with their clients to address these unprecedented challenges. Dr Abbey Canon developed the AASV's COVID-19 webpage and gathered a wealth of information regarding the SARS-CoV-2 virus and its impact on human and animal populations. She has authored numerous updates and messages distributed to AASV members via email alerts and e-Letter articles. Sherrie Webb has provided her years of pig welfare expertise to provide insights regarding humane euthanasia and mass depopulation to help veterinarians guide their clients through the decision-making process when faced with the unthinkable challenge of having to dispose of large numbers of animals. Sherrie worked with the AASV Pig Welfare Committee to consider the options facing producers and veterinarians regarding the decision to depopulate herds and develop a position statement on the issue, which was subsequently adopted by the AASV Board of Directors.

Abbey and Sherrie have emphasized the importance of the health and well-being of our member veterinarians working on the front lines during this pandemic. They have posted additional resources on the AASV website to raise awareness about human wellness and initiated discussions with Dr Elizabeth Strand from the University of Tennessee that resulted in the implementation of HEARD VET, a swine veterinarian-peer support group. This virtual group offers a space to share your experiences with your fellow veterinarians. Dr Strand has agreed to provide this service to AASV members for as long as it is needed. Whether it is through Heard Vet or some other support structure, I hope you will take advantage of the resources available to promote your mental well-being.

> *"Above all, we are here to support you and provide you with whatever resources and information we can."*

The AASV office is in Dallas County, which has been one of the counties with the highest rate of positive COVID-19 cases in Iowa. As local and state officials closed businesses and requested residents to stay at home, I instructed our staff to work from home when possible. Dr Sue Schulteis agreed to continue managing the office and has worked diligently to coordinate phone calls, emails, invoicing, et cetera while wrapping up the 2020 Annual Meeting and preparing for the 2021 Annual Meeting in San Francisco. We just held a successful virtual Program Planning Committee meeting under the very capable direction of AASV President-elect Dr Mary Battrell. The group has proposed an excellent list of timely topics and speakers for next year's meeting. We are proceeding in the hopes of holding an in-person meeting but are exploring virtual options as well. Stay tuned, we will keep you updated.

Above all, we are here to support you and provide you with whatever resources and information we can. I hope by the time you read this, we will be on the recovery side of this outbreak and looking forward to getting back to what we do best – caring for the animals, working to support the farmers who raise those animals, and producing safe wholesome food.

Harry Snelson, DVM
Executive Director

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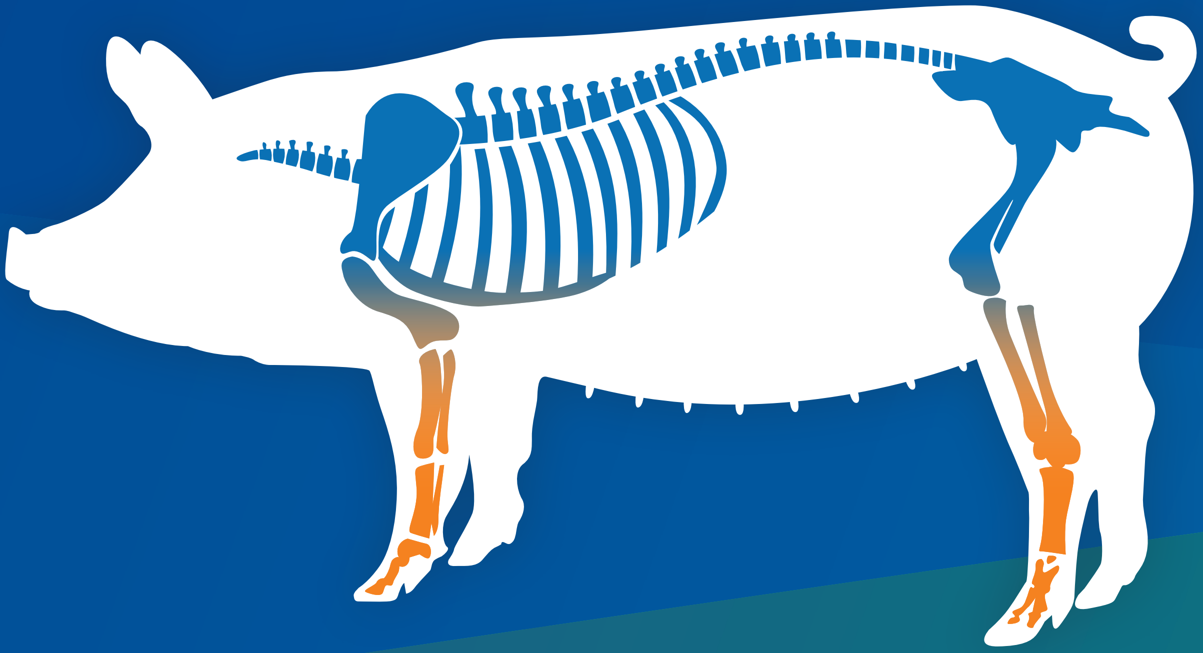

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Write, write, submit, repeat

The scope of the *Journal of Swine Health and Production* (JSHAP) is to publish peer-reviewed information that encompasses an applied and practical focus in the many facets of swine production. This issue is a solid example of the diversity of topics the journal reviews as well as a solid example of the diversity of genres we consider. I really enjoyed reading the manuscripts in this issue and I hope you do as well. The journal encourages prospective authors to review our journal genres, and for more details regarding the different genres the journal publishes, I direct you to one of my previous messages that highlights those details.[1]

I cannot help but wonder how the coronavirus disease 2019 (COVID-19) pandemic is going to influence submissions to scientific journals, and more specifically to JSHAP. Also, how is this time of uncertainty influencing people's schedules, priorities, and time availability to dedicate to the peer-review process. The journal has seen both ends of the spectrum with some authors and reviewers having more time availability and others with nothing to spare. It is clear that we are all experiencing this pandemic differently. The COVID-19 pandemic has impacted many facets of life as we know it, and the swine industry has most certainly felt the impact. What about ongoing research and new swine-focused applied research? How do researchers and veterinarians conduct, or encourage participation in, new research projects in an applied farm setting during a human disease pandemic? I don't have a full answer, but I suspect a partial answer is very carefully. We need to be mindful of human health. We need to look after our health, the health of the animals in our care, and the health of our industry.

To find the silver lining in all of this, and if you are in the category of finding yourself with extra time on your hands, perhaps this is an ideal opportunity to get back to writing those manuscripts that have been sitting in the "to-do" pile. I know I have a few. The JSHAP office is in full operation, we have been doing this remotely for years. So, stand up, dust off those partly finished manuscripts, write, write, submit, repeat! Be well and enjoy this issue!

> "We need to look after our health, the health of the animals in our care, and the health of our industry."

Reference

*1. O'Sullivan T. Manuscript genres [editorial]. *J Swine Health Prod*. 2013;21:183.

* Non-referred reference.

Terri O'Sullivan, DVM, PhD
Executive Editor

Growth performance and hematology characteristics in pigs treated with iron at weaning as influenced by nursery diets supplemented with copper

Mark J. Estienne, PhD; Sherrie G. Clark-Deener, DVM, PhD; Kimberly A. Williams, BS

Summary

Objective: Determine the effects of dietary copper on growth in pigs given iron at weaning.

Materials and methods: Weanlings (n = 144) were allocated to a 2 × 2 × 2 factorial arrangement of treatments (6 pens/treatment, 3 pigs/pen). Factors were size (large or small), 100 mg intramuscular iron doses (birth or birth and weaning), and dietary copper (14.2 or 250 ppm). Average daily gain (ADG), feed intake (ADFI), and gain to feed ratio were determined for 49 days. Blood was sampled at weaning and days 7 and 49.

Results: Hemoglobin ($P < .001$) and hematocrit ($P = .002$) at weaning were less in large pigs. Pigs receiving two doses of iron had greater hemoglobin ($P = .05$) and hematocrit ($P = .04$). Hemoglobin ($P = .03$) and hematocrit ($P = .03$) were greater in pigs fed the control diet. In large pigs only, body weights at day 49 were greater ($P = .05$) for individuals receiving two doses of iron. The interaction between number of iron doses and diet affected many growth measures including ADG ($P = .02$) and ADFI ($P = .04$) for the overall trial. In all cases, performance was greater in copper-fed pigs receiving two doses of iron.

Implications: At weaning, larger pigs had hematology characteristics consistent with a lower iron status. Iron treatment at weaning increased hemoglobin. Copper enhanced growth only if pigs received iron at weaning. In copper-fed pigs, hemoglobin was less, possibly indicating a negative effect on iron absorption.

Keywords: swine, nursery, iron, copper, hematology

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Resumen - Desempeño de crecimiento y características hematológicas en cerdos tratados con hierro al destete según la influencia de las dietas de destete suplementadas con cobre

Objetivo: Determinar los efectos del cobre en la dieta sobre el crecimiento en cerdos que reciben hierro al destete.

Materiales y métodos: Se asignaron cerdos destetados (n = 144) a una disposición factorial de tratamientos 2 × 2 × 2 (6 corrales/tratamiento, 3 cerdos/corral). Los factores fueron el tamaño (grande o pequeño), dosis de hierro intramuscular de 100 mg (nacimiento o nacimiento y destete) y cobre dietético (14.2 o 250 ppm). La ganancia diaria promedio (ADG), el consumo de alimento (ADFI) y la relación ganancia alimento se determinaron durante 49 días. Se tomaron muestras de sangre al destete y los días 7 y 49.

Resultados: La hemoglobina ($P < .001$) y el hematocrito ($P = .002$) al destete fueron menores en los cerdos grandes. Los cerdos que recibieron dos dosis de hierro tuvieron mayor hemoglobina ($P = .05$) y hematocrito ($P = .04$). La hemoglobina ($P = .03$) y el hematocrito ($P = .03$) fueron mayores en los cerdos alimentados con la dieta control. Solo en cerdos grandes, el peso corporal en el día 49 fue mayor ($P = .05$) para los individuos que recibieron dos dosis de hierro. La interacción entre el número de dosis de hierro y la dieta afectó muchas medidas de crecimiento, incluyendo ADG ($P = .02$) y ADFI ($P = .04$) para la prueba en general. En todos los casos, el desempeño fue mayor en los cerdos alimentados con cobre que recibieron dos dosis de hierro.

Implicaciones: Al destete, los cerdos más grandes tenían características hematológicas consistentes con un estado de hierro más bajo. El tratamiento con hierro al destete aumentó la hemoglobina. El cobre aumentó el crecimiento solo si los cerdos recibieron hierro al destete. En los cerdos alimentados con cobre, la hemoglobina fue menor, posiblemente indicando un efecto negativo sobre la absorción de hierro.

Résumé - Performances de croissance et caractéristiques hématologiques chez des porcs traités avec du fer au moment du sevrage telles qu'influencées par une diète en pouponnière supplémentée avec du cuivre

Objectif: Déterminer les effets du cuivre dans l'alimentation sur les performances de croissance de porcs ayant reçu du fer au moment du sevrage.

MJE, KAW: Tidewater Agricultural Research and Extension Center, College of Agriculture and Life Sciences, Virginia Tech, Suffolk, Virginia.

SGC-D: Large Animal Clinical Sciences, Virginia-Maryland College of Veterinary Medicine, Blacksburg, Virginia.

Corresponding author: Dr Mark J. Estienne, 6321 Holland Road, Suffolk, VA 23437; Tel: 757-807-6551; Email: `mestienn@vt.edu`.

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

Estienne MJ, Clark-Deener SG, Williams KA. Growth performance and hematology characteristics in pigs treated with iron at weaning as influenced by nursery diets supplemented with copper. *J Swine Health Prod.* 2020;28(4):190-203.

Matériels et méthodes: Des porcelets sevrés (n = 144) furent assignés à un arrangement factoriel 2 x 2 x 2 de traitements (6 enclos/traitement, 3 porcs/enclos). Les facteurs étaient la taille (large ou petit), doses de 100 mg de fer intramusculaire (naissance ou naissance et sevrage) et cuivre alimentaire (14.2 ou 250 ppm). Le gain moyen quotidien (ADG), la prise d'aliment (ADFI) et le ratio gain/aliment furent déterminés pour 49 jours. Des échantillons de sang furent prélevés au sevrage ainsi qu'aux jours 7 et 49.

Résultats: Les valeurs d'hémoglobine ($P < .001$) et d'hématocrite ($P = .002$) au moment du sevrage étaient moindres chez les porcs larges. Les porcs ayant reçu deux doses de fer avaient des valeurs plus élevées d'hémoglobine ($P = .05$) et d'hématocrite ($P = .04$). Les valeurs d'hémoglobine ($P = .03$) et d'hématocrite ($P = .03$) étaient plus élevées chez les porcs nourris avec la diète témoin. Seulement chez les porcs de la catégorie large a-t-on remarqué que le poids corporel au jour 49 était plus élevé ($P = .05$) chez les individus recevant deux doses de fer. L'interaction entre le nombre de doses de fer et la diète affecta plusieurs mesures de la croissance incluant l'ADG ($P = .02$) et l'ADFI ($P = .04$). Dans tous les cas, les performances de croissance de porcs nourris avec une diète contenant du cuivre étaient meilleures chez ceux ayant reçus deux doses de fer.

Implications: Au moment du sevrage, les porcs de la catégorie large avaient des caractéristiques hématologiques compatibles avec un niveau de fer inférieur. Un traitement au fer au moment du sevrage augmenta l'hémoglobine. Le cuivra augmenta la croissance seulement si les porcs recevaient du fer au moment du sevrage. Chez les porcs nourris avec du cuivre, l'hémoglobine était moindre, indiquant un effet négatif possible sur l'absorption du fer.

Copper is an essential trace mineral used for the synthesis of hemoglobin and several oxidative enzymes critical for normal metabolism. Although the dietary copper requirement for weaned pigs is 5 to 6 ppm,[1] diets supplemented with levels of copper in excess of requirements (100 to 250 ppm) enhance growth during the nursery phase of production.[2-5] Dietary copper at levels deficient or in excess of nutritional requirements, however, have negative effects on iron absorption from the gastrointestinal tract.[6,7] Recent research has demonstrated that fast-growing pigs of modern genotypes are often iron deficient or anemic at weaning, despite having received intramuscular (IM) iron during the first week of life.[8-10] Clinically, pigs are considered anemic if blood concentrations of hemoglobin are less than 9.0 g/dL, and iron deficient if hemoglobin levels are above 9.0 g/dL but less than 11.0 g/dL.[8,11] An additional iron treatment at weaning could be important, particularly for nursery pigs consuming diets supplemented with pharmacological levels of copper to enhance growth performance. Thus, the experiment reported herein was conducted to determine the effects of an additional 100 mg iron treatment at weaning on growth performance and hematology characteristics in nursery pigs fed a diet supplemented with 250 ppm copper.

Materials and methods

The protocol for this experiment was reviewed and approved by the Institutional Animal Care and Use Committee at Virginia Tech (Blacksburg, Virginia).

Study animals and housing

Yorkshire × Landrace sows (n = 18) farrowed 169 Duroc-sired piglets, of which 144 high-health pigs (n = 76 males and n = 68 females) were employed. Piglets (n = 25) were excluded from the experiment because of unusually heavy or light body weights, signs of being unthrifty, hernias, or leg problems. Within 24 hours after birth, piglets were ear notched for identification, weighed, needle teeth were resected, and tails docked. All pigs received an IM injection of 100 mg iron hydrogenated dextran (Iron-100; Durvet, Inc) in the neck muscle behind the ear using a 20-gauge, 1.27 cm-long needle and a disposable 3 cc syringe (Becton, Dickinson and Company). To simulate commercial procedures, a standard amount of iron was administered shortly after birth rather than amounts based on body weight.[1] Similar to our previous work,[10] the dosage of iron was chosen because 1) lower doses are less likely to be toxic and cause oxidative stress; 2) greater doses of iron increase liver hepcidin secretion, which perturbs systemic iron metabolism; and 3) the 100 mg dose soon after birth would likely increase the number of anemic pigs at weaning, allowing for the evaluation of how these pigs respond to dietary copper supplementation. Boar piglets were castrated at seven days of age using a sterile scalpel. All piglets had access to sow feeders but no access to creep feed during the suckling period. At weaning, pigs were moved to an environmentally controlled nursery facility. Each nursery pen measured 0.91 × 1.22 m^2 over galvanized steel bar slats and contained a nipple drinker and a stainless-steel feeder with four feeding spaces.

Study design

At 21.8 (0.5) days of age (mean [SE]), pigs were weaned, vaccinated against porcine circovirus type 2 and *Mycoplasma hyopneumoniae* (Circumvent PCV-M G2; Merck Animal Health), weighed, and divided into equal groups of the largest and smallest pigs (8.72 [0.40] and 5.97 [0.40] kg, respectively). Six blocks of eight pens each were created by placing a total of 12 pigs of each size category in pens of three pigs each. Each pen had at least one barrow and one gilt and pigs from at least two different litters. The eight pens within a block were randomly allocated to a 2 × 2 × 2 factorial arrangement of treatments. The factors were: 1) size of pig (large or small); 2) number of 100 mg IM iron doses (one dose administered within 24 hours after birth or two doses [one administered within 24 hours after birth and the other at weaning]); and 3) level of dietary copper (14.2 [control] or 250 ppm). There were six replicate pens per treatment combination (total of 48 pens).

Experimental diets

Pigs were allowed ad libitum access to a three-phase feeding regimen with all diets meeting the requirements for the various nutrients[1] and copper adjusted to concentrations previously indicated. For each phase, a basal diet was first prepared, containing most of the corn and all the common ingredients for each experimental diet. Copper sulfate (Pestell Minerals and Ingredients) or an equal amount of ground corn was added to the basal diet to create the copper or control diets, respectively (Table 1).

Data and sample collection

Pigs were weighed at weaning (day 0) and at days 7, 21, and 49 post weaning. Average daily gain (ADG) was determined for day 0 to 7, day 8 to 21, day 22 to 49, and day 0 to 49. Feed additions were recorded so that for each period, average daily feed intake (ADFI) and the gain to feed ratio (G:F) could be calculated. Feed remaining in feeders was removed with a vacuum (Shop-vac) and weighed.

A blood sample from the barrow weighing closest to the mean weight of pigs in each pen was collected at weaning (before the

Table 1: Composition of copper-supplemented and control diets fed to nursery pigs for 49 days*

	Dietary phase (days fed post weaning)		
Feed component, %	**1 (0 - 7)**	**2 (8 – 21)**	**3 (22 - 49)**
Ground corn	42.13	54.94	64.94
Soybean oil	3.00	3.00	3.00
Dried whey	25.00	10.00	0.00
Menhaden fish meal	4.00	2.00	0.00
Soycomil[†]	3.00	2.00	2.00
Soybean meal	19.85	24.90	26.65
Dicalcium phosphate	1.00	1.00	1.25
Calcium carbonate	0.70	1.00	1.00
Salt	0.20	0.20	0.20
Lysine-HCL	0.40	0.30	0.30
DL-methionine[‡]	0.12	0.06	0.06
Vitamin-trace mineral[§]	0.50	0.50	0.50
Copper sulfate or ground corn	0.10	0.10	0.10
Totals	**100.00**	**100.00**	**100.00**
Calculated analysis, %			
Crude protein	20.57	20.33	19.57
Lysine	1.53	1.37	1.27
Methionine	0.46	0.39	0.37
Calcium	0.88	0.83	0.74
Phosphorous	0.75	0.65	0.61

* Copper sulfate or control diets were prepared by mixing copper sulfate (Pestell Minerals and Ingredients) or ground corn, respectively, with the basal diet consisting of the major portion of the ground corn and all other common ingredients. The control diet contained 14.2 ppm copper, 113 ppm iron, and 113 ppm zinc.

[†] Archer Daniels Midland Co.

[‡] Rhodimet NP 99.

[§] ANS Swine Breeder Premix manufactured for Agri-Nutrition Services, Inc. Trace minerals in sulfate forms were in a polysaccharide complex.

second dose of iron was administered to the appropriate pigs), and at days 7 and 49 post weaning. The same pig was used for each collection. For sampling, barrows were placed supine on a v-board and approximately 7 mL of blood was collected via jugular venipuncture (20-gauge, 2.54 cm-long needle) into a Vacutainer tube (Becton, Dickinson and Company) containing EDTA. Hematology analyses were conducted using a Coulter Multisizer 3 cell counter (Beckman Coulter, Inc) by Animal Laboratory Services of the Virginia-Maryland College of Veterinary Medicine (Blacksburg, Virginia). The following hematological determinations were made: number of red blood cells, reticulocytes, white blood cells, neutrophils, lymphocytes, monocytes, eosinophils, basophils, and platelets, percentage of reticulocytes, hemoglobin concentration, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin concentration, red blood cell distribution width, and mean platelet volume.

