Animal Welfare Institute
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José Arce, DVM, President
Panel on Animal Depopulation
American Veterinary Medical Association
1931 North Meacham Road, Suite 100
Schaumburg, IL 60173-4360

Reference: Classification of Ventilation Shutdown Methods in the AVMA Guidelines for the Depopulation of Animals

Dear Dr. Arce and Members of the Panel on Animal Depopulation:

We are writing on behalf of the Animal Welfare Institute (AWI) regarding the classification of various forms of ventilation shutdown (VSD) in the AVMA's *Guidelines for the Depopulation of Animals*. The AVMA House of Delegates and Board of Directors recently referred to the AVMA Panel on Depopulation a resolution to reclassify as "not recommended" all forms of VSD, including VSD+, in which heat, humidity, and/or carbon dioxide is added after the ventilation system is shut down.[1]

AWI encourages the Panel to revise its position on ventilation shutdown. Methods of ventilation shutdown that rely primarily on heatstroke or hyperthermia, including VSD and VSD + heat and/or humidity should be classified as *not recommended*. Though referenced in the *Guidelines*, the method of "VSD + carbon dioxide (CO_2)" has been little studied by this name. As discussed further below, available research suggests VSD+ CO_2 is essentially equivalent to whole house gassing (WHG) with carbon dioxide, a more widely used and studied depopulation method. Consequently, references to VSD+CO_2 should be removed from the *Guidelines*.

In support of our recommendations, we would like to raise several important issues for consideration by the Panel. First, there are serious concerns about the methods and conclusions of some of the VSD research that was or will be considered. Second, new research on more humane, rapid, and effective depopulation methods should be reviewed by the Panel. Finally, the Panel must consider the effect that classification of VSD/VSD+ may have on planning, preparedness, and decision making by the poultry and pork industries. Should the *Guidelines* continue to classify some form(s) of VSD as "permitted in constrained circumstances," it is imperative that the *Guidelines* describe in detail which circumstances qualify and explicitly exclude depopulation of healthy animals due to supply chain disruption.

Research on VSD

Heatstroke pathophysiology in porcine and avian patients

As you are likely aware, limited research has been carried out on methods of ventilation shutdown, particularly on their implications for animal welfare. The available research indicates that, unless combined with very high concentrations of carbon dioxide (CO_2), ventilation shutdown typically causes death via hyperthermia, or heatstroke, rather than hypoxia or hypercapnia in both pigs and poultry.[2-3]

In terrestrial vertebrates, heatstroke is universally recognized as being detrimental to welfare. This is among the reasons the World Organisation for Animal Health (OIE) does not recommend any form of VSD, even in disease control situations.[4] In mammals, the pathophysiology of heatstroke is well preserved across species. People afflicted with heatstroke describe feeling anxiety, muscle cramps, headache, nausea, and malaise.[5] In dogs, a species in which it has been well studied, heatstroke causes direct hyperthermal injury to tissues and blood vessels, causing widespread cellular necrosis (cell death) and hypotension (low blood pressure).[6] In order to dissipate heat, blood is shunted toward the skin and away from the splanchnic circulation that supplies the gastrointestinal tract. The resultant hypoxia and oxidative stress cause extremely uncomfortable gastrointestinal symptoms, such as hematemesis (vomiting blood), melena (defecating digested blood), and gelatinous, bloody diarrhea. Other sequelae include rhabdomyolysis (destruction of muscle tissue), hepato- and splenomegaly (enlargement of the liver/spleen which can be painful), acute respiratory distress syndrome, and disseminated intravascular coagulation. One of the authors of this letter (GRI) has treated numerous canine heatstroke patients and can attest to their suffering and distress.

Research carried out specifically on pigs commercially raised for meat confirms that their gut is very sensitive to heatstroke and heat stress. In one experiment, in which pigs were subjected to a temperature of 95˚F (35˚C) and 24–43% humidity, they exhibited reduced intestinal integrity.[7] In another study, pigs subjected to heat stress (temperature of 98.6˚F [37˚C] and 40% humidity) had changes to their intestinal integrity after only two hours, with intestinal sloughing noted soon after.[8] Both of these studies documented a doubling of respiratory rate under conditions of heat stress. The environmental conditions in these two studies pale in comparison to those reported in a recent VSD study (discussed below), in which the maximum temperature during each VSD cycle was between 155.3˚F (60.5˚C) and 170.1˚F (76.7˚C), with humidity as high as 96.8%.[9] Recent literature reviews of swine depopulation methods concluded that the welfare costs, in terms of suffering and distress, of any form of VSD were simply too great for it to ever be used.[10-11]