Statistical analysis

Data were subjected to ANOVA using the mixed models procedure of SAS (SAS Institute Inc). Body weights, ADG, ADFI, and G:F were analyzed using a model that included pig size, number of iron doses, diet, and all two- and three-way interactions as possible sources of variation. Block was included as a random variable and pen served as the experimental unit. A repeated measures model was used for analyzing hematological characteristics and included pig size, number of iron treatments, diet, day, and all two-, three-, and four-way interactions as possible sources of variation. Block was included as a random variable and individual pig was the experimental unit. Individual means were compared using the LSMEANS option of PROC MIXED and were adjusted using the Tukey-Kramer procedure. Differences in means were considered statistically significant at $P < .05$.

Results

There were no pig deaths or removals during the experiment.

Hematology characteristics

There were no three- or four-way interactions of main effects on hematology characteristics. The number and percentage of reticulocytes were affected ($P = .05$) by an interaction of pig size and the number of iron doses (Figure 1). In large pigs only, reticulocyte number and percentage were greater ($P = .05$) for animals receiving two versus one iron dose.

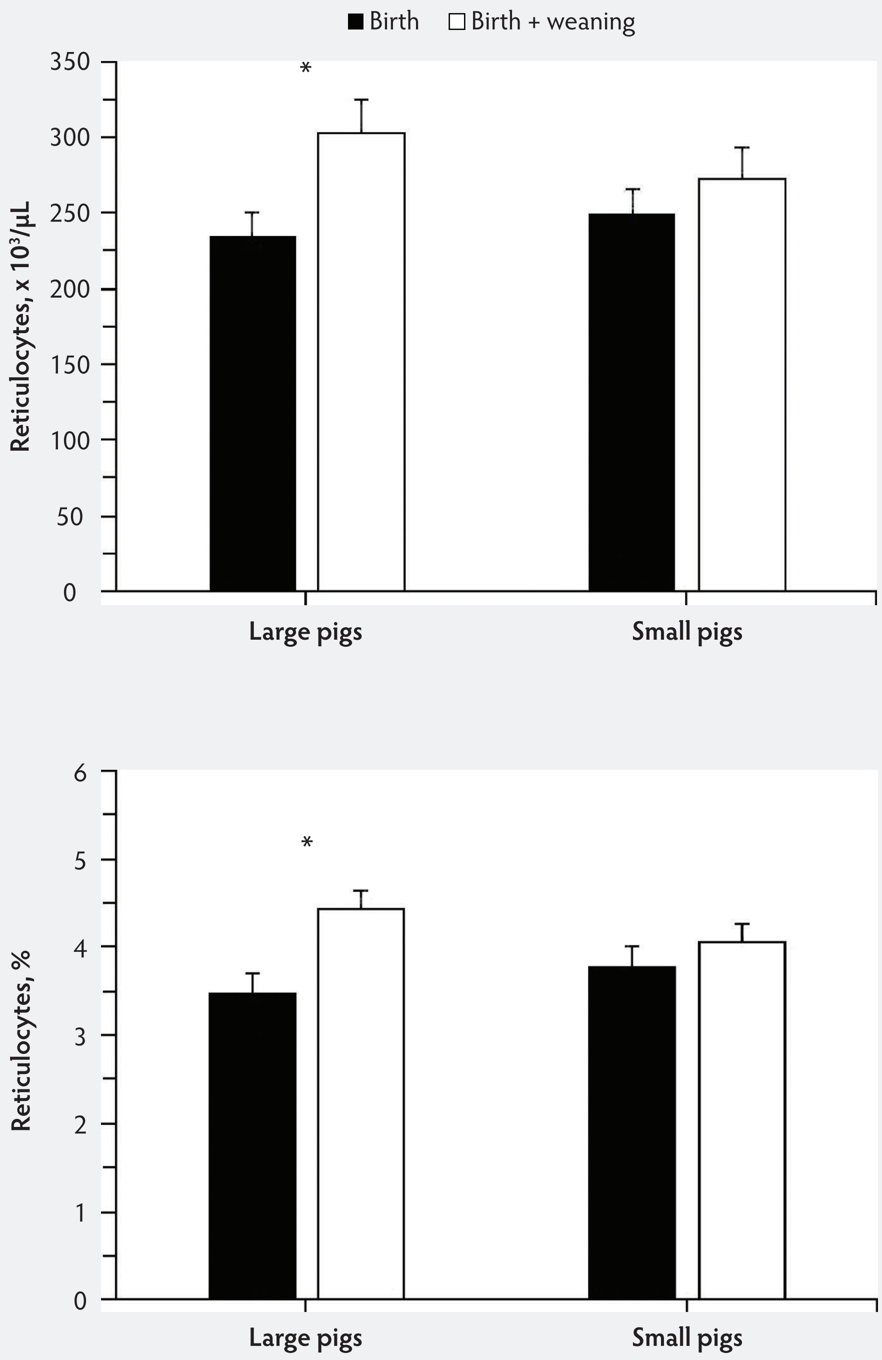
Mean corpuscular volume ($P = .01$) and reticulocyte percentage ($P = .001$) and number ($P = .001$) were affected by an interaction between number of iron doses and day post weaning (Figure 2). On day 7, but not on days 0 or 49, mean corpuscular volume ($P = .06$) and reticulocyte percentage ($P < .001$) and number ($P < .001$) were greater for pigs receiving two versus one iron dose.

There was an interaction of number of iron doses and diet for mean corpuscular hemoglobin ($P = .04$). Compared to pigs receiving iron only at birth, pigs receiving an additional iron dose at weaning had slightly greater mean corpuscular hemoglobin if fed the copper diet, but slightly decreased values if fed the control diet (Figure 3). Basophil concentration ($P = .05$; Figure 3) was also affected by an interaction of number of iron doses and diet. For pigs receiving only one dose of iron, basophil concentrations were less ($P = .04$) in animals fed copper. This effect of diet did not exist ($P = .98$) for pigs receiving iron at both birth and at weaning.

The interaction of pig size and day affected hemoglobin concentrations ($P < .001$), hematocrit ($P < .001$), mean corpuscular volume ($P < .001$), mean corpuscular hemoglobin ($P = .008$), red blood cell distribution width ($P = .001$), and reticulocyte percentage ($P = .02$) and number ($P = .02$; Figure 4). Hemoglobin concentrations and mean corpuscular volume on days 0 ($P < .001$ and $P < .001$, respectively) and 7 ($P = .02$ and $P < .001$, respectively), hematocrit on day 0 ($P = .002$), and mean corpuscular hemoglobin concentration on day 7 ($P = .008$) were less in large versus small pigs; there were no differences detected on day 49. In contrast, red blood cell distribution width was greater in the large pigs on both day 0 ($P = .001$) and 7 ($P = .002$). Reticulocyte percentage ($P = .09$) and number ($P = .04$) were greater for large versus small pigs on day 7, but not on the other days.

Table 2 contains hematology characteristics in nursery pigs as affected by the main effects of pig size, number of iron doses, diet, and day post weaning. Concentration of eosinophils ($P = .03$) were greater in the large versus small pigs. Hemoglobin ($P = .05$) and hematocrit ($P = .04$) were greater, and the number of platelets was less ($P = .05$) in pigs receiving iron doses at birth and at weaning

Figure 1: Reticulocyte A) number and B) percentage (SE) in blood collected from large and small weaned pigs receiving one (birth) or two (birth and weaning) doses of 100 mg iron dextran by intramuscular injection. Data were subjected to ANOVA for repeated measures. Reticulocyte number and percentage were affected ($P = .05$) by the interaction of pig size and number of iron doses. The second dose of iron increased ($P = .05$; *) both values in large pigs but not small pigs.



compared to at birth only. Hemoglobin (*P* = .03), hematocrit (*P* = .03), and mean corpuscular volume (*P* = .04) were greater in pigs fed the control versus copper-supplemented diet. Red (*P* < .001) and white (*P* = .006) blood cell numbers, and mean platelet volume (*P* < .001) increased from day 0 to day 7, and then remained similar until day 49. Concentrations of lymphocytes (*P* < .001), monocytes (*P* < .001), basophils (*P* < .001), and platelets (*P* < .001) decreased from day 0 to day 7, and further decreased from day 7 to day 49.

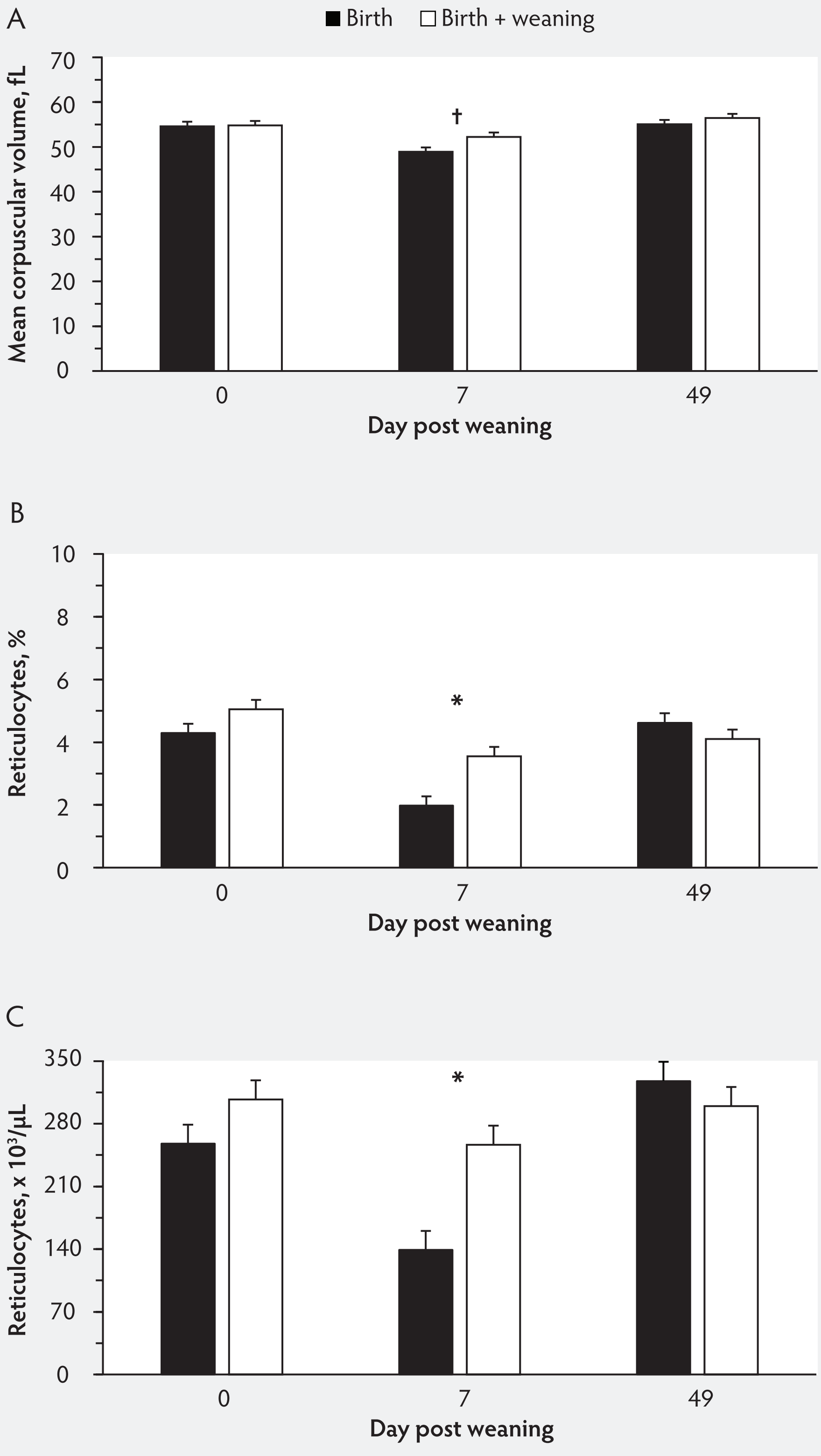
Growth performance

There were no three-way interactions among pig size, number of iron doses, and diet for body weights at weaning or days 7, 21, or 49 post weaning. Day 49 body weights were affected by interactions of size of pig and number of iron doses (*P* = .05; Figure 5), and number of iron doses and diet (*P* = .04; Figure 6). In large pigs only, body weight was greater (*P* = .05) for individuals receiving two versus one dose of iron (Figure 5). Body weight was greater (*P* = .04) for copper-fed pigs that received two versus one dose of iron, however, body weights were not affected (*P* = .99) by the number of iron doses in control-fed pigs (Figure 6).

The interaction between number of iron doses and diet affected ADG and G:F from day 0 to 7 (*P* = .04 and *P* = .05, respectively) and day 8 to 21 (*P* = .009 and *P* = .01, respectively), ADFI from day 22 to 49 (*P* = .03), and ADG (*P* = .02) and ADFI (*P* = .04) for day 0 to 49 (Figures 7, 8, 9, and 10). In all cases, performance measures were greater in copper-fed pigs receiving two versus one dose of iron. In contrast, growth was unaffected by the number of iron doses in animals fed the control diet.

Table 3 summarizes body weights and growth performance in nursery pigs as affected by the main effects of size of pig, number of iron doses, and diet. Large pigs weighed more than small pigs on days 0, 7, and 21 of the experiment (*P* < .001). From day 0 (weaning) to 7, size of pig did not affect ADG (*P* = .50), ADFI (*P* = .18), or G:F (*P* = .18). For days 8 to 21 and 22 to 49, ADG and ADFI were greater in the large versus small pigs (*P* < .001 and *P* = .02, and *P* < .001 and *P* < .001, respectively). The G:F was also greater for large pigs from day 8 to 21 (*P* < .001) but not from day 22 to 49 (*P* = .41). For the overall trial (day 0 to 49 post weaning), ADG and ADFI were

Figure 2: A) Mean corpuscular volume and reticulocyte B) percentage and C) number (SE) at day 0, 7, and 49 post weaning in pigs receiving one (birth) or two (birth and weaning) doses of 100 mg iron dextran by intramuscular injection. Data were subjected to ANOVA for repeated measures. Mean corpuscular volume (*P* = .01) and reticulocyte percentage (*P* < .001) and number (*P* < .001) were affected by an interaction between number of iron doses and day post weaning. Values were greater (*P* = .06, †; *P* < .001, *) on day 7 post weaning in pigs receiving two doses of iron.

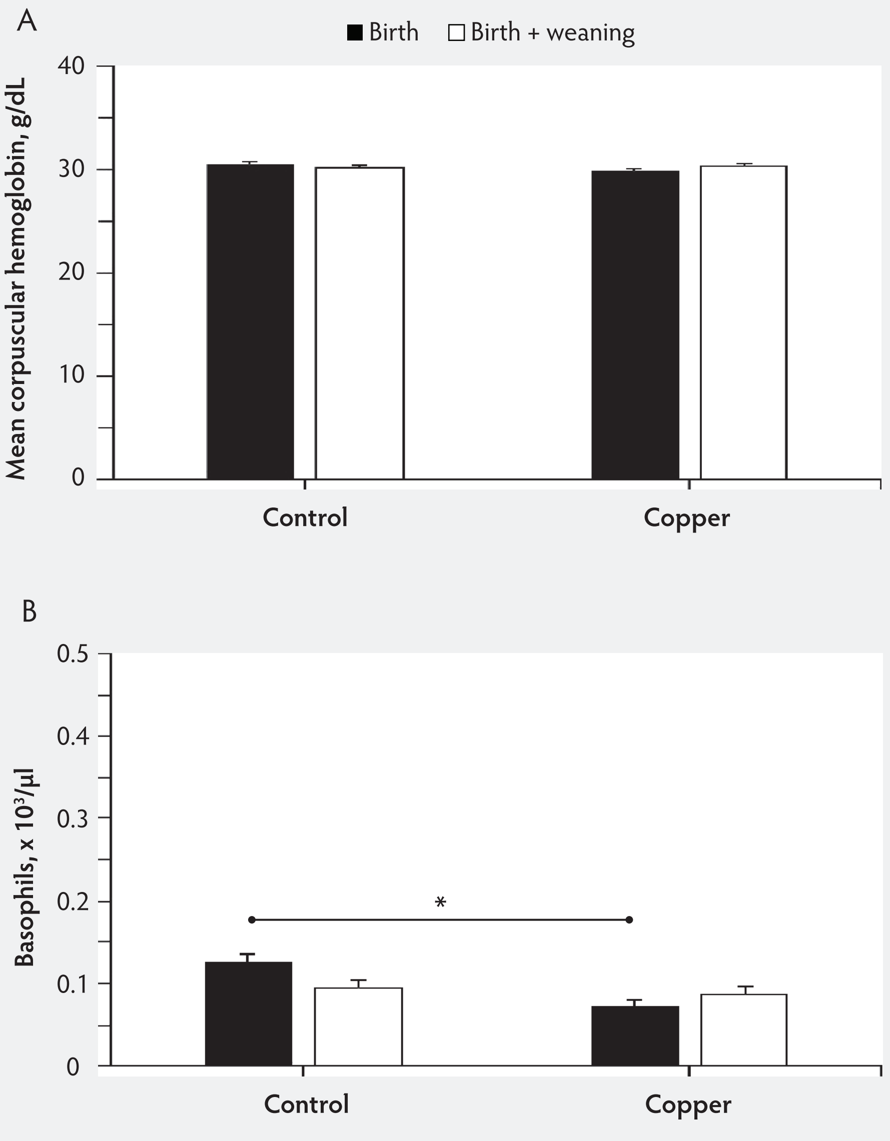


greater ($P < .001$) in large pigs, and G:F was similar ($P = .34$) for the different sized animals. Body weights were greater at day 21 ($P < .001$) in pigs receiving two versus one dose of iron.

Discussion

Hemoglobin is a protein molecule that allows red blood cells to carry oxygen from the lungs to bodily tissues and return carbon dioxide from tissues back to the lungs. Iron is a critical constituent of hemoglobin and iron deficiency anemia occurs if iron levels in the body are inadequate to maintain normal concentrations of hemoglobin in the blood. Clinically, pigs are considered anemic if blood concentrations of hemoglobin are less than 9.0 g/dL, and iron deficient if hemoglobin levels are above 9.0 g/dL but less than 11.0 g/dL.[8,11] To prevent iron deficiency anemia, pigs reared in confinement operations typically receive IM treatment with iron, usually in the form of iron dextran, within a few days after birth. The exact timing, dosage, and number of injections of iron dextran, however, varies widely among commercial pig farms.[12] Nevertheless, several research groups reported that a significant number of pigs, particularly the fastest growing animals within a litter, were iron deficient or anemic at weaning, despite receiving treatment with iron early in life,[8-10] and pigs that are anemic at weaning display poorer growth in the nursery compared with non-anemic pigs.[13] The results of the current experiment, when 100 mg iron was administered at birth, are consistent with those previous studies that demonstrated an increased risk of anemia at weaning in larger pigs. Indeed, small pigs weaned in the present study had greater hemoglobin concentrations, hematocrit, and mean corpuscular volume compared to large pigs. Mean corpuscular hemoglobin was also greater in small pigs on day 7 post weaning. In contrast, red blood cell distribution width, a measure of variability in the size of cells that increases in anemic individuals, was greater at weaning in the large versus small pigs. By the end of the 49-day trial there were no differences between size groups for hemoglobin, hematocrit, mean corpuscular volume, or red blood cell distribution width. In the current experiment, a standard dose of iron was employed and our finding that 100 mg iron was sufficient to prevent anemia in smaller but not larger pigs, suggests that body weight should be considered when iron is administered to newborns.

Figure 3: A) Mean corpuscular hemoglobin and B) number of basophils (SE) in control- or copper-fed pigs receiving one (birth) or two (birth and weaning) doses of 100 mg iron dextran by intramuscular injection. Data were subjected to ANOVA for repeated measures. Mean corpuscular hemoglobin (*P* = .04) and basophil concentration (*P* = .05) were affected by an interaction between number of iron doses and diet. For pigs receiving only one dose of iron, the copper (*P* = .04; *) but not control (*P* = .98) diet suppressed basophil concentrations.



Others have reported that eosinophil concentrations were less in anemic versus non-anemic pigs.[14] Interestingly, in the current study, eosinophil concentrations were greater in the pigs classified as large at weaning, despite the display of hematological data consistent with iron deficiency. Cases of concurrent iron deficiency anemia and eosinophilia have been reported in humans diagnosed with internal parasites,[15] and oral inoculation of pigs with infective ascaris eggs resulted in eosinophilia in the peripheral blood and a serum antibody response.[16] It is doubtful, however, that pigs in the current study had high numbers of internal parasites. The experiment was conducted in an intensively managed and highly sanitary university facility and sows were treated with 1.8% fenbendazole as per label (Safe-Guard; Merck Animal Health) before farrowing.

Hemoglobin concentrations, hematocrit, and mean corpuscular volume were greater in control pigs versus pigs fed a diet supplemented with copper. These findings are consistent with the hypothesis that pharmacological levels of dietary copper decrease iron absorption

Figure 4: Hematology characteristics (SE) in large and small pigs at 0, 7, and 49 days post weaning. Data were subjected to ANOVA for repeated measures. A) Hemoglobin ($P < .001$), B) hematocrit ($P < .001$), C) mean corpuscular volume ($P < .001$), D) mean corpuscular hemoglobin ($P = .008$), E) red blood cell distribution width ($P = .001$), F) reticulocyte percentage ($P = .02$), and G) reticulocyte number ($P = .02$) were affected by an interaction of pig size and day. For each hematology characteristic, bars for large and small pigs within day marked with an * differ ($P < .05$).

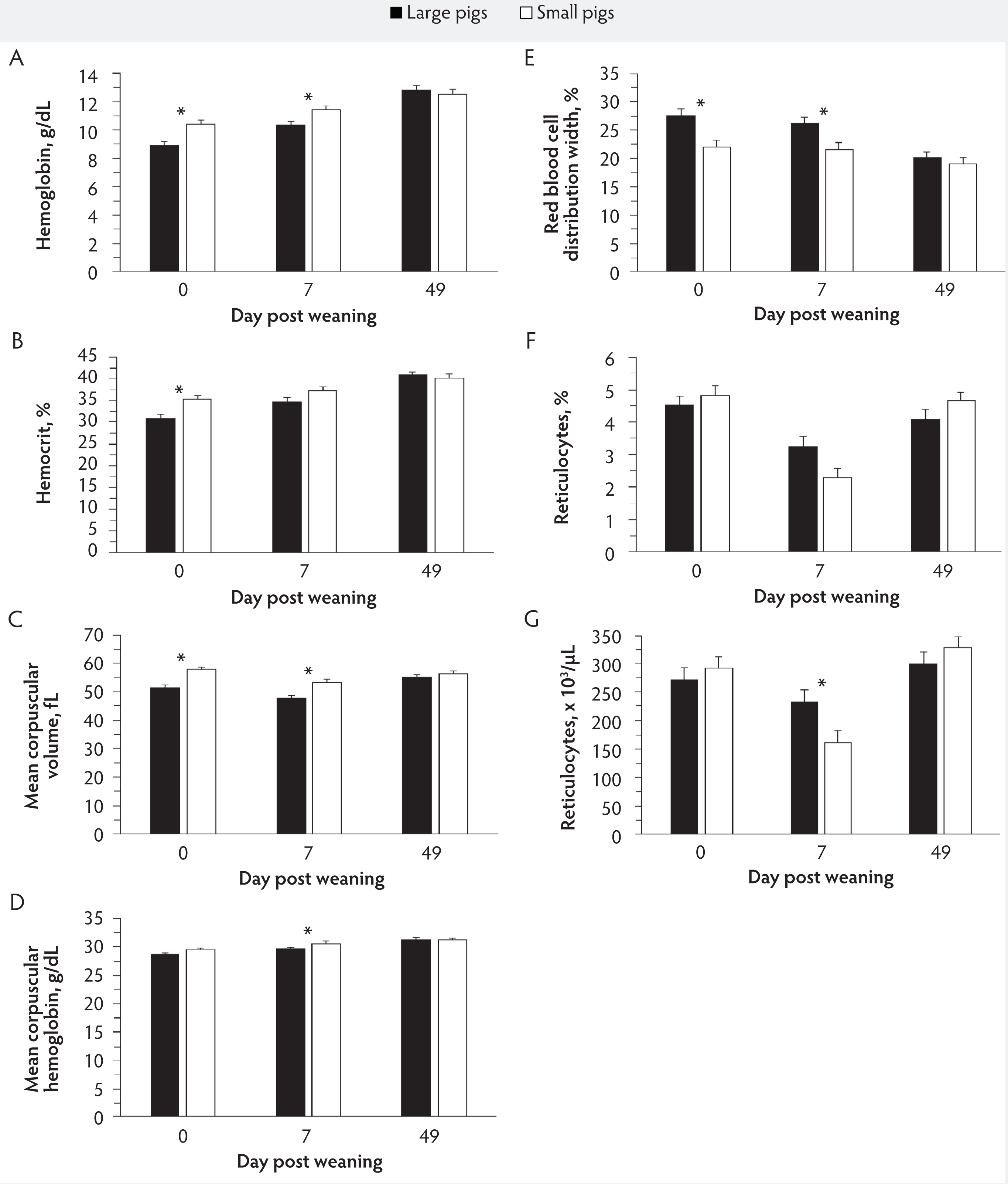


Table 2: Hematology characteristics of large and small nursery pigs treated intramuscularly with 100 mg iron dextran at birth or at birth and at weaning and fed control (14.2 ppm copper) or copper-supplemented (250 ppm) diets for 49 days

	Pig size				Iron doses (100 mg)				Diet				Day post weaning				
Hematological parameter	**Large (n = 24)**	**Small (n = 24)**	**SE**	***P*¶**	**Birth (n = 24)**	**Birth + weaning (n = 24)**	**SE**	***P*¶**	**Control (n = 24)**	**Copper (n = 24)**	**SE**	***P*¶**	**0 (n = 48)**	**7 (n = 48)**	**49 (n = 48)**	**SE**	***P*¶**
Red blood cells, ×10^{6}/μL	6.90	6.74	0.09	.22	6.76	6.87	0.09	.41	6.86	6.78	0.09	.51	6.07^{a}	7.13^{b}	7.26^{b}	0.09	< .001
Hemoglobin, g/dL*	10.67	11.44	0.24	.004	10.80	11.31	0.24	.05	11.36	10.76	0.24	.03	9.64^{a}	10.86^{b}	12.66^{c}	0.23	< .001
Hematocrit, %*	35.49	37.55	0.72	.01	35.67	37.38	0.72	.04	37.44	35.60	0.72	.03	33.14^{a}	35.95^{b}	40.48^{c}	0.71	< .001
Mean corpuscular volume, fL*†	51.48	55.88	0.86	< .001	52.87	54.50	0.86	.12	54.75	52.61	0.86	.04	54.72^{a}	50.59^{b}	55.74^{a}	0.76	< .001
Mean corpuscular hemoglobin, g/dL*‡	29.92	30.46	0.24	.002	30.17	30.21	0.24	.81	30.28	30.10	0.24	.30	29.10^{a}	30.18^{b}	31.30^{c}	0.25	< .001
Red blood cell distribution width, %*	24.65	20.90	1.04	< .001	23.55	21.99	1.04	.11	22.10	23.44	1.04	.16	24.88^{a}	23.93^{a}	19.51^{b}	0.99	< .001
Reticulocytes, %*†§	3.95	3.91	0.18	.85	3.63	4.23	0.18	< .001	4.00	3.86	0.18	.43	4.67^{a}	2.76^{b}	4.36^{a}	0.23	< .001
Reticulocytes, ×10^{3}/μL*†§	268.8	260.5	13.2	.49	241.5	287.8	13.3	< .001	268.9	260.4	13.2	.48	282.4^{a}	197.8^{b}	313.7^{a}	16.6	< .001
White blood cells, ×10^{3}/μL	14.25	12.88	1.18	.41	12.75	14.39	1.18	.33	14.08	13.05	1.18	.53	9.95^{a}	15.58^{b}	15.17^{b}	1.57	.006
Neutrophils, ×10^{3}/μL	4.62	4.71	0.46	.84	4.25	5.08	0.46	.07	4.50	4.82	0.46	.48	4.30	5.33	4.36	0.51	.08
Lymphocytes, ×10^{3}/μL	7.10	7.04	0.31	.88	7.33	6.81	0.31	.18	7.04	7.09	0.31	.91	4.78^{a}	6.98^{b}	9.44^{c}	0.31	< .001
Monocytes, ×10^{3}/μL	0.47	0.53	0.04	.11	0.50	0.51	0.04	.84	0.50	0.50	0.04	.95	0.26^{a}	0.52^{b}	0.73^{c}	0.05	< .001
Eosinophils, ×10^{3}/μL	0.51	0.37	0.06	.03	0.42	0.46	0.06	.52	0.42	0.46	0.06	.51	0.43	0.50	0.39	0.06	.12
Basophils, ×10^{3}/μL‡	0.09	0.10	0.01	.48	0.10	0.09	0.01	.49	0.11	0.08	0.01	.01	0.04^{a}	0.10^{b}	0.14^{c}	0.01	< .001
Platelets, ×10^{3}/μL	416.8	412.8	30.0	.91	450.0	379.6	30.0	.05	382.6	447.0	30.0	.07	530.7^{a}	405.0^{b}	308.8^{c}	28.9	< .001
Mean platelet volume, fL	9.65	9.71	0.51	.85	9.60	9.77	0.52	.61	9.53	9.84	0.52	.36	10.56^{a}	9.25^{b}	9.23^{b}	0.30	< .001

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* Affected by interaction of pig size and day ($P < .001$ for hemoglobin, hematocrit, mean corpuscular volume; $P = .001$ for red blood cell distribution width; $P = .008$ for mean corpuscular hemoglobin; and $P = .02$ for reticulocyte number and percentage).

† Affected by interaction of iron treatments and day ($P = .001$ for reticulocyte number and percentage; and, $P = .01$ for mean corpuscular volume).

‡ Affected by interaction of iron treatments and diet ($P = .04$ for mean corpuscular hemoglobin, and $P = .05$ for basophils).

§ Affected by interaction of pig size and iron treatments ($P = .05$ for reticulocyte number and percentage).

¶ Data were subjected to ANOVA for repeated measures. For the main effect of day, values with different superscripts (a,b,c) differ ($P < .05$).

in pigs.[6,7] Interestingly, basophil concentrations in pigs receiving iron at birth only were less in copper-fed individuals compared to controls. The biological significance of this finding, however, is unclear.

In the current experiment, hemoglobin concentrations, hematocrit, and reticulocyte number and percentage were affected by day of sampling and pig size. Hemoglobin and hematocrit were greater, and platelet counts were less, in pigs receiving an additional iron injection at weaning. These changes reflect a positive effect of iron therapy in individuals that may be anemic or iron deficient, and are consistent with previous reports in the literature.[17,18] For example, a second injection of 200 mg iron dextran at 20 days of age increased hemoglobin concentrations in pigs weaned and blood sampled at 34 days of age.[18] Our finding that platelet counts were less in pigs receiving an additional dose of iron at weaning are consistent with a previous study in which humans with iron deficiency anemia had greater platelet counts than those with adequate iron stores; oral iron supplementation decreased platelet counts in anemic individuals but not in those with normal iron levels.[19]

For the study reported here, pigs classified as large at weaning weighed approximately 2.8 kg more than pigs classified as small. The difference between size groups increased during the study and was approximately 7.6 kg at day 49 post weaning. That larger pigs at weaning maintain or expand a size advantage over small pigs at weaning has been previously reported.[10,20-23] Feed conversion efficiency is a function of body weight, and as a pig grows, it may become less efficient at converting feed into body weight gain,[24] which could explain our finding that small pigs displayed greater G:F from day 8 to 21 in the nursery than large pigs. In the current experiment, however, final body weight was impacted by an interaction between pig size and the number of iron doses. As mentioned above, hemoglobin levels were less in large versus small pigs at weaning. Perhaps an iron deficiency was mitigated by iron treatment at weaning, allowing the large pigs to achieve maximum size. Moreover, we cannot discount potential effects of dietary iron on improved growth responses.

Figure 5: Body weights (SE) at day 49 post weaning in large and small pigs receiving one (birth) or two (birth and weaning) doses of 100 mg iron dextran by intramuscular injection. Data were subjected to ANOVA. Bars within pig size marked with an * differ ($P < .05$).

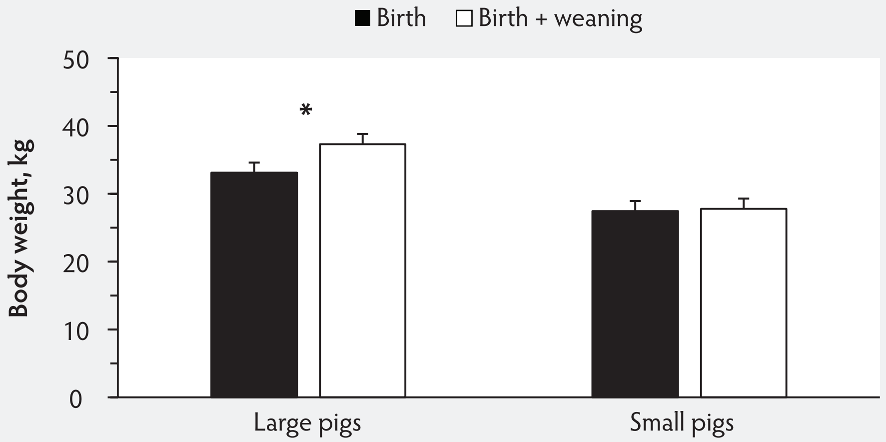
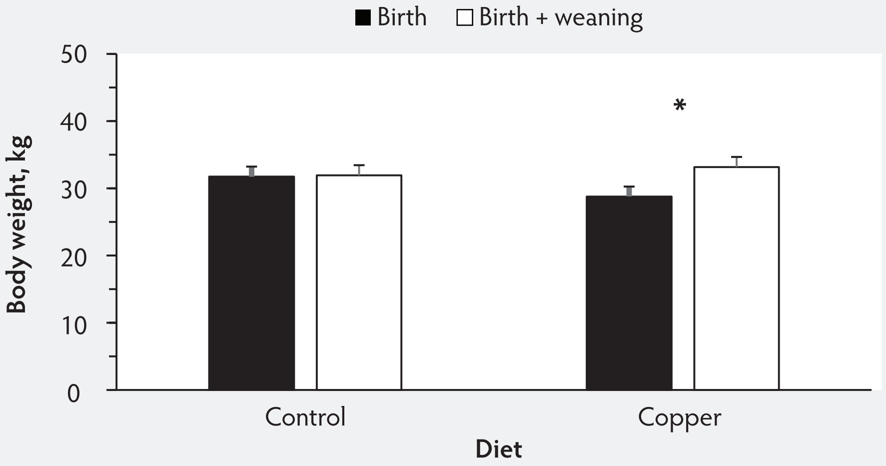


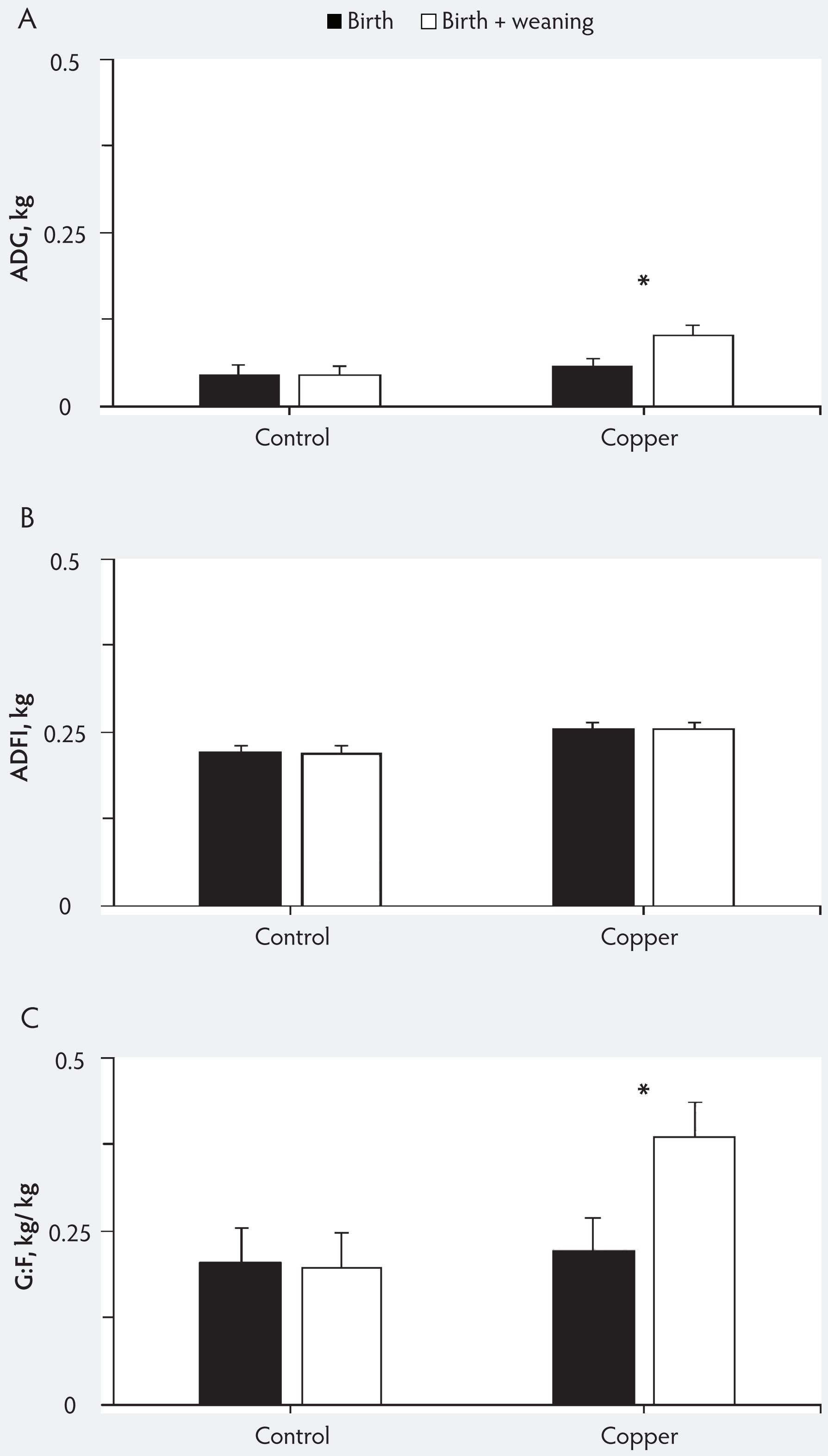
Figure 6: Body weights (SE) at day 49 post weaning in control- (14.2 ppm copper) and copper-fed (250 ppm) pigs receiving one (birth) or two (birth and weaning) doses of 100 mg iron dextran by intramuscular injection. Data were subjected to ANOVA. Bars within diet marked with an * differ ($P < .05$).



Increased growth in nursery pigs provided pharmacological concentrations of dietary copper have been well-documented[2-5] and, consistent with previous reports, pigs fed the copper-supplemented diet in the current study exhibited greater weight gain, feed intake, and feed conversion efficiency than control pigs during the first week post weaning. More importantly, many aspects of growth performance were influenced by an interaction between the number of iron treatments and diet. Indeed, ADG (days 0 to 7, 8 to 21, and 0 to 49), ADFI (days 22 to 49 and 0 to 49) and G:F (days 0 to 7 and 8 to 21) were enhanced by dietary copper only if an additional 100 mg iron dose was administered at weaning. Based on these results, it appears that an adequate level of iron in the body is requisite for dietary copper to enhance growth performance in nursery pigs. As reported, iron injected at weaning did not enhance growth performance in pigs fed the control diet.

Studies in which additional iron was given by either increasing the dosage administered at birth or by administering an additional dose during the suckling period or at weaning, have yielded equivocal growth responses. Consistent with our results for the pigs receiving copper, pigs receiving injections of 200 mg iron at birth and 200 mg iron at 7 to 14 days prior to weaning had increased ADG compared to pigs receiving 200 mg iron at birth only.[18,25] In contrast, growth performance was not affected or was only slightly influenced by increasing the dosage of iron given at birth from 200 to 300 mg,[26,27] or by injecting 200 mg at birth and 100 to 200 mg at 17 days of age or at weaning.[17,27]

Figure 7: A) ADG, B) ADFI, and C) G:F (SE) between day 0 and 7 post weaning in pigs that received one (birth) or two (birth and weaning) doses of 100 mg iron dextran and were fed a control diet (14.2 ppm copper) or diet supplemented with 250 ppm copper. Data were subjected to ANOVA. Average daily gain ($P = .04$) and G:F ($P = .05$) were affected by an interaction of diet and number of iron doses. In copper-fed pigs only, ADG and G:F were greater ($P < .05$; *) for individuals receiving two versus one dose of iron. ADG = average daily gain; ADFI = average daily feed intake; G:F = gain to feed ratio.