As heatstroke is an uncommon presentation in clinical avian medicine, less research on its pathophysiology is available. However, heat stress has long been associated with reduced welfare status, and temperature-humidity combinations that are high enough to cause death also cause severe stress and suffering.[12-13] In broilers, heat stress has been documented to increase serum concentration of corticosterone (a marker of stress and negative welfare in birds) and impair intestinal integrity, suggesting that birds likely experience similar discomfort and distress as mammals.[14] Experimental induction of heatstroke in anesthetized galahs and rock doves documented congestion of the lungs and intra-airway hemorrhage in some subjects, which suggests that non-anesthetized birds affected by heatstroke likely experience respiratory distress.[15]

The only published study on use of VSD+ in a commercial poultry facility, which implemented the temperature and time parameters described in the 2019 *Guidelines*, confirms that, with VSD + heat, carbon dioxide levels remain sublethal and heatstroke causes the birds' death.[16] The study did not focus on animal welfare, but the few animal-based measures it includes indicate serious welfare concerns. Though average time until death/unconsciousness was not determined, most birds did not begin to lie down until 135 minutes after the start of the process and some remained standing more than 210 minutes. From the start to the end of VSD+ cycle, the animals' core and surface body temperatures increased, on average, approximately 8.5˚F (4.7˚C) and 26.6˚F (14.8 ˚C), respectively.

Given what we know about heatstroke in pigs and poultry, killing via inducing hyperthermia fails to meet the *Guidelines'* key criteria for an acceptable method of depopulation, including that animals "experience a rapid loss of consciousness or loss of brain function under the prevailing conditions," experience "loss of consciousness followed by death with a minimum of pain or distress," and "are handled in a humane manner before and during their depopulation."[17]

North Carolina State University study on VSD/VSD+ use in hens

In the 2019 *Guidelines*, the only VSD research cited was a study entitled "Evaluating hen behavior and physiological stressors during VSD for the development of humane methodologies for mass depopulation during a disease outbreak," which was funded by the US poultry industry and carried out by Dr. Ken Anderson at North Carolina State University (NCSU).[18] During the comment period on the draft guidelines, this study had not been peer reviewed or released to the public.

After the study was released, AWI reviewed it and solicited evaluations of the research by several avian welfare experts. Numerous concerns about the study were identified, the most serious of which are listed below (and further described in Attachment 1):

- The report was so poorly written and/or edited that it was difficult at times to discern what the author was attempting to communicate. (For example: "Since temperature did not appear to be the primary contributor to hyperthermia in the VSD treatment as the primary component related to the TOD as was the case.")
- Several reporting and mathematical errors called into question the reliability of all the data. (For example, none of the percentages for the four treatments presented in Table 2 add up to 100; instead, the percentages add up to 109, 119, 90, and 81.)
- The report characterized certain depopulation methods as "humane" despite the fact that the study does not define "humane."
- The study's primary measure of "humaneness" appeared to be Heat Shock Protein (HSP), which has not been validated as a welfare indicator in birds.
- The study reported the duration of time to death and the percentage of time unconscious for the different depopulation methods. However, the length of time birds spent in a conscious state, which is a critical measure, was not provided or discussed, and cannot be calculated from the data.

AWI identified serious problems in all aspects of the ventilation shutdown study, including the methodology, the reporting of findings, and the conclusions. AWI informed NCSU of these concerns, and a subsequently published article did not attempt to assess animal welfare.[19] Importantly, the study was carried out with very low numbers of hens in a setting extremely different from a commercial henhouse: phases 1 and 2 involved single hens in "individual treatment/observation chambers" and phase 3 involved construction of a chamber (15 ft. x 7.5 ft. x 5.3 ft.) which contained two cages. Since no studies focused on animal welfare have been replicated in a commercial setting, the true time to death and lethality of the VSD methods are not know.

On VSD+CO_2

To AWI's knowledge, this NCSU study is the only time the method "VSD+CO_2" has been studied by that name. The subsequently published report states that the time until death was 1.5 hours when the constructed chamber was, over the course of 1.25 hours, filled with carbon dioxide to a concentration of 41%.[20] No research to date has studied a procedure identified as VSD+CO_2 in any commercial poultry setting or for pigs.

However, numerous studies in commercial settings are available on whole house gassing of poultry with CO_2, a process that involves sealing off the entire barn, including the ventilation system, and causes death by hypercapnic hypoxia. In one such study, CO_2 was rapidly infused into the barn, reaching a concentration of 45% within 19 minutes.[21] In this situation, hens lost consciousness within 6 to 10.5 minutes (average 7.8 minutes) and died in 12 to 22.1 minutes.