In summary, hematological analyses conducted in this study reflect an increased risk of anemia at weaning in larger pigs. That 100 mg of iron given at birth was sufficient to prevent anemia in smaller but not larger pigs suggests that body weight should be considered when iron is administered to newborns. Based on hematological evidence, high levels of dietary copper appear to decrease iron absorption, and it appears that an adequate level of iron in the body is requisite for dietary copper to enhance growth performance in nursery pigs. These findings illustrate the complex relationship among trace minerals in swine and the need for further research in this area of nutrition.

Implications

Under the conditions of this study:

- Iron treatment at weaning increased hemoglobin levels.
- Copper enhanced nursery growth only if pigs received iron at weaning.
- Hemoglobin levels were less in copper-fed pigs compared to controls.

Acknowledgments

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Conflict of interest

None reported.

Disclaimer

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Figure 8: A) ADG, B) ADFI, and C) G:F (SE) between day 8 and 21 post weaning in pigs that received one (birth) or two (birth and weaning) doses of 100 mg iron dextran and were fed a control diet (14.2 ppm copper) or diet supplemented with 250 ppm copper. Data were subjected to ANOVA. Average daily gain (P = .009) and G:F (P = .01) were affected by an interaction of diet and number of iron doses. For each performance measure, bars with different superscripts differ (P < .05). ADG = average daily gain; ADFI = average daily feed intake; G:F = gain to feed ratio.

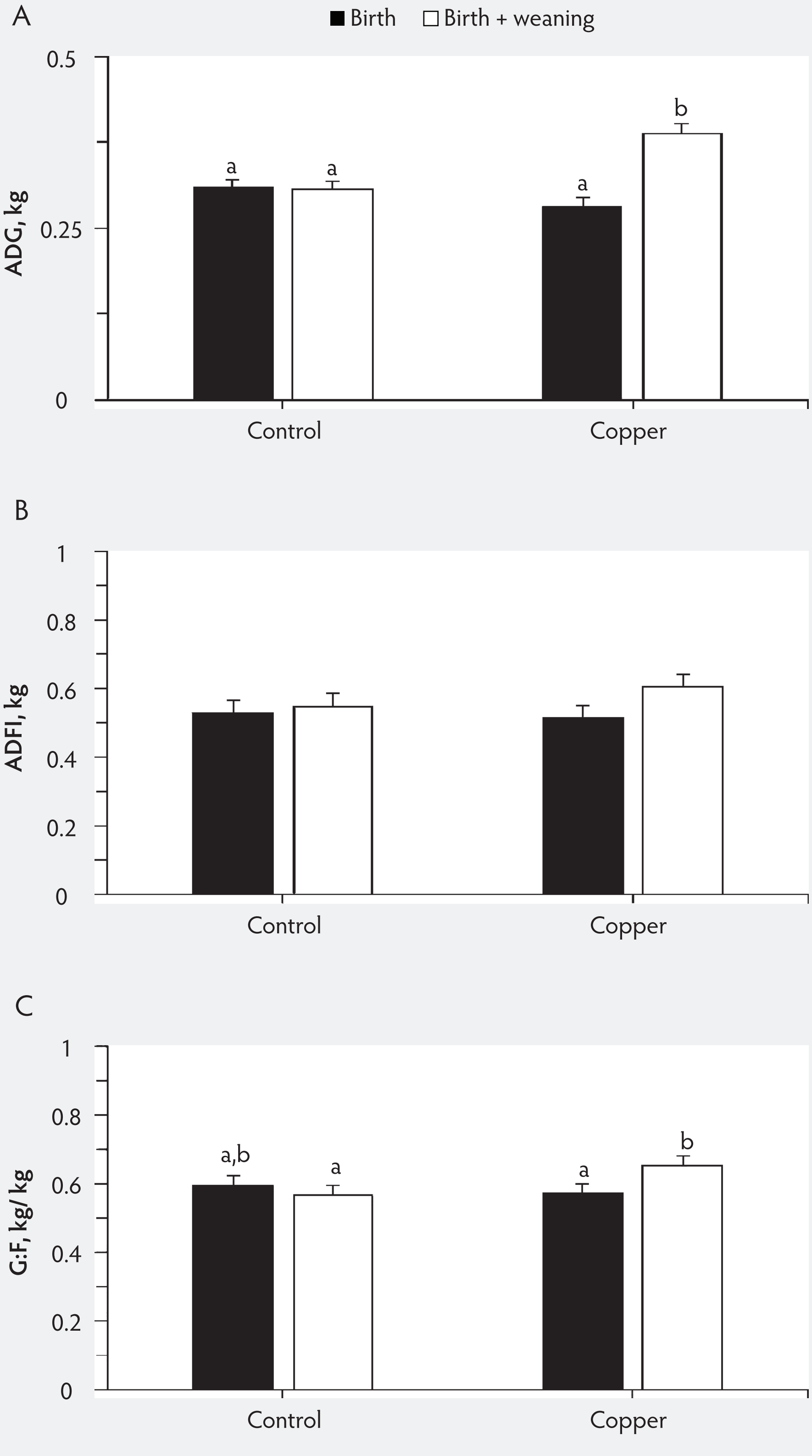

Figure 9: A) ADG, B) ADFI, and C) G:F (SE) between day 22 and 49 post weaning in pigs that received one (birth) or two (birth and weaning) doses of 100 mg iron dextran and were fed a control diet (14.2 ppm copper) or diet supplemented with 250 ppm copper. Data were subjected to ANOVA. Average daily feed intake (*P* = .03) was affected by an interaction of diet and number of iron doses, and in copper-fed pigs was greater (*P* = .03; *) for individuals receiving two versus one dose of iron. ADG = average daily gain; ADFI = average daily feed intake; G:F = gain to feed ratio.

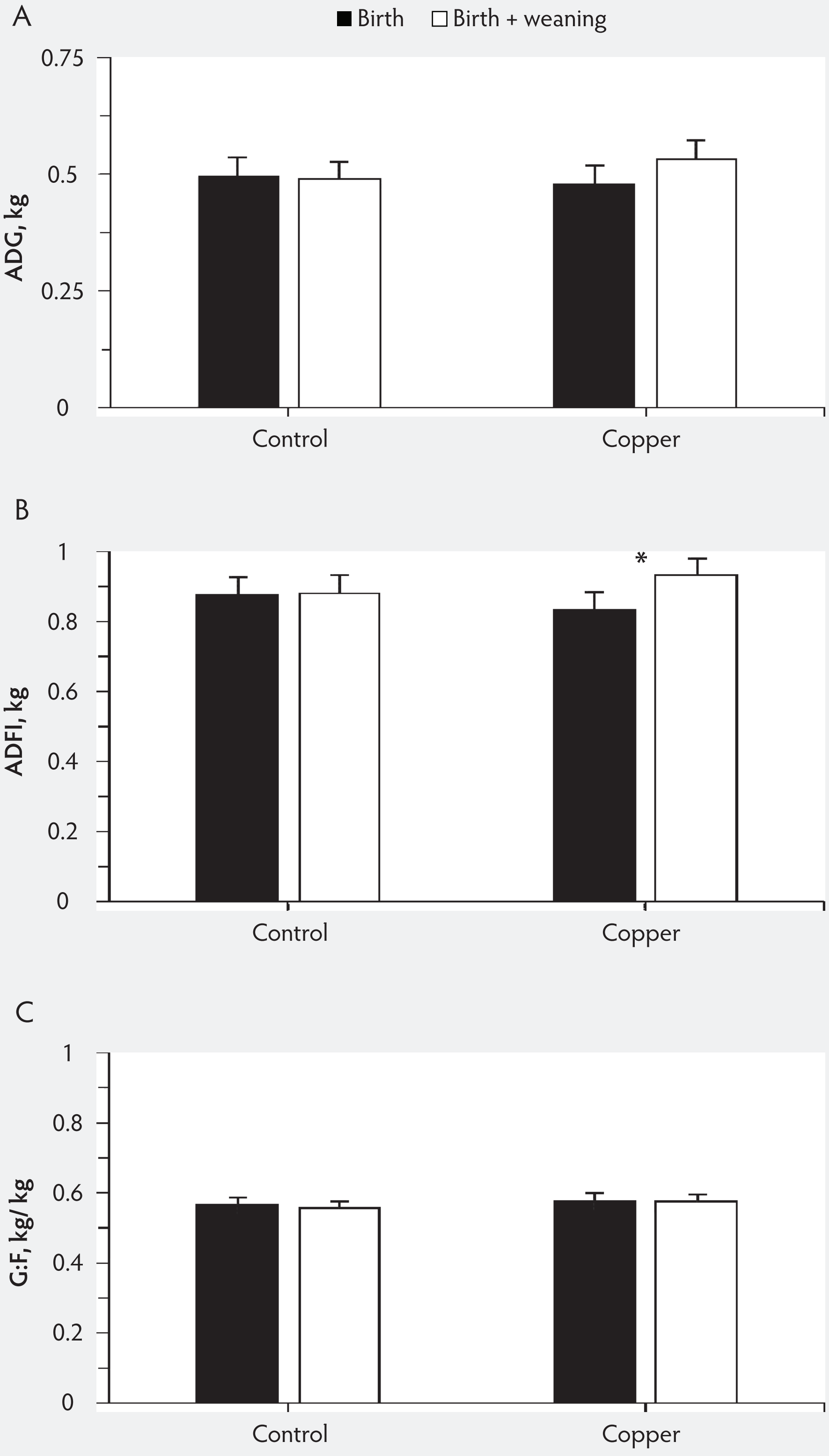

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Figure 10: A) ADG, B) ADFI, and C) G:F (SE) between weaning (day 0) and day 49 post weaning in pigs that received one (birth) or two (birth and weaning) doses of 100 mg iron dextran and were fed a control diet (14.2 ppm copper) or diet supplemented with 250 ppm copper. Data were subjected to ANOVA. Average daily gain (*P* = .02) and ADFI (*P* = .01) were affected by an interaction of diet and number of iron doses. Both performance measures were greater (*P* < .05; *) in copper-fed pigs receiving two versus one dose of iron.

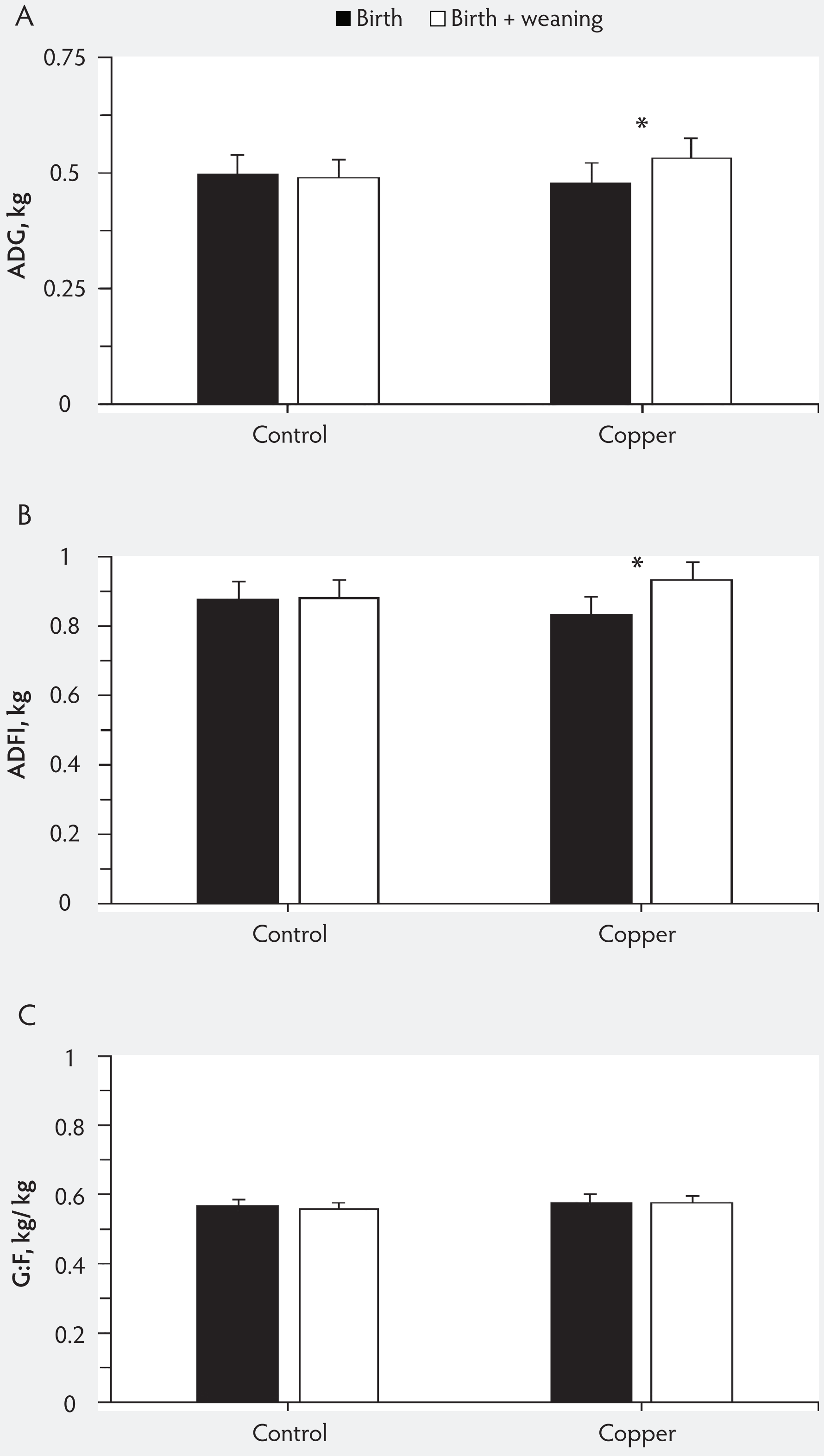

Table 3: Body weights and growth performance of large and small nursery pigs injected once or twice with iron dextran (100 mg) and fed control (14.2 ppm copper) or copper (250 ppm) supplemented diets for 49 days

	Pig size				**Iron doses (100 mg)**				**Diet**			
Items:	**Large (n = 24)**	**Small (n = 24)**	**SE**	***P*[§]**	**Birth (n = 24)**	**Birth + Weaning (n = 24)**	**SE**	***P*[§]**	**Control (n = 24)**	**Copper (n = 24)**	**SE**	***P*[§]**
Body weights, kg												
Day 0	8.72	5.97	0.40	< .001	7.35	7.34	0.40	.99	7.36	7.32	0.40	.82
Day 7	9.11	6.37	0.38	< .001	7.66	7.82	0.38	.48	7.68	7.80	0.38	.57
Day 21	14.05	9.90	0.56	< .001	11.29	12.66	0.56	.001	12.09	11.86	0.56	.64
Day 49[*][†]	35.20	27.62	1.33	< .001	30.26	32.56	1.33	.02	31.83	30.99	1.33	.38
Day 0 to 7												
ADG, kg/d[‡]	0.06	0.07	0.01	.50	0.05	0.07	0.01	.05	0.05	0.08	0.01	.004
ADFI, kg/d	0.24	0.23	0.01	.18	0.24	0.24	0.01	.96	0.22	0.25	0.01	.006
G:F[‡]	0.22	0.28	0.04	.18	0.21	0.29	0.04	.06	0.20	0.30	0.04	.02
Day 8 to 21												
ADG, kg/d[‡]	0.37	0.28	0.02	< .001	0.29	0.35	0.02	.01	0.31	0.33	0.02	.18
ADFI, kg/d	0.58	0.52	0.03	.02	0.52	0.58	0.02	.03	0.54	0.56	0.02	.40
G:F[‡]	0.64	0.55	0.07	< .001	0.58	0.61	0.07	.24	0.58	0.61	0.07	.13
Day 22 to 49												
ADG, kg/d	0.75	0.66	0.02	< .001	0.70	0.71	0.02	.50	0.71	0.70	0.02	.97
ADFI, kg/d[‡]	1.31	1.12	0.03	< .001	1.19	1.25	0.03	.04	1.22	1.21	0.03	.64
G:F	0.58	0.59	0.01	.41	0.59	0.57	0.01	.10	0.58	0.59	0.01	.45
Day 0 to 49												
ADG, kg/d[‡]	0.54	0.46	0.02	< .001	0.49	0.51	0.02	.07	0.49	0.50	0.02	.35
ADFI, kg/d[‡]	0.94	0.82	0.02	< .001	0.85	0.90	0.02	.03	0.88	0.88	0.02	.87
G:F	0.57	0.56	0.02	.34	0.57	0.57	0.02	.55	0.56	0.58	0.02	.09

[*] Affected (*P* = .05) by interaction between size of pig and number of iron treatments.

[†] Affected (*P* = .04) by interaction of number of iron treatments and diet.

[‡] Affected by interaction of number of iron treatments and diet (Day 0 to 7, *P* = .04 for ADG and *P* = .05 for G:F; Day 8 to 21, *P* = .009 for ADG and *P* = .01 for G:F; Day 22 to 49, *P* = .03 for ADFI; and Day 0 to 49, *P* = .02 for ADG and *P* = .04 for ADFI).

[§] Data were subjected to ANOVA.

ADG = average daily gain; ADFI = average daily feed intake; G:F = gain to feed ratio.

CONVERSION TABLES

Weights and measures conversions

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

Temperature equivalents (approx)

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

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

Conversion chart, kg to lb (approx)

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

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

Comparison of heat lamps and heat mats in the farrowing house: effect on piglet production, energy use, and piglet and sow behavior through live observation

Karli J. Lane, MS; Anna K. Johnson, PhD; Carson E. J. Stilwill, BS; Locke A. Karriker, DVM; Jay D. Harmon, PhD; Kenneth J. Stalder, PhD

Summary

Objectives: To determine the effect of heat lamps versus heat mats on piglet performance measures, sow lying behavior, piglet behavior, and energy use.

Materials and methods: Seventeen multiparous crossbred sows housed in farrowing stalls were randomly assigned to one of two heat source treatments: Baby Pig Heat Mat - Single 48 (MAT; n = 8) or Poly Heat Lamp Fixture (LAMP; n = 9). Piglets were weighed on day 1 and at weaning and any mortalities were recorded to evaluate piglet production measures. For 7 days over the course of lactation (day 1, 2, 3, 4, 5, week before weaning, and day before weaning), sows and their litters were observed for 2 hours twice daily to evaluate behavior. Electric meters were attached to individual heat source units to monitor energy use.

Results: Piglet production parameters were unaffected by treatment type; litter weaning weight ($P = .85$), litter average daily gain ($P = .79$), and preweaning mortality ($P = .58$). Piglet behavior had variation in the number of piglets using a heat source within day across treatments ($P < .001$). The number of piglets in contact with the sow decreased during early lactation for both treatment types and increased during late lactation with more MAT pigs tending to be in contact with the sow ($P < .001$).

Implications: Using heat mats as supplemental heat in the farrowing house may result in decreased energy use and increased savings without hindering piglet production parameters.

Keywords: swine, farrowing, preweaning mortality, heat sources, energy use

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Resumen - Comparación entre lámparas de calor y tapetes térmicos en la maternidad: efecto sobre la producción del lechón, el uso de energía y el comportamiento de los lechones y cerdas a través de la observación en vivo

Objetivos: Determinar el efecto de las lámparas de calor versus los tapetes térmicos sobre las medidas de desarrollo del lechón, el comportamiento de las cerdas al estar acostadas, el comportamiento del lechón y el uso de energía.

Materiales y métodos: Diecisiete cerdas híbridas multíparas alojadas en jaulas de maternidad se asignaron aleatoriamente a uno de dos tratamientos de fuente de calor: Baby Pig Heat Mat - Single 48 (MAT; n = 8) o Poly Heat Lamp Fixture (LAMP; n = 9). Los lechones se pesaron el día 1 y al destete y se registraron las muertes para evaluar las medidas de producción de los lechones. Durante 7 días en el curso de la lactancia (día 1, 2, 3, 4, 5, una semana antes del destete, y el día antes del destete), se observó a las cerdas y a sus camadas durante 2 horas dos veces al día para evaluar el comportamiento. Para registrar el uso de energía se conectaron medidores eléctricos a las unidades de fuente de calor individuales.

Resultados: Los parámetros de producción de los lechones no se vieron afectados por el tipo de tratamiento; peso al destete de la camada ($P = .85$), ganancia diaria promedio de la camada ($P = .79$), y mortalidad antes del destete ($P = .58$). El comportamiento de los lechones entre días tuvo una variación en el número de lechones que usaron una fuente de calor por tratamiento ($P < .001$). En ambos tratamientos el número de lechones en contacto con la cerda disminuyó durante la lactancia temprana y aumentó durante la lactancia tardía con un mayor número de cerdos MAT tendiendo a estar en contacto con la cerda ($P < .001$).

Implicaciones: El uso de tapetes térmicos como fuente de calor suplementario en la maternidad puede dar como resultado un

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menor uso de energía y un mayor ahorro sin afectar los parámetros productivos de los lechones.

Résumé - Comparaison entre lampes chauffantes et tapis chauffants dans la maternité: effets sur les performances de production des porcelets, l'utilisation d'énergie et le comportement des porcelets et des truies par observation visuelle

Objectifs: Déterminer les effets de lampes chauffantes versus des tapis chauffants sur les données de performance des porcelets, le comportement de décubitus des truies, le comportement des porcelets et la consommation d'énergie.

Matériels et méthodes: Dix-sept truies croisées multipares logées dans des cages de maternité furent assignées de manière aléatoire à une des deux sources de chaleur : matelas chauffant (Baby Pig Heat Mat – Single 48 (MAT; n = 8) ou lampe chauffante (Poly Heat Lamp Fixture (LAMP; n = 9). Les porcelets furent pesés au jour 1 et au sevrage, et les mortalités furent notées pour évaluer les données de production des porcelets. Pendant 7 jours durant la lactation (jour 1, 2, 3, 4, 5, semaine avant le sevrage, et jour précédent le sevrage), les truies et leurs portées furent observées pendant 2 h deux fois par jour afin d'évaluer les comportements. Des compteurs électriques étaient reliés à chaque unité de source de chaleur pour vérifier la consommation d'énergie.

Résultats: Les paramètres de production des porcelets n'étaient pas affectés par le type de traitement; poids de la portée au sevrage ($P = .85$), gain quotidien moyen de la portée ($P = .79$), et mortalité pré-sevrage ($P = .58$). Le comportement des porcelets présentait des variations dans le nombre de porcelets utilisant une source de chaleur à l'intérieur d'une journée entre les traitements ($P < .001$). Le nombre de porcelets en contact avec la truie diminua durant le début de la lactation pour les deux types de traitement et augmenta durant la phase avancée de la lactation avec plus de porcelets du groupe MAT ayant tendance à être en contact avec la truie ($P < .001$).

Implications: L'utilisation de tapis chauffants comme source de chaleur supplémentaire dans la maternité pourrait résulter en une utilisation moindre d'énergie et augmente les épargnes sans affecter les paramètres de production des porcelets.

Preweaning mortality continues to be a cause for concern in the US swine industry. Current preweaning mortality estimates[1] from US commercial swine operations have been relatively stable at 17.5% between 2015 to 2017. At a 20% preweaning mortality level, it has been estimated to cost the US pork industry $650 to $800 million annually.[2] The majority of these losses occur during the perinatal period (during farrowing and the first 3 days after birth) and can account for up to 50% of total preweaning mortality.[3] Preweaning mortality has been described as multifactorial and include low birth weight, lack of sufficient energy stores, poor body temperature regulation, or strong competition between littermates for colostrum and milk.[4,5]

Within the farrowing environment, the sow and her piglets are at two very different life stages and have different requirements regarding their thermal, social, and physical production system environments. For example, ambient temperature requirements for the lactating sow range from 15°C to 26°C, but a higher temperature of 34°C is preferred by individual newborn piglets.[6,7] At birth, piglets are poorly equipped to deal with the environment they experience outside of the sow. They are especially susceptible to cold stress at birth because they lack a coat of hair, have a large surface area to body weight ratio, lack suitable energy reserves, and have poor body thermostability.[8,9] When the environmental temperature falls below 34°C the newborn piglet is subjected to cold stress and will begin to mobilize its glycogen reserves from the liver and skeletal muscles. The newborn piglet increases heat production by consuming nutrient dense colostrum produced by the sow during the first few hours of lactation.[10] Under cold stress, the piglet undergoes reduced locomotive vigor resulting from weakness through starvation leading to decreased capabilities to avoid movements exhibited by the sow.[11,12] During lactation, littermates huddle to increase their thermal insulation and conduction.[13,14] In conventional indoor confinement systems, caretakers can provide piglets with supplemental heat sources (eg, lamps and mats) in an attempt to keep the piglets warm and away from their mother to reduce preweaning mortality.

Previous work by Stinn and Xin[15] compared a heat mat to a heat lamp on piglet mortality, rate of gain, and electric power use. The authors concluded that there was no difference in rate of gain or mortality, but mats used 36% less power compared to heat lamps. In agreement with this study, MacDonald and colleagues[16] found that heat mats can have a 50% cost savings without detrimentally affecting piglet weaning weight or average daily weight gain. Finally, Hrupka and colleagues[17] reported that heat lamp location within a farrowing stall did not affect preweaning mortality but did conclude that fewer piglets were within 8 cm of the sow and more were located in the area of the heat source. However, technology advancements in heat mats and heat lamps have occurred since these previous studies were published. Additionally, there are no publications to the authors' knowledge in the scientific literature that examines the combination of heat source, piglet behavior, and the economics of various sources used to provide supplemental heat to piglets during lactation. Therefore, the objectives of this work were to 1) evaluate piglet performance and preweaning mortality when piglets are supplied with two different heat source treatments, 2) evaluate sow lying behavior and piglet location behavior in regard to heat source and proximity to the sow, and 3) evaluate the energy efficiency of two different heat sources.

Materials and methods

The research protocol was approved by the Iowa State University Institutional Animal Care and Use Committee (IACUC-18-256). Sows were allotted a minimum of a 72-hour acclimation period prior to farrowing.

Animals, location, and housing

A total of 17 sow and litter units housed at the Iowa State University Allen E. Christian Swine Teaching Farm in farrowing stalls during 2 farrowing groups (October to November 2018 and November to December 2018) were used in this study. The farrowing stalls used in this study had interlocking plastic flooring and a creep area on both sides of the sow. The total stall area measured 2.0 × 1.7 m^2. The center sow area measured 2.0 × 0.6 m^2 with two creep areas measuring 2.0 × 0.55 m^2 on either side. Solid flooring, 1.2 × 0.4 m^2, on one side of the piglet creep area was where the heat source was provided. The stalls were distributed across 2 farrowing rooms (7 stalls per room) located in a negative-pressure, mechanically ventilated barn set at 21.1°C. Each stall contained a sow and her litter with no cross fostering, and the stall was the experimental unit. Multiparous crossbred sows (parity 1 = 5; 2 = 3; 3 = 4; 4 = 1; and ≥ 7 = 4) were randomly assigned to a treatment prior to entering the farrowing room. Sows were provided ad libitum access to water via one nipple and were hand fed once daily prior to farrowing. Post farrowing, sows were hand fed to appetite 3 times daily in 0.9 kg increments. All diets were prepared by a commercial feed mill (Key Cooperative) composed of primarily corn, soybean meal, dried distillers grains, and nutrients formulated according to NRC (2012) guidelines to meet or exceed gestating and lactating sow nutrient requirements. The diet contained 19.6% crude protein, 32 Mcal metabolizable energy/kg, and 1.17% total lysine.

Treatments

Two treatments were compared: Baby Pig Heat Mat - Single 48 (MAT; Kane Manufacturing; 85 W; 34.29 × 121.92 cm^2; polyethylene; n = 8; Figure 1) and Poly Heat Lamp Fixture (LAMP; Hog Slat; n = 9; 125 W; 25.4 × 30.48 cm^2; polypropylene; Figure 2). The heat lamp thermal zone used for piglet observation was an area covering 40 × 121 cm^2.

Both heat sources were set at 32.2°C. The LAMP was controlled via a single step mechanical thermostat for a maximum temperature and height was adjusted to match the temperature regimen of MAT, which was controlled via Thermostat Programmable 1 Zone (Kane Manufacturing). Heat source temperatures were confirmed with an infrared temperature gun (Tool House Digital Infrared Thermometer; model 770343S; Alltrade Tools, LLC; accuracy: 2°C). Sows and their piglets were blocked by parity and assigned to one of the heat source treatments throughout lactation. Mean piglet weaning age was 21 days.

Production measures

Piglets were counted and weighed at processing and weaning. Piglets were administered 1 mL of Iron Hydrogenated Dextran (VetOne) and 0.5 mL of Excede (Zoetis) following manufacturer and veterinary guidelines used when developing farm standard operating procedures. Number born alive was recorded for each litter. Preweaning mortality was defined as a loss incurred post farrowing and prior to weaning, calculated as percent mortality = (the number of pigs weaned/number of pigs born alive) × 100. Piglets were weighed individually on day 1 and at weaning using a digital scale (Mettler PM30-K; Mettler Toledo; accuracy: 0.5 g). All piglet deaths were recorded and included day, sex, and weight.

Behavioral evaluation

Sows and their litters were observed by a single trained observer at 2 time segments over a 24-hour period on days 1, 2, 3, 4, 5, week before weaning (DW), and day before weaning (DD) using a live observation methodology. Each time segment consisted of 2 consecutive hours (09:00 to 11:00 and 21:00 to 23:00) and observations were collected every 15 minutes. Observer training took place prior to the first farrowing until the undergraduate student observer had > 95% agreement with the graduate student who developed the ethogram according to the study objectives and trained the observer. An ethogram was created that included 5 mutually exclusive sow postures, 2 piglet locations, and piglet contact with the sow (Table 1).

Electrical use

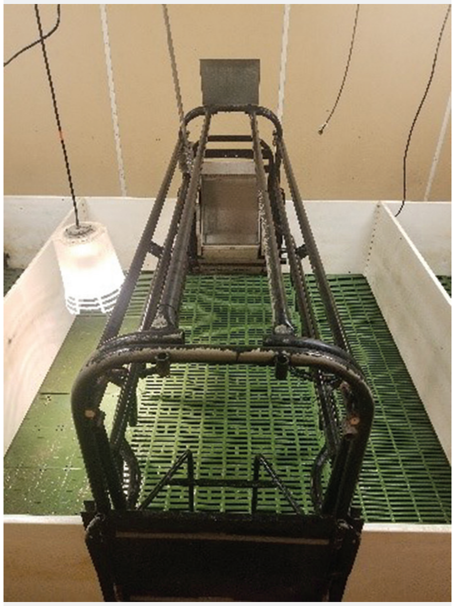
Kill-A-Watt EZ Meter P4460 (P3 International Corporation; accuracy: 0.02%) were connected to the allotted heat source for the entire lactation duration to measure energy use by each experimental unit. Electric meter readings were monitored and recorded twice weekly by farm staff. Final energy use readings were recorded at weaning.

Statistical analysis

All data were evaluated using mixed model methodology (Proc Mixed; SAS version 9.4; SAS Institute Inc). Sources of model variation were considered significant at $P < .05$. When fixed effect model variation was significant, least squares means for each level within the fixed effect source were separated using the pdiff option within the Proc Mixed procedure. Fixed effects in the model included group, parity, location of heat source, and treatment. Production data were analyzed using a generalized mixed model (Proc Glimmix; SAS version 9.3; SAS Institute Inc). A random effect for the interaction between room and stall was included in the model. Behavioral data were analyzed using a generalized mixed model with i-link distribution (Proc Glimmix). Fixed effects in the model included day, treatment, and time. Random effects were room and stall.

Figure 1: Farrowing stall with heat mat. The Baby Pig Heat Mat – Single 48 (Kane Manufacturing) dimensions were 34.29 × 121.92 cm^2.

Figure 2: Farrowing stall with Poly Heat Lamp Fixture (Hogslat) and 125 W heat bulb.



Results

Production

No litter weaning weight ($P = .85$) or litter average daily gain ($P = .79$) differences were observed when comparing piglets provided heat lamps and piglets provided heat mats in the study (Table 2). No treatment differences were observed in preweaning mortality ($P = .58$). Sixty percent of mortalities occurred within the first 24 hours post farrowing.

Behavior

The number of piglets using either a heat lamp or heat mat differed within a treatment day, with lamp being used by more piglets on day 1, 3, 4, DW, and DD (Figure 3; $P < .001$). The number of piglets using the heat lamp treatment across days of lactation decreased after day 4 (Figure 4; $P < .001$). Similarly, the number of piglets using the heat mat treatment over days of lactation decreased at DW until the end of lactation (Figure 5; $P < .001$).

The number of piglets in physical contact with their dam by treatment within lactation day differed, with MAT piglets having greater physical contact with their dam on day 3 and 4 (Figure 6; $P < .001$). The number of piglets in physical contact with their dam, within treatment, across days of lactation resulted in greater variation within LAMP treatment (Figure 7; $P < .001$). The number of piglets in physical contact with their dam, within treatment, over days of lactation demonstrated that the piglets' physical contact with their dam remained relatively constant when provided supplemental heat using the MAT treatment (Figure 8; $P < .001$).

Sow lying behavior was not affected by heat source type or location ($\chi^2 = 2.14$, $P = .14$). As a result of sows spending most of the time lying laterally, analysis was focused on these traits. Sow lying preference demonstrated that 7 sows preferred to lay laterally right and 8 sows preferred to lay laterally left. Five sows favored lying with their udder toward the heat source and 10 favored lying with their udder away from the heat source. There were 2 sows that showed no preference for lying position and therefore udder direction to the heat source.

Energy

The mean (SD) energy consumption for the heat mat treatment (19.4 [2.99] kWh) was less than the energy use for the heat lamp treatment (68.5 [1.97] kWh) with a difference of 49.1 kWh/litter ($P < .001$). Initial heat lamp and heat mat costs vary, with heat lamps requiring less initial investment, but has a greater cost associated with energy use (Table 3). Using an average cost of $0.12/kWh in the Midwest,[2] the average 49.05 kWh energy savings can be translated into an average energy cost savings of $5.89/litter (49.1 kWh × $0.12/kWh = $5.89).

Discussion

Challenges continue to exist in the farrowing house for the caretaker to supply a suitable environment for the sow and her piglets immediately after parturition and through the lactation period.[8] Consistent results across studies indicate that preweaning mortality will remain relatively constant regardless of supplemental heat source (ie, heat lamps or heat mats) used.[15,17] The current study supports the production parameter findings from previous studies, with no supplemental heat source effects on weaning weight, daily gain, or preweaning mortality further indicating that heat source type should be a management decision regarding what works best within a particular system. In agreement

Table 1: Sow and piglet behaviors measured during lactation to compare heat lamps and heat mats as supplemental heat sources for piglets

Measure*	Definition
Definition	
Mat	75% or more of the piglet is touching the heat mat
Lamp	75% or more of the piglet is under the heat lamp
Other	Anywhere in the stall not associated with the heat source
Piglet contact with dam	
Touch	Any part of the piglet is touching the sow
Not	No part of the piglet is touching the sow
Sow posture	
Lateral lie left	Pig lying on left side
Lateral lie right	Pig lying on right side
Sternal lie	Pig lying on sternum
Standing	All four feet on flooring
Sitting	Hindquarter on floor, front feet on flooring

* Measures were observed through live observation by a single observer using a 15-minute scan sample between 09:00 and 11:00 and 21:00 and 23:00 on days 1 through 5, week before weaning, and day before weaning.

Table 2: Least squares means (SE) of production traits when comparing heat lamps and heat mats as supplemental heat sources for piglets during lactation*

Treatment	Litter wean weight†, kg	Litter average daily gain‡, kg/day	Mortality§, %
Lamp	44.5 (8.50)	1.5 (0.29)	15.3 (2.52)
Mat	47.0 (8.86)	1.6 (0.30)	12.3 (3.32)

* No differences in production traits observed ($P \geq .58$).
† Piglets were weighed individually then summed together for litter weaning weight.
‡ Litter average daily gain = (litter wean weight – litter birth weight) / days of lactation.
§ Percent mortality = (total mortalities / total number born alive) × 100.

Figure 3: Number (SE) of piglets using the heat source within lactation day ($P < .001$). Differing superscript letters within a lactation day indicate treatments were significantly different ($P < .05$). DW = week before weaning; DD = day before weaning.

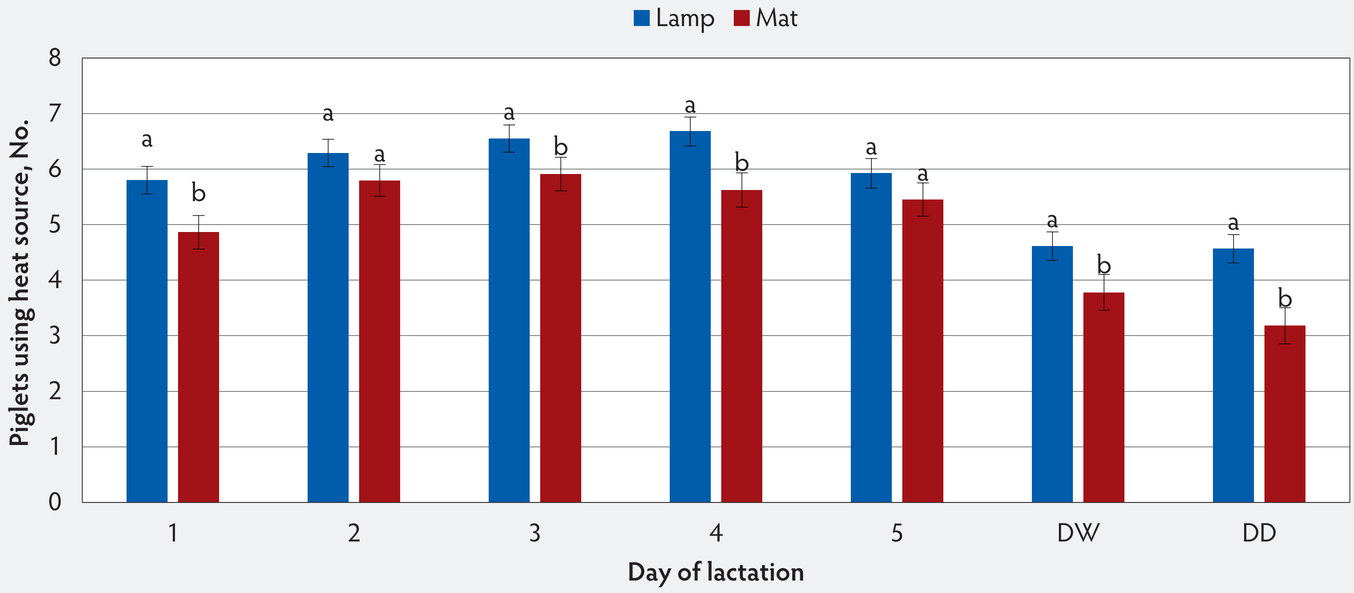
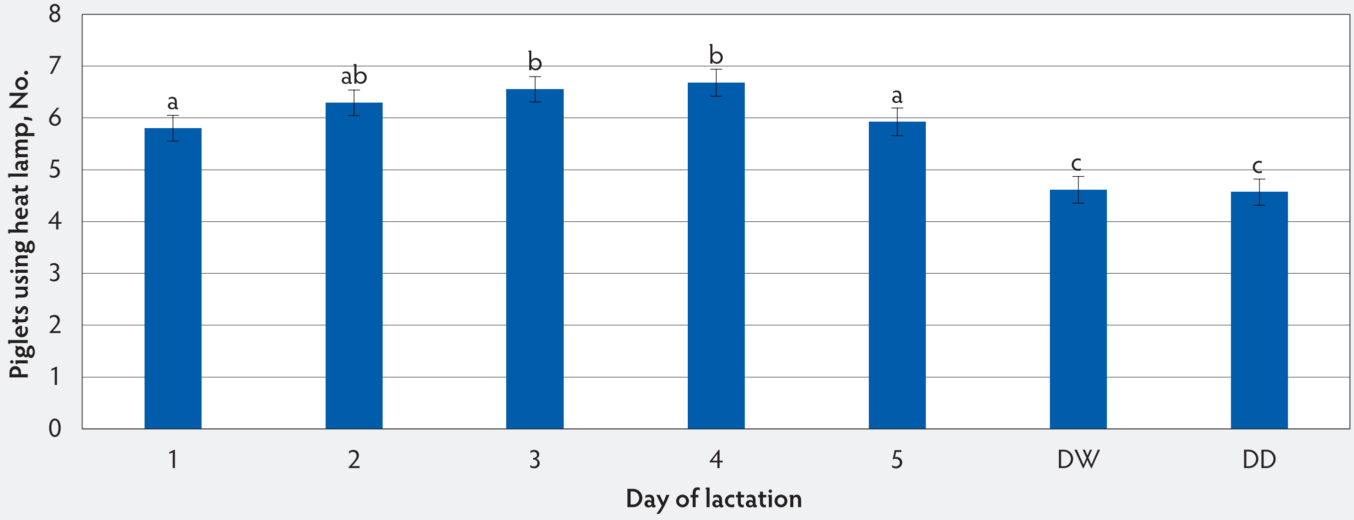


Figure 4: Number (SE) of piglets using the heat lamp by lactation day within treatment ($P < .001$). Differing superscript letters indicate a significant difference between lactation day within treatment ($P < .05$). DW = week before weaning; DD = day before weaning.



with previous studies, the majority of preweaning mortality occurred within the first 24 hours post farrowing.[18]

During the first 24 hours, when mortality rates were the greatest, behavior findings showed a greater number of piglets spending time in contact with their dam across treatments. Other studies have reported that the day-old piglets spend 60% to 75% of their time nursing or lying near their dam regardless of supplemental heat source position.[19] In the current study, heat source type did not affect this behavior. Several biological factors could provide an explanation for this piglet behavior difference. The sow provides nutrition for the piglet, which is critical for the piglet to produce heat so that it can maintain its thermodynamics. Additionally, milk let-down initially is constant, therefore piglet nursing bouts and teat fidelity have not been established until later in lactation. Other factors that may contribute to the piglets' preference to lie next to or near the sow include odors and sounds the sow makes that might be comforting to piglets. However, further research is needed to identify factors truly associated with the piglets' desire to lie next to or very near their dam. Regardless of motivation, the area around the sow remains dangerous to piglets with crushing being an imminent threat as the number one reason for piglet mortality continues to be crushing or laid on by the sow.[12] After the initial 24 hours post farrowing, supplemental heat source use by piglets increased across

Figure 5: Number (SE) of piglets using the heat mat by lactation day within treatment ($P < .001$). Differing superscript letters indicate a significant difference between lactation day within treatment ($P < .05$). DW = week before weaning; DD = day before weaning.