Based on these studies, the main difference between VSD+CO_2 and WHG with CO_2 appears to be the speed at which carbon dioxide is introduced. In the WHG study, concentrations sufficient to cause loss of consciousness and death were achieved in ¼ the time as the VSD+CO_2 study. Liquid carbon dioxide was utilized and caused a dramatic drop in barn temperature, as low as 0˚C (32˚F). This suggests that, in a commercial setting, the addition of CO_2 would not be expected to hasten death by heatstroke, since rapid delivery of the amount of CO_2 needed to cause loss of consciousness or death would lower the temperature such that heatstroke could not occur. Furthermore, in the USDA's decision tree regarding use of VSD+, it is noted that VSD+ should not even be considered unless CO_2 is not available.[22]

If CO_2 is introduced into a barn to facilitate depopulation, it is essential that veterinarians and operators have a clear understanding of the preparations, equipment, and speed and volume of gas delivery needed to make the process as humane as possible. Given that these issues have been and continue to be studied under the descriptor "Whole House Gassing," the Guidelines can better fulfill their stated purpose of providing "guidance for veterinarians about options for killing animals in emergency situations" by removing VSD+CO_2 from the Ventilation Shutdown sections and directing veterinarians considering this method to the literature on whole house gassing with CO_2.

Regarding pigs, use of CO_2 has been studied and used as a method of on-farm euthanasia and depopulation.[23] This research indicates that the concentration and speed of delivery of CO_2 needed to kill pigs precludes introducing the gas into a sealed barn; rather dump-bed trucks or trailers are used as mobile euthanasia chambers.[24-25] Pigs become extremely distressed, exhibiting, escape attempts, and vocalizations, at CO_2 concentrations of 15%, which is too low to cause death or loss of consciousness.[26] Given the size of typical pig barns, pigs would likely be subjected to sublethal but highly aversive concentrations of CO_2 for a prolonged period were a method such as VSD+CO_2 to be attempted. The *Guidelines* already state that "construction of chambers will need to occur to accomplish depopulation by CO_2 inhalation for large numbers of pigs"; thus, they have already effectively ruled out whole barn gassing with CO_2 (i.e., VSD+CO_2).

Recent *JAVMA* Study on use of VSD+TH for depopulating pigs

Recently, *JAVMA* published "A case study of ventilation shutdown with the addition of high temperature and humidity [VSD+TH] for depopulation of pigs."[27] In reviewing the depopulation of 243,016 pigs via VSD+TH, the report claims that this method of ventilation shutdown, with the addition of high temperature and humidity, meets the conditions described in the 2019 *Guidelines* for the use of VSD+ in pigs: > 95% death rate in < 1 hour.

To meet this criterion, "time 0" was set, not at the point when ventilation was literally shut down and operators began adding heat to the building, but 15 to 94 minutes *later*, when the barn temperature reached a scorching 130˚F (54˚C) and steam was introduced. The report attempts to justify starting the clock at this point by claiming that "during the proof-of-concept trials, [130˚F (54˚C)] was the temperature at which the animals began to show signs of increased respiration." The claim is presented without any support data and multiple previous studies call its veracity into question. For example, a previous study documented a doubling of respiratory rate (from 50.5 bpm to 119.5 bpm) within two hours under much milder conditions of heat stress (98.6˚F [37˚C] and 40% humidity).[28] Another study reports a similar doubling of respiratory rate (from 52 to 119 bpm) in pigs subjected to a temperature of 95˚F (35˚C) and 24–43% humidity.[29] Moreover, the pork industry's own standards state that the preferred temperature range for nursery and finishing pigs is 65-80˚F (18.3 ˚C-26.7˚C) and 50-75˚F (10˚C-23.9 ˚C), respectively, and the "upper critical thermal limit" is 95˚F.[30]

If we start counting from the moment the barn was sealed and heat began to be pumped in, the report indicates that each VSD "cycle" took an average of 90.4 minutes for nursery pigs and 110.3 minutes for finishing pigs, lasting in one case for over 2.5 hours. This "total time" more accurately reflects how long these pigs suffered before expiring, which fails to meet the *Guideline's* standard of >95% mortality in less than one hour.

Although not confirmed by the research report, AWI suspects the VSD+TH study may have taken place at Iowa Select Farms (ISF), whose use of VSD+TH was the subject of a covert investigation by the animal protection group, Direct Action Everywhere (DxE).[31] In 2019, prior to any changes related to the pandemic, an ISF employee became concerned about a sudden increase in swine stocking densities and worsening animal welfare at the operation. Concerned that the overcrowding violated Iowa laws, the whistleblower contacted state regulators. When they took no action, he contacted DxE, later informing them when ISF