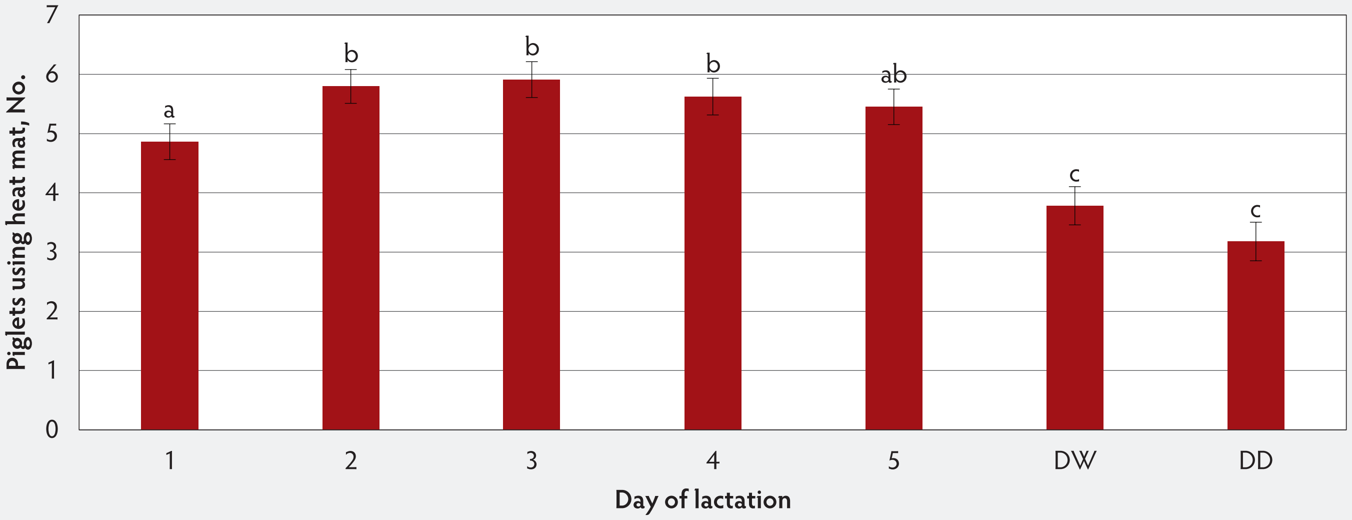
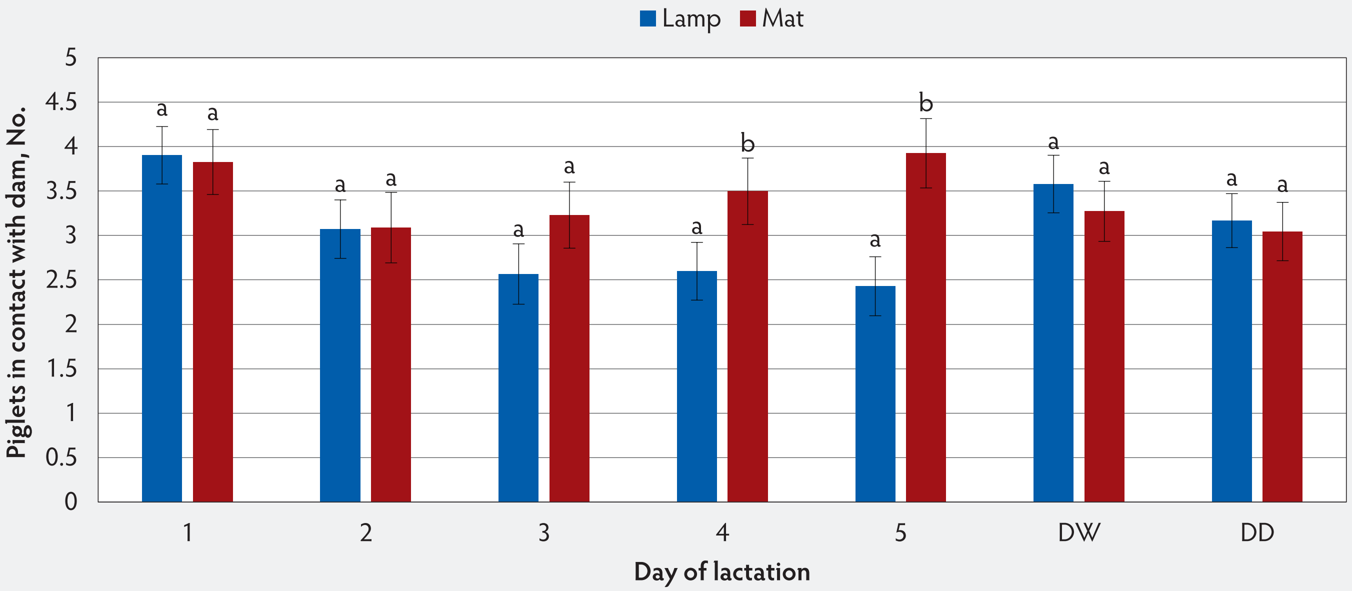


Figure 6: Number (SE) of piglets in physical contact with the dam across treatments by lactation day ($P < .001$). Differing superscript letters within a lactation day indicate treatments were significantly different ($P < .05$). DW = week before weaning; DD = day before weaning.



treatments, likely as a result of better thermodynamics and nursing bouts being initiated. Sow posture was unaffected by supplemental heat source location, decreasing heat stress concern from the supplemental heat provided for piglets. Additional research work is needed to examine other supplemental heat source options and piglet preference or motivation for each heat source.

However, consideration should be placed on the energy savings when utilizing heat mats. Under the circumstances in the current study, energy savings can be achieved by controlling heat mats with a controller as compared to varying heat lamp height. Heat mats can result in a savings of \$18.30/farrowing stall or a total of \$5856 return on investment (ROI) in year 1, a 21.2% ROI (initial year savings = [initial cost of heat lamp + heat mat energy costs] – [initial cost of lamp + bulb replacement + heat lamps energy costs]). In subsequent years that do not require heat source replacement, a savings of \$89.87/stall or \$28,758.40 total ROI, or 104.5%, can be acquired (total savings with mat = energy cost of mat – energy cost of lamp). Given the energy savings of the heat mat, a payback period of 11.7 months can be achieved. As

Figure 7: Number (SE) of piglets in physical contact with the dam within the heat lamp treatment by lactation day ($P < .001$). Differing superscript letters indicate a significant difference between lactation day within treatment ($P < .05$). DW = week before weaning; DD = day before weaning.

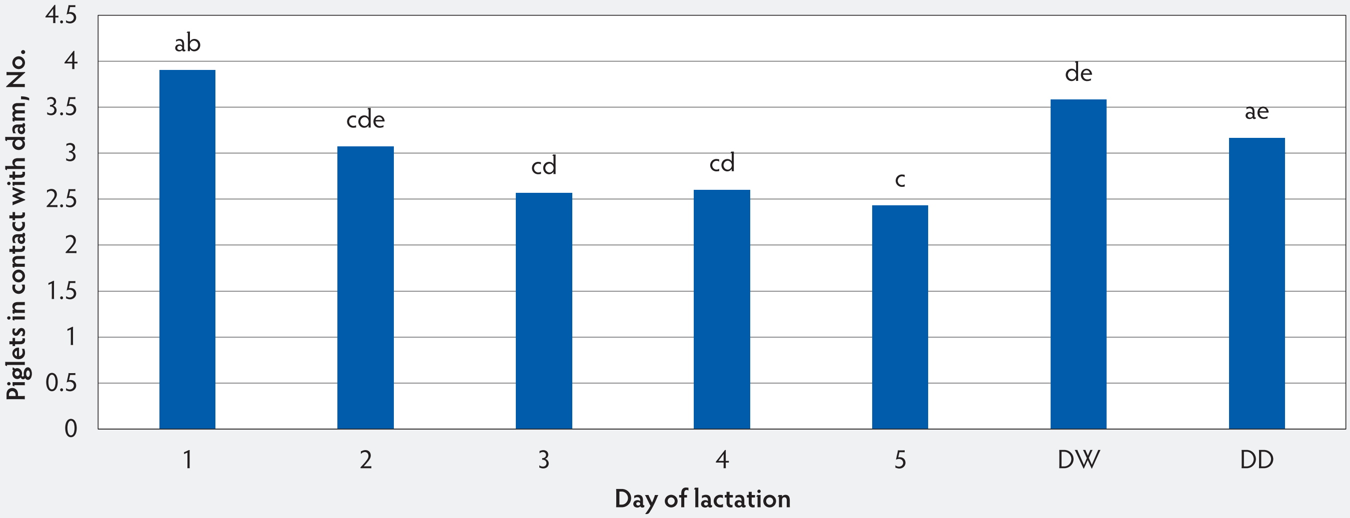
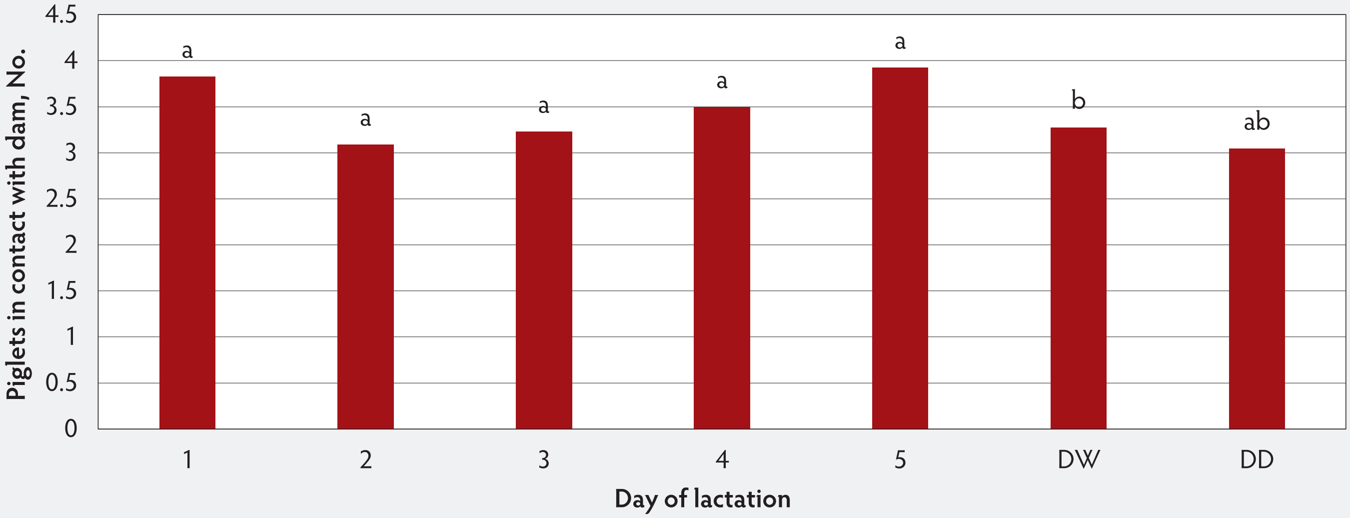


Figure 8: Number (SE) of piglets in physical contact with the dam within the heat mat treatment by lactation day ($P < .001$). Differing letters indicate a significant difference between lactation day within treatment ($P < .05$). DW = week before weaning; DD = day before weaning.



stewards of the land and the environment, according to the Pork Quality Assurance Plus Good Production Practices, additional value can be found in minimizing the carbon footprint of swine production.[20]

Implications

Under the conditions of this study:

- Choice of mats or lamps can be based on factors other than pig performance.
- Energy savings can be achieved by using heat mats with a controller.

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This project was funded in part by Kane Manufacturing. Support from the Department of Animal Science, College of Agriculture and Life Sciences at Iowa State University, and the US Department of Agriculture. A special thanks to the farm staff at the Allen E. Christian Iowa State University Swine Teaching Farm for their assistance in completing this project.

Conflict of interest

None reported.

Disclaimer

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Table 3: Initial cost comparison of heat mats managed with a controller on a decreasing temperature regimen compared to heat lamps raised to decrease temperature*

	Heat Mat[†]	Heat Lamp[‡]
Total farrowing house cost, $	27,520.00	4617.60
Cost/farrowing room, $	3440.00	577.20
Cost/farrowing stall	86.00	14.43
Annual replacement cost, $	0.00[§]	1.58[¶]
Energy use/turn, kWh	19.4	68.5
Energy use/y, kWh**	291.3	1027.05
Energy cost/Year[††], $	34.96	123.25
Total cost Year 1[††], $	120.96	139.26
Payback period, mo	11.7	

* The example farm used in this analysis was an 8-room farrowing house that contains 4 rows/room and 10 stalls/row, with a total of 40 stalls/room and 320 total farrowing stalls in the farrowing house.

[†] Heat mat set up included Baby Pig Heat Mat – Single 48 (Kane Manufacturing) with controller and relays required to achieve energy savings. Costs for this setup provided by Kane Manufacturing.

[‡] Heat lamp set up included one 125 W bulb per Poly Heat Lamp Fixture (Hogslat). Costs for this setup available at www.hogslat.com.

[§] Heat mat replacement rate is every 7 to 10 years.

[¶] Bulbs have a 5000-hour life or 208 days, therefore at least one replacement will be required per year.

** Assuming 15 turns/year (2 days prefarrowing, 21-day lactation, and 1 day for cleaning).

[††] Assuming $0.12/kWh.

the rules and regulations governing research or the practice of veterinary medicine in their country or region.

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Inactivation of porcine epidemic diarrhea virus in contaminated swine feed through inclusion of a dry lactic acid-based product

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Summary

Survivability and infectivity of porcine epidemic diarrhea virus within complete feed was tested in the presence or absence of a dry lactic acid-based feed acidifier product (Guardicate) at levels of 0.75%, 1.0%, or 1.5%. The virus was inactivated, and contaminated feed did not cause infection at all three inclusion rates.

Keywords: swine, diarrhea, virus, lactic acid, feed

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Resumen - Inactivación del virus de la diarrea epidémica porcina en alimento porcino contaminado mediante la inclusión de un producto seco a base de ácido láctico

Se evaluó la capacidad de supervivencia e infectividad del virus de la diarrea epidémica porcina en alimento terminado en presencia o ausencia de un producto acidificante seco a base de ácido láctico (Guardicate) a niveles de 0.75%, 1.0%, o 1.5%. El virus fue inactivado y el alimento contaminado no causó infección en los tres porcentajes de inclusión.

Résumé - Inactivation du virus de la diarrhée épidémique porcine dans de la moulée porcine contaminée par inclusion d’un produit sec à base d’acide lactique

La capacité de survie et le potentiel infectieux du virus de la diarrhée épidémique porcine dans de la moulée complète furent testés en présence ou absence d’un produit acidifiant sec à base d’acide lactique (Guardicate) à des concentrations de 0.75%, 1.0%, ou 1.5%. Le virus fut inactivé, et la moulée contaminée ne causa pas d’infection quel que soit le taux d’inclusion du produit.

Porcine epidemic diarrhea virus (PEDV) is an enveloped, single-stranded, positive-sense RNA virus belonging to the order Nidovirales, the family Coronaviridae, and the genus *Alphacoronavirus*.[1] Following detection in the US swine population during May 2013, the virus spread rapidly across the country.[2] In 2014, contaminated feed was proposed as a possible risk factor for PEDV spread between farms and possibly countries. Initial reports indicated the ability of PEDV to survive in dry feed for 7 days and in wet feed for 28 days when stored at room temperature.[3] Proof of concept that contaminated complete feed could serve as a route of PEDV transmission to naïve pigs was published[4] and the minimum infectious dose in complete feed has been calculated[5] as 5.6×10^1 median tissue culture infectious doses/mL (Cycle threshold [Ct] = 37).

Given concerns regarding the transmission of PEDV via ingestion of contaminated feed, there has been considerable effort to identify commercially available products that can be incorporated into the feed allowing for a disease mitigation effect. The use of chemical feed mitigants such as formaldehyde-based products have been shown to effectively reduce the risk of PEDV survivability and infectivity in contaminated feed.[6,7] However, adoption of commercial formaldehyde-based products by US swine producers has been limited given worker safety concerns and the need for specialized feed mill equipment to administer liquid product. Medium chain fatty acid blends at 1% to 2% of the diet have been shown to enhance RNA degradation of PEDV in swine feed and ingredients and reduce infectivity[7]; however, commercial adoption is limited due to cost. Another potential candidate to mitigate viral risk in feed are the organic acids, possibly through the reduction in pH in the gastrointestinal tract.[8] Therefore, the objective of this study was to determine the impact of a commercial lactic acid (LA)-based

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product (Guardicate; Alltech) on the survival of PEDV in complete feed and whether inoculated, LA-treated feed could prevent PEDV infection in pigs.

Methods

All protocols involving animals were reviewed and approved by the South Dakota State University (SDSU) Institutional Animal Care and Use Committee, study approval No. 15-121A.

Diagnostic procedures

All diagnostic testing, including reverse transcription-polymerase chain reaction (RT-PCR), and virus isolation (VI) was conducted using protocols developed and validated by the SDSU Animal Disease Research and Diagnostic Laboratory.[4] Samples were submitted by code to the laboratory thereby blinding personnel to treatment identity.

Experiment 1: Survivability in feed

Experiment 1 was designed to evaluate the survivability of PEDV in corn and soy-based complete feed treated with a dry LA-based product. A 454-g sample of complete feed was acquired from a commercial swine herd and tested by RT-PCR to document a PEDV RNA-negative status prior to use. The experimental design included three treatments: Feed + 0.75% LA, Feed + 1.0% LA, and Feed + 1.5% LA. Thirty grams of feed was used for each treatment and 2 replicates were assigned per treatment. To promote proper mixing, each feed sample and its designated quantity of LA were combined, inverted 10 times, and vortexed for 2 minutes. Immediately after, the pH of each sample was measured using an Orion Star A100 Series pH meter (Thermo Fisher Scientific).

Following treatment, all complete feed samples were inoculated with 2 mL PEDV (total dose 4×10^5 fluorescent focus units (FFU); Ct = 14.46) and mixed as previously described. This quantity of PEDV was selected in an effort to provide a final mean Ct value in complete feed of approximately 25 (range: 19-30) following mixing, based on data from actual field cases of PEDV-contaminated feed and challenge levels used in published studies.[4,6] In addition, a positive control, a 30-g control sample of feed (PEDV RNA-positive by RT-PCR, no LA), a negative control (PEDV and LA-negative), and a stock virus control (total dose 4×10^5 FFU; Ct = 14.46) were included in the design. Samples were incubated for 24 hours at 20°C and then tested by PEDV RT-PCR and PEDV VI.

Experiment 2: Infectivity

Swine bioassay. The purpose of the swine bioassay was to determine whether viable PEDV was present in any feed ingredient sample that had tested positive for PEDV RNA on RT-PCR but negative for PEDV on VI. This study was conducted in a Biosafety Level 2+ room at the SDSU Animal Resource Wing (ARW).

Facilities and source of animals. Animals (n = 15; 7-day old piglets) were sourced from a PEDV-naïve herd and were tested on arrival to the ARW via blood sampling and collection of rectal swabs from each pig. Prior to animal arrival, all rooms (walls, ceilings, floors, and drains) were monitored for the presence of PEDV RNA by RT-PCR using sampling procedures previously described.[4,6] Five stainless steel gnotobiotic units measuring 0.6m wide x 1.2m long x 0.6m high were used to house the piglets. Units were divided into 3 semi-isolated housing units, allowing for 3 piglets per unit with individual feeding arrangements. Treatment or control groups were housed in one of five units: unit 1 = 0.75% LA treatment, unit 2 = 1.0% LA treatment, unit 3 = 1.5% LA treatment, unit 4 = positive control, and unit 5 = negative control. Flooring consisted of an open weave rubberized mat on a perforated stainless-steel grate raised 10 cm for waste collection. Each unit was covered with an inflatable 20 mil plastic canopy and fitted with 2 pair of dry-box gloves for feeding and procedures inside the canopy. Each canopy was secured and sealed to the unit with duct tape and ratchet straps. Ventilation was supplied by an electric fan maintaining sufficient positive pressure inside the canopy to keep it inflated above the unit. Incoming and outgoing air to each unit was HEPA-filtered. Each unit was initially sterilized using 47% aerosolized formalin, which was allowed to dissipate for 2 weeks prior to introduction of the animals. All incoming and outgoing materials needed during the study (eg, swabs, injectable medication, blood collection supplies) were passed through an airtight stainless-steel port and sterilized using 5% peracetic acid before entering or exiting the port.

Preparation of bioassay inocula. For preparation of the inocula, new (30 g) samples of complete feed and varying amounts of LA (0.75%, 1.0%, or 1.5%) were mixed with 50 mL of sterile phosphate-buffered saline in a 250 mL centrifuge tube, inverted 10 times to mix, and vortexed for 2 minutes. Three inocula were prepared for each of the 3 concentrations of treated feed and 3 were prepared for each control group for a total of 15 inocula, one for each pig in the experiment. Each suspension was centrifuged at 5200*g* for 15 minutes, and the supernatant decanted and tested by RT-PCR prior to piglet inoculation. Each pig in the unit received 1 mL of the designated inoculum orally via syringe and was observed for 7 days. The 3 positive-control piglets were inoculated orally with a designated sample of feed spiked with 2 mL PEDV (total dose 4×10^5 FFU; Ct = 14.46) and the 3 negative-control piglets were inoculated orally with a designated sample of feed spiked with 2 mL sterile saline.

Piglet monitoring and testing. The ARW personnel inspected animals daily for clinical signs of PED. Showers were taken upon entry to the rooms and room-specific coveralls, footwear, hairnets, gloves, and P95 masks (3M) were worn. Rectal swabs (Dacron swabs, Fisher Scientific) were collected from each pig on days 0, 2, 3, 5, and 7 post inoculation (PI). Swabs were tested by RT-PCR for the presence of PEDV RNA. At the end of the 7 days, all pigs were humanely euthanized with intravenous sodium pentobarbital.

Results

Experiment 1: Survivability in feed

Porcine epidemic diarrhea virus RNA was detected by RT-PCR across all feed samples spiked with PEDV (Table 1). The negative-control sample was RT-PCR negative. Both the complete feed positive-control samples and the virus stock controls were VI positive at 24 hours PI. The complete feed negative-control samples and all LA-treated feed samples across all 3 inclusion rates were VI negative at 24 hours PI. Finally, while not analyzed statistically, addition of the LA product appeared to reduce pH of the feed on a numerical basis, as compared to control samples.

Table 1: Summary of survivability diagnostic data 24 hours post PEDV inoculation (experiment 1)

	Ct		FFU		pH	
Treatment	**Replicate 1**	**Replicate 2**	**Replicate 1**	**Replicate 2**	**Replicate 1**	**Replicate 2**
Positive control	19.6	19.6	7680	7680	5.8	5.8
Negative control	38.0	38.0	< 20	< 20	6.7	6.7
Virus stock	14.4	14.4	440,000	440,000	8.1	8.1
LA - 0.75%*	25.8	25.9	< 20	< 20	5.5	5.4
LA - 1.0%†	27.1	28.9	< 20	< 20	5.0	5.1
LA - 1.5%‡	30.6	31.1	< 20	< 20	5.0	4.9

* Samples in each replicate contained Guardicate at a 0.75% level.

† Samples in each replicate contained Guardicate at a 1.0% level.

‡ Samples in each replicate contained Guardicate at a 1.5% level.

PEDV = porcine epidemic diarrhea virus; Ct = cycle threshold; FFU = fluorescent focus units; LA = lactic acid.

Table 2: Summary of PEDV bioassay data (experiment 2)

		Ct values*						
Treatment	**Inoculum pH**	**Inoculum**	**Day 0**	**Day 2**	**Day 3**	**Day 5**	**Day 7**	**Diarrhea†**
Positive control								
Sample 1	5.8	**21.68**	38.0	**34.4**	**28.5**	**23.6**	Not tested	**positive**
Sample 2	5.6	**21.55**	38.0	**32.6**	**29.5**	**25.3**		
Sample 3	5.8	**21.05**	38.0	**34.1**	**30.1**	**29.6**		
Negative control								
Sample 1	6.0	38.0	38.0	38.0	38.0	38.0	38.0	negative
Sample 2	6.0	38.0	38.0	38.0	38.0	38.0	38.0	
Sample 3	5.9	38.0	38.0	38.0	38.0	38.0	38.0	
LA - 0.75%‡								
Sample 1	5.5	**25.31**	38.0	38.0	38.0	38.0	38.0	negative
Sample 2	5.6	**24.83**	38.0	38.0	38.0	38.0	38.0	
Sample 3	5.4	**26.78**	38.0	38.0	38.0	38.0	38.0	
LA - 1.0%§								
Sample 1	5.2	**26.50**	38.0	38.0	38.0	38.0	38.0	negative
Sample 2	5.3	**27.23**	38.0	38.0	38.0	38.0	38.0	
Sample 3	5.1	**26.14**	38.0	38.0	38.0	38.0	38.0	
LA - 1.5%¶								
Sample 1	5.0	**28.60**	38.0	38.0	38.0	38.0	38.0	negative
Sample 2	4.8	**31.14**	38.0	38.0	38.0	38.0	38.0	
Sample 3	4.9	**33.75**	38.0	38.0	38.0	38.0	38.0	

* Ct values from rectal swabs collected from the 3 bioassay pigs in each group on designated days post inoculation. A Ct value of 38 is considered a RT-PCR-negative sample.

† Clinical observations in groups of pigs.

‡ Samples in each replicate contained Guardicate at a 0.75% level.

§ Samples in each replicate contained Guardicate at a 1.0% level.

¶ Samples in each replicate contained Guardicate at a 1.5% level.

PEDV = porcine epidemic diarrhea virus; Ct = cycle threshold; LA = lactic acid.

Experiment 2: Infectivity

All 3 piglets in the positive-control unit displayed evidence of diarrhea and shed PEDV RNA in feces (Table 2). In contrast, all piglets (n = 12) inoculated with LA-treated complete feed samples and the negative-control piglets remained healthy and all rectal swabs were negative by RT-PCR. As before, while not analyzed statistically, addition of the LA product appeared to reduce pH of the feed on a numerical basis, as compared to control samples.

Discussion

Feed contamination with PEDV is a significant concern, when considering the small quantity of virus to cause infection in complete feed. Therefore, given the potential risk of PEDV feed contamination within the feed supply chain, it highlights the importance of having proper biosecurity practices that minimize potential disease transmission events. In this brief communication, we describe the results of a study designed to provide proof of concept data regarding the efficacy of a lactic acid-based feed additive. While the design of the study was purposefully limited to small sample sizes and reduced replications, the results indicate that the product appeared to negatively impact the survivability and infectivity of PEDV. While the study was not designed to ascertain the mechanism of action, these observations may have been due to a reduction of sample pH. Furthermore, it provided potential inclusion rates for how the product may be used, should it gain acceptance in the field. As this is a very small study, more testing is required involving more replications, larger population sizes housed under controlled field conditions, and multiple pathogens, which are currently underway. However, if proven efficacious, this type of product may provide advantages regarding safety and ease of application resulting in a new option to provide a safe and efficacious means to reduce the risk of virus-contaminated feed for the swine industry.

Implications

- Contaminated feed may serve as a vehicle for PEDV transport and transmission.
- For risk mitigation, feed biosecurity changes are needed at the farm and mill.
- An LA-based feed additive may provide a solution pending a large-scale study.

Acknowledgments

The authors would like to recognize Dr Michele Mucciante, Amanda Zubke, and the ARW team for their significant contributions to the success of this study. Funding was provided by the participating companies.

Conflict of interest

All authors and their employers developed the product offering discussed in this manuscript and have an ongoing financial interest in the sale of the product.

Disclaimer

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

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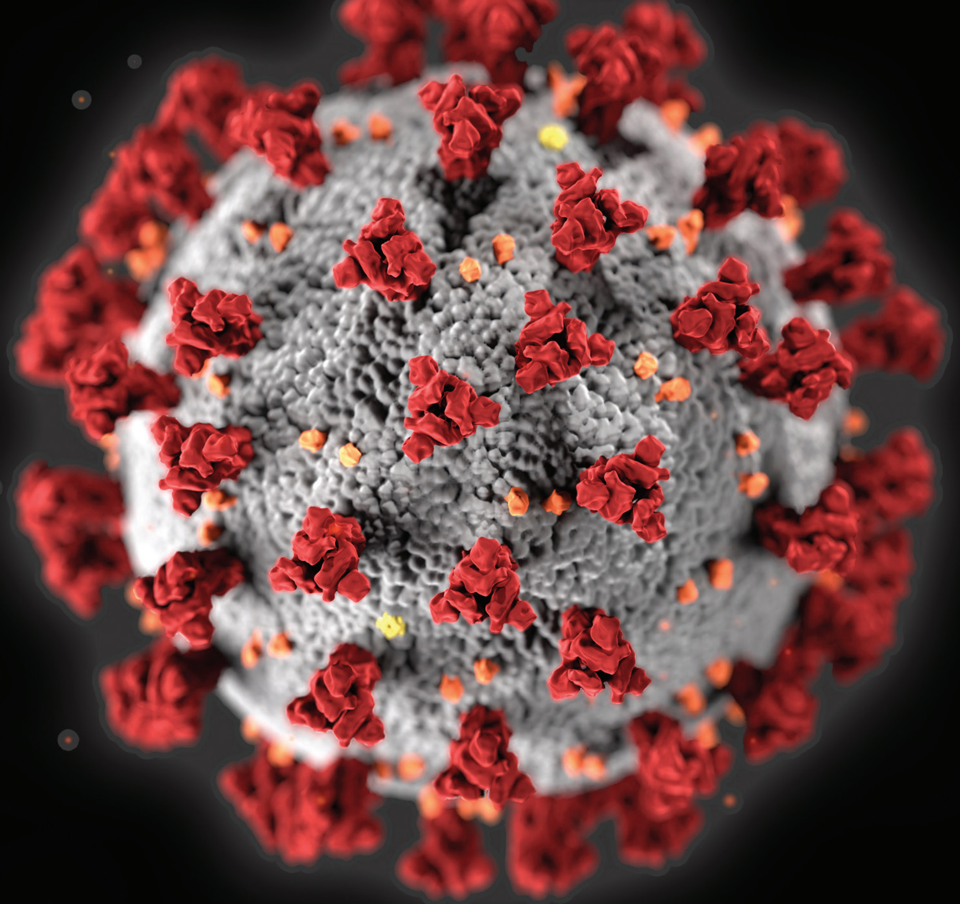

COVID-19

AASV Resources for Swine Veterinarians

aasv.org/resources/publichealth/covid19

Swine veterinarians have an essential role in providing services that protect public health and swine health and welfare.

The COVID-19 pandemic is impacting our practices, communities, clients, and families. The AASV continues to ensure you have the information you need to stay healthy and continue meeting a critical need. Find resources for:

- Veterinary practice, business, legislation, and CE
- Producers
- Crisis planning and animal welfare
- Industry

The AASV is committed to providing members with resources to promote and enhance well-being – the state of being comfortable, healthy, and happy.

Visit AASV's Veterinarian Well-being webpage at
aasv.org/resources/wellbeing

to find resources to assess and improve your own well-being and resources to help support colleagues, clients, friends, and family.

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PHARMACOSMOS

PM-048-00

Be safe: ensure your clients have SMART farms

Coronavirus disease 2019 has created increased interest in hog farms, making site security more critical than ever to protect farms, employees, and animals. While spare time is at a premium these days, taking a few steps to increase farm-level security now may save time and trouble down the road.

Secure – Establish check-in/check-out procedures and engage all workers in enforcement. Maintain basic security, including locks on buildings, proper lighting, alarms, and cameras. Consider hiring or assigning a security detail.

Monitor – Watch for red flags and enlist trusted employees to help keep an eye out for any suspicious activity. Use the web, social media, and industry associations to stay aware of possible threats.

Alert – Build rapport with local, county, and state officials now and proactively share your concerns. Watch for drones or cars parked nearby.

Research – Know your rights as a property and business owner. Carefully vet job applicants while complying with the laws. Even if you urgently need help, time spent on follow-up is worth it. Report all suspicious or illegal activity to the proper authorities.

Take action – Assign someone, or schedule time for yourself, to make daily progress toward increased farm security.

For more information, visit `animalagalliance.com`.

8 Things to Know Before Moving Your Pigs Outdoors

Although a small percentage of US pigs live their lives in outdoor-based pens or pastures, most American farmers raise pigs in modern barns where the animals are protected from the elements and potential predators. However, more producers than ever are thinking about how to successfully move their pigs to outdoor spaces given the recent housing crunch triggered by packing plant closures due to COVID-19 issues.

"It is critical to think through how moving pigs to an outdoor environment will affect them in every possible way," says Dr Chris Hostetler, animal science director for the Pork Checkoff. "It's not as simple as quickly fencing off part of a pasture and calling it good. Even nearly grown pigs will go through some level of shock going from inside to outside if proper steps are not taken to limit downside risks."

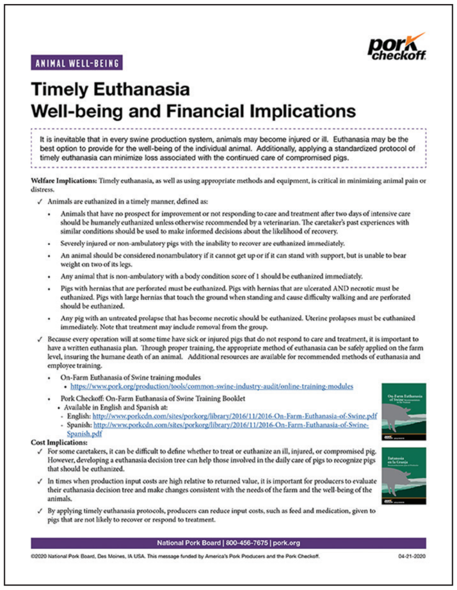
To learn more about tips on moving pigs outside, visit `library.pork.org` and search for "8 things" or contact Dr Chris Hostetler at `chostetler@pork.org` or 515-223-2600.

Checkoff creates Timely Euthanasia fact sheet

For some caretakers, it can be difficult to define whether to treat or euthanize an ill, injured, or compromised pig. However, developing a euthanasia decision tree can help those involved in the daily care of pigs to recognize pigs that should be euthanized. In times when production input costs are high relative to returned value, it is important for producers to evaluate their euthanasia decision tree and make changes consistent with the needs of the farm and the well-being of the animals.

By applying timely euthanasia protocols, producers can reduce input costs, such as feed and medication, given to pigs that are not likely to recover or respond to treatment.

For more information, visit `pork.org` or contact Dr Sara Crawford at `scrawford@pork.org` or 515-223-2600.



ANIMAL WELL-BEING

Timely Euthanasia
Well-being and Financial Implications

It is inevitable that in every swine production system, animals may become injured or ill. Euthanasia may be the best option to provide for the well-being of the individual animal. Additionally, applying a standardized protocol of timely euthanasia can minimize loss associated with the continued care of compromised pigs.

Welfare Implications: Timely euthanasia, as well as using appropriate methods and equipment, is critical in minimizing animal pain or distress.

- ✓ Animals are euthanized in a timely manner, defined as:
  - Animals that have no prospect for improvement or not responding to care and treatment after two days of intensive care should be humanely euthanized unless otherwise recommended by a veterinarian. The caretaker's past experiences with similar conditions should be used to make informed decisions about the likelihood of recovery.
  - Severely injured or non-ambulatory pigs with the inability to recover are euthanized immediately.
  - An animal should be considered nonambulatory if it cannot get up or if it can stand with support, but is unable to bear weight on two of its legs.
  - Any animal that is non-ambulatory with a body condition score of 1 should be euthanized immediately.
  - Pigs with hernias that are perforated must be euthanized. Pigs with hernias that are ulcerated AND necrotic must be euthanized. Pigs with large hernias that touch the ground when standing and cause difficulty walking and are perforated should be euthanized.
  - Any pig with an untreated prolapse that has become necrotic should be euthanized. Uterine prolapses must be euthanized immediately. Note that treatment may include removal from the group.
- ✓ Because every operation will at some time have sick or injured pigs that do not respond to care and treatment, it is important to have a written euthanasia plan. Through proper training, the appropriate method of euthanasia can be safely applied on the farm level, insuring the humane death of an animal. Additional resources are available for recommended methods of euthanasia and employee training.
  - On-Farm Euthanasia of Swine training modules
    - https://www.pork.org/production/tools/common-swine-industry-audit/online-training-modules
  - Pork Checkoff: On-Farm Euthanasia of Swine Training Booklet
    - Available in English and Spanish at:
      - English: http://www.porkcdn.com/sites/porkorg/library/2016/11/2016-On-Farm-Euthanasia-of-Swine.pdf
      - Spanish: http://www.porkcdn.com/sites/porkorg/library/2016/11/2016-On-Farm-Euthanasia-of-Swine-Spanish.pdf

Cost Implications:

- ✓ For some caretakers, it can be difficult to define whether to treat or euthanize an ill, injured, or compromised pig. However, developing a euthanasia decision tree can help those involved in the daily care of pigs to recognize pigs that should be euthanized.
- ✓ In times when production input costs are high relative to returned value, it is important for producers to evaluate their euthanasia decision tree and make changes consistent with the needs of the farm and the well-being of the animals.
- ✓ By applying timely euthanasia protocols, producers can reduce input costs, such as feed and medication, given to pigs that are not likely to recover or respond to treatment.

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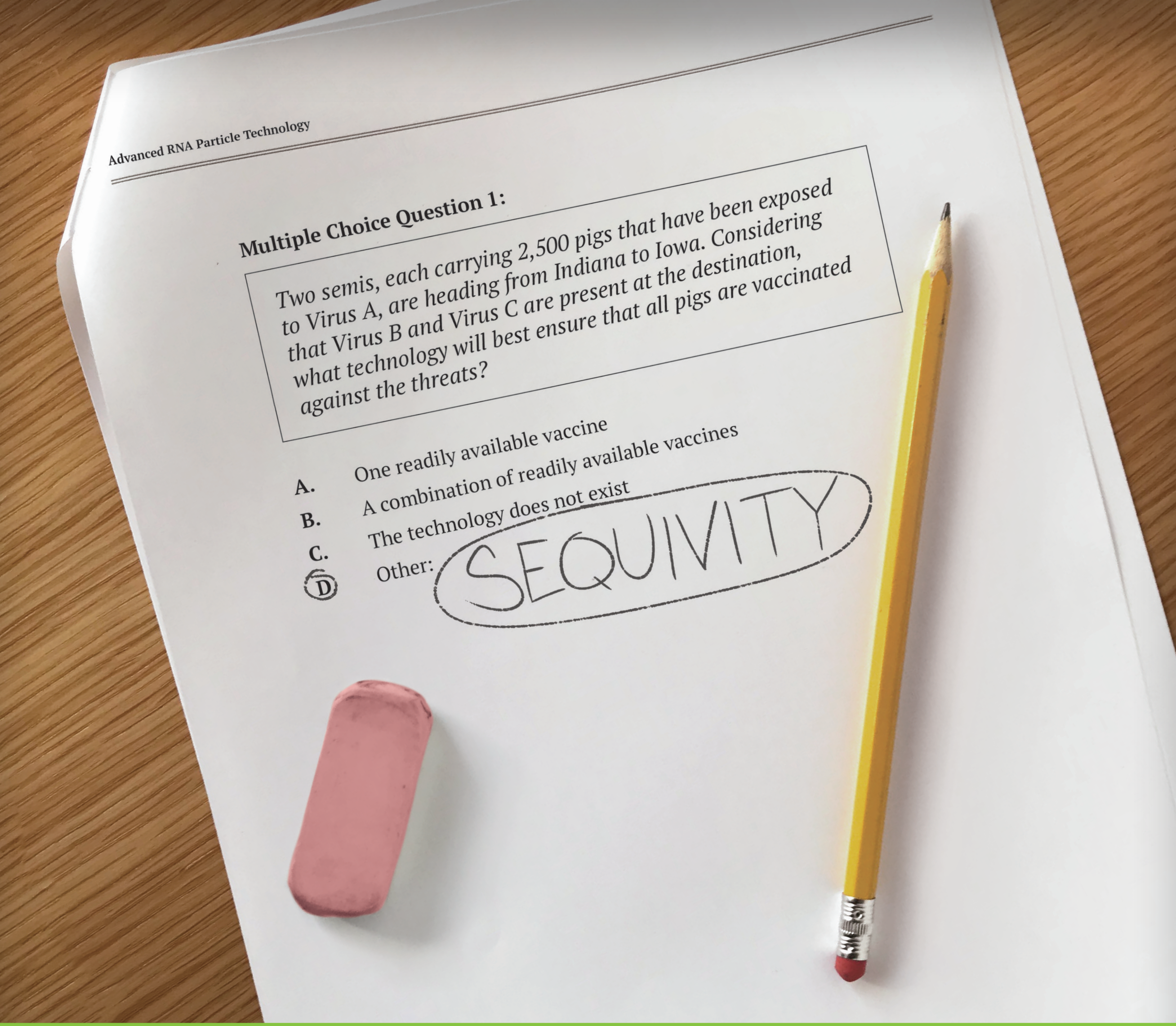

Advanced RNA Particle Technology

Multiple Choice Question 1:

Two semis, each carrying 2,500 pigs that have been exposed to Virus A, are heading from Indiana to Iowa. Considering that Virus B and Virus C are present at the destination, what technology will best ensure that all pigs are vaccinated against the threats?

A. One readily available vaccine
B. A combination of readily available vaccines
C. The technology does not exist
[✓ **D.**] Other: SEQUIVITY

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For veterinarians looking to stay ahead of ever-changing disease challenges, SEQUIVITY is the answer. A revolutionary RNA particle technology, SEQUIVITY is a platform for the creation of herd- and strain-specific vaccines for disease challenges such as PCV2, PCV3, rotavirus, influenza and more.

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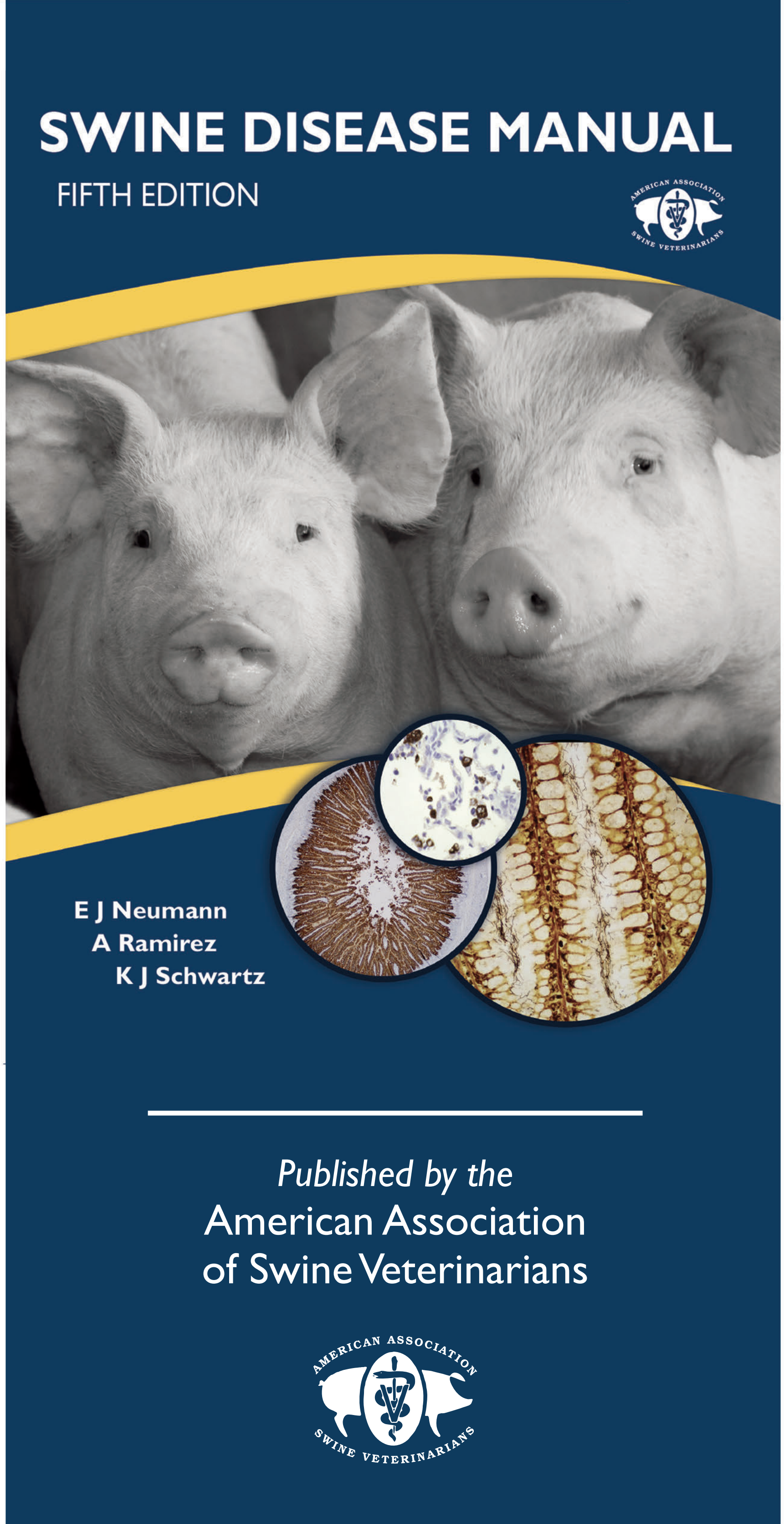

SWINE DISEASE MANUAL

FIFTH EDITION

E J Neumann
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AASV NEWS

Call for abstracts – Student Seminar

The American Association of Swine Veterinarians announces an opportunity for veterinary students to make a scientific presentation at the AASV Annual Meeting in San Francisco, California, on Sunday, February 28, 2021. Interested students are invited to submit a one-page abstract of a research paper, clinical case study, or literature review for consideration. The submitting student must be a current (2020-2021) student member of the AASV at the time of submission and must not have graduated from veterinary school prior to February 28, 2021. Submissions are limited to one (1) abstract per student.

Abstract submission

Abstracts and supporting information must be submitted online at **aasv2021.exordo.com**. Submissions must be completed before **11:59 PM Central Daylight Time on Wednesday, September 16, 2020** (firm deadline). Late submissions will not be considered.

Students will receive an email from Ex Ordo confirming receipt of their submission. If they do not receive this confirmation email, they must contact Dr Andrew Bowman (bowman.214@osu.edu) by Friday, September 18, 2020 with supporting evidence that the submission was made in time; otherwise the abstract will not be considered for judging.

The abstracts will be reviewed by an unbiased, professional panel consisting of private practitioners, academicians, and industry veterinarians. Fifteen abstracts will be selected for oral presentation in the Student Seminar at the AASV Annual Meeting. Students will be notified by October 15, 2020, and those selected to participate will be expected to provide the complete paper or abstract, reformatted for publication, by November 12.

Student Seminar and Scholarships

As sponsor of the Student Seminar, **Zoetis** provides a total of $26,250 in support to fund travel stipends and the top student presenter scholarship. The student presenter of each paper selected for oral presentation receives a $750 stipend to help defray the costs of attending the AASV meeting. Veterinary students whose papers are selected for oral presentation also compete for one of several scholarships awarded through the AASV Foundation. The oral presentations will be judged to determine the amount of the scholarship awarded. Zoetis funds a $5000 scholarship for the student whose paper, oral presentation, and supporting information are judged best overall. **Elanco Animal Health** provides $20,000 in additional funding enabling the AASV Foundation to award scholarships of $2500 each for 2nd through 5th place, $1500 each for 6th through 10th place, and $500 each for 11th through 15th place.

Student Poster Session

Abstracts that are not selected for oral presentation in the Student Seminar will be considered for presentation in a poster session at the annual meeting. **Zoetis**, sponsor of the Student Poster Session, provides a $250 stipend for each student poster presenter who attends the meeting to participate in the session. Those selected for poster presentation will be expected to supply a brief paper, formatted for publication in the conference proceedings, by November 12. The guidelines for preparing posters for the display are available at aasv.org/annmtg/2021/posters.php.

Veterinary Student Poster Competition

The presenters of the top fifteen poster abstracts compete for scholarship awards ranging from $200 to $500 in the Veterinary Student Poster Competition, sponsored by **United Animal Health**. See aasv.org/annmtg/2021/postercomp.htm for poster judging details.

Complete information for preparing and submitting abstracts is available on the AASV website at aasv.org/annmtg/2021/studentseminar.htm. The rules for submission should be followed carefully. For more information, contact the AASV office by phone, 515-465-5255, or email, aasv@aasv.org.

The AASV is moving forward with plans for the 2021 AASV Annual Meeting with the understanding that guidelines associated with COVID-19 may necessitate changes yet to be determined. Please check **aasv.org/annmtg** regularly for updated information and revisions.

AASV news continued on page 225


To prevent disease, we approach protection from every angle.

AASV news continued from page 223

Call for abstracts – Research Topics session

Plans are underway for the 52nd annual meeting of the American Association of Swine Veterinarians (AASV), to take place February 27 - March 2, 2021 in San Francisco, California. As part of the meeting, there will be a session highlighting research projects related to swine health and production. Abstracts are now being accepted for potential presentation during the Research Topics session, which will be held Sunday, February 28.

Those interested in making a 15-minute oral presentation should submit a 1-page abstract on applied research related to swine health and production issues (virology, bacteriology, parasitology, environment, food safety, odor, welfare, etc) to `aasv@aasv.org` by **August 14, 2020.** Include the presenting author's name, mailing address, phone number, and email address with each submission.

Abstracts not selected for oral presentation will be considered for poster presentation. All submitting authors will be notified of selection results in September. Authors of abstracts selected for oral or poster presentation must provide their paper, formatted for publication in the meeting proceedings, by November 12, 2020.

PLEASE NOTE: Participation in the Research Topics oral and poster session is at the presenter's expense. The presenting author is required to register for the meeting (nonmember participants may register at the AASV regular member rate). No speaking stipend or travel expense reimbursement is paid by the AASV.

Call for abstracts – Industrial Partners sessions

The American Association of Swine Veterinarians invites submissions for the Industrial Partners oral and poster sessions at the 52nd AASV Annual Meeting. This is an opportunity for commercial companies to make brief presentations of a technical, educational nature to members of the AASV. The conference will be held February 27 - March 2, 2021 in San Francisco, California.

The oral sessions consist of a series of 15-minute presentations scheduled from 1:00 to 5:00 PM on Sunday afternoon, February 28th. A poster session takes place the same day. Poster authors will be required to be stationed with their poster from noon until 1:00 PM, and the posters will remain on display throughout the afternoon and the following day for viewing.

SUBMISSION PREREQUISITE: All companies submitting topics for presentation during the Industrial Partners sessions must register to participate in the AASV Technical Tables Exhibit before October 1st.

Restricted program space necessitates a limit on the number of presentations per company. Companies that are a member of the *Journal of Swine Health and Production* (JSHAP) Industry Support Council **and** sponsor the AASV e-Letter may submit three topics for oral presentation. Companies that are **either** a member of the JSHAP Industry Support Council **or** sponsor the AASV e-Letter may submit up to two topics. All other companies may submit one topic for oral presentation. In addition, every company may submit one topic for poster presentation, but the topic must not duplicate the oral presentation. All topics must represent information not previously presented at the AASV annual meeting or published in the meeting proceedings.

To participate, send the following information to `aasv@aasv.org` by October 1, 2020:

1. Company name
2. Presentation title
3. Brief description of the presentation content
4. Presenter name and contact details (mailing address, telephone number, and email address)
5. Whether the submission is intended for oral or poster presentation

Receipt of submissions will be confirmed by email. Presenters will be notified of their acceptance by October 15 and must submit a paper by November 12 for publication in the meeting proceedings. Failure to submit the paper in a timely manner will jeopardize the company's future participation in these sessions.

All presenters are required to register for the meeting, either as a Tech Table representative, or as an individual registrant (nonmember oral and poster presenters are eligible to register at the AASV regular member rate). AASV does not provide a speaking stipend or travel reimbursement to Industrial Partners presenters.

The AASV is moving forward with plans for the 2021 AASV Annual Meeting with the understanding that guidelines associated with COVID-19 may necessitate changes yet to be determined. Please check `aasv.org/annmtg` regularly for updated information and revisions.

Chip in … golf for the foundation!

It's time to recruit your golf team to support the AASV Foundation! Registration is now open for the annual AASV Foundation Golf Outing, which is returning to Veenker Memorial Golf Course in Ames, Iowa on **Thursday, August 20**. Last year, 51 golfers enjoyed a picture-perfect day on this well-groomed course. While we cannot promise the same weather again this year, there is plenty of room for additional golfers – so dust off those clubs and register to spend a relaxing day with your colleagues in support of the foundation.

Members of AASV, industry stakeholders, clients, staff, family, and friends are all welcome to register a 4-person team for this fun, 18-hole, best-ball tournament. Individual golfers and couples are also welcome and will be assigned to a team.

Once again, Dr Josh Ellingson is coordinating the event. Golfer check-in begins at 11:00 AM on August 20th, with practice balls available for warming up on the driving range before the contest begins. A noon shotgun start kicks off the competition. Golfers compete as a foursome against the challenges of the course (and the other teams) in addition to participating in individual contests along the way.

Boxed lunches, sponsored by **APC**, and beverages, courtesy of **Zoetis**, will be supplied on-course. Sponsored contests, games, and giveaways will add to the fun. When the golfing is completed, team and individual contest winners will be recognized and receive prizes during the pork dinner sponsored by **Boehringer Ingelheim Animal Health**.

The registration fee includes 18 holes of best-ball golf, cart, lunch, beverages, awards dinner, and prizes. Funds raised by the event support AASV Foundation programs, including research grants, travel stipends for students attending the AASV annual meeting, swine externship grants, scholarships for veterinarians pursuing board certification in the American College of Animal Welfare, student debt relief scholarships, tuition grants at the Swine Medicine Education Center, and more.

For a sneak peek at the golf course, visit `www.veenkergolf.com`. For more information or to register, contact AASV by phone, 515-465-5255, or email, `aasv@aasv.org`.

AASV Foundation
Golf Outing

Join us Thursday,
August 20, 2020
11am – 6pm

REGISTRATION FORM

☐ **INDIVIDUAL registration - $125.00**
(per person - includes 18 holes of golf, golf-cart rental, refreshments, box lunch, and closing dinner)

☐ **TEAM registration - $500.00**
(group of four - list names below)

1. ____________________
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Name ____________________
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Return this form with payment by August 5.
Submit credit card payment online at `ecom.aasv.org/misc` or mail check payable to the AASV Foundation to 830 26th Street, Perry, IA 50220.

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To help and be helped

In times of crisis, the advice offered by Fred Rogers often comes to mind: "When I was a boy and I would see scary things in the news, my mother would say to me, 'Look for the helpers.' You will always find people who are helping." The advice was meant to help children process scary situations and see that there is light to be found even within the darkest moments. As an adult, the advice serves as a reminder to find the strength within ourselves to rise and meet the challenge when help is needed.

In the wake of the coronavirus disease 2019 (COVID-19) pandemic and disruption of US pork processing, many helpers emerged to aid producers in their time of need. In addition to ensuring the health, safety, and well-being of their own staff, veterinarians have assisted producers in developing and implementing alternative strategies aimed to optimize the health, safety, and welfare of the animals and their caretakers within the pandemic constraints. And when all strategies were exhausted, veterinarians helped producers make the devastating decision to depopulate animals that no longer had a marketplace.

Signs & Symptoms of Stress

Physical:

- Nausea, sweating, diarrhea
- Chest pain, rapid heartbeat, headache
- Dizziness, sleep disturbances, chills, tremors

Emotional:

- Feeling irritation, anger, denial
- Feeling uncertain, nervous, anxious
- Feeling tired, overwhelmed, isolated
- Feeling sad or depressed
- Lacking motivation
- Worrying about others

Cognitive:

- Slowed thinking, difficulty making decisions, confusion, difficulty concentrating or remembering
- Seeing the event over and over

The American Veterinary Medical Association's (AVMA) Guidelines for the Depopulation of Animals serves as the primary reference for planning once the decision to depopulate has been made. The swine section was written by the AVMA Panel on Depopulation Swine Working Group, which was composed of AASV member volunteers, and classifies each method as either Preferred or Permitted Under Constrained Circumstances based on the available scientific literature at the time. When deciding which method to use, the veterinarian must consider a host of factors including but not limited to human safety, animal welfare, available resources, time constraints, disposal limitations, and public perception. To aid veterinarians in weighing these factors during depopulation planning, the AASV published supplemental recommendations to provide additional details on resources and logistics.

The need for help does not end once the depopulation and disposal are complete. It is likely the impacts of COVID-19 will be long-lasting and felt throughout the swine industry resulting in adaptation in how we operate, although it remains to be seen exactly how. Winston Churchill's advice to "never waste a good crisis" might seem strange, but the true meaning applies now. Be strong and resilient, get through a crisis to the best of our ability, and be sure to learn from it. It is important that we reflect on our experiences during this emergency to improve our resources, build new tools, learn to adapt, and be better prepared for the next emergency, whatever that may be. The AASV will continue to provide opportunities for members to share their experiences and explore how to turn those lessons learned into resources that improve our industry preparedness and response.

In addition to protecting public health and swine health and welfare, swine veterinarians are often tasked with providing emotional support for their clients, colleagues, friends, and family members during and after emergency events. Infectious disease outbreaks, natural disasters, and other emergencies can cause stress, anxiety, fear, and other strong emotions. Amidst this turmoil, it is crucial to remember that sometimes the helpers need help too. Learn to recognize the signs and symptoms of stress (see sidebar), strengthen your resilience, and know where to get help.

The AASV continues to provide members with resources to assess and improve well-being, which is the overall state of being comfortable, healthy, and happy and encompasses nine dimensions: intellectual, emotional, creative, environmental, physical, occupational, social, financial, and spiritual. Social well-being can be improved by surrounding yourself with a network of support built on mutual trust, respect, and compassion. To support the social dimension of well-being, the AASV is offering HEARD VET, a confidential, virtual, peer social support group for AASV members to share or listen to experiences unique to swine veterinarians. The virtual support group sessions provide a venue for AASV members to connect with peers to discuss events associated with the COVID-19 pandemic or other emergency responses. Trained swine veterinarian peer mentors join University of Tennessee College of Veterinary Medicine's Dr Elizabeth Strand, a licensed clinical social worker, resiliency coach, and Founding Director of Veterinary Social Work, to moderate the group discussion.

In the midst of a crisis or during a regular day, the best social support can be found in a place where you feel accepted, understood, and respected for who you are. Learn from and lean on each other. Talk. Smile. Laugh. Take a break. Make time to unwind. Enjoy life outside of work.

"Know when to relax, how not to overdo. To care for others, we must care for us, too." While not directly from Dr Seuss, but certainly Seuss-inspired, it is important to remember that the most effective helpers must care for themselves too.

Abbey Canon, DVM, MPH, DACVPM
Director of Public Health
and Communications

Sherrie Webb, MSc
Director of Swine Welfare

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UPCOMING MEETINGS

Allen D. Leman Swine Conference - VIRTUAL

September 19 - 22, 2020 (Sat-Tue)
Hosted by the University of Minnesota
The conference will be conducted online

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

Emerging Animal Infectious Disease Conference - NEW DATE

October 5 - 7, 2020 (Mon-Wed)
State College, Pennsylvania

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

United States Animal Health Association 124th Annual Meeting

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

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

International Conference on Pig Survivability

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

Conference contact:
Dr Joel DeRouchey
Email: `jderouch@ksu.edu`
Web: `piglivability.org/conference`

26th International Pig Veterinary Society Congress - NEW DATE

November 3 - 6, 2020 (Tue-Fri)
Rio de Janeiro, Brazil

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

ISU James D. McKean Swine Disease Conference

November 5 - 6, 2020 (Thu-Fri)
Scheman Building
Iowa State University
Ames, Iowa

For registration information:
Registration Services
Iowa State University
1601 Golden Aspen Drive #110
Ames, Iowa 50010
Tel: 515-294-6222
Email: `registrations@iastate.edu`

For questions about program content:
Dr Chris Rademacher
Conference Chair
Iowa State University
Email: `cjrdvm@iastate.edu`

American Association of Swine Veterinarians 52nd Annual Meeting

February 27 - March 2, 2021 (Sat-Tue)
San Francisco Marriott Marquis
San Francisco, California

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

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

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AASV Resources online at aasv.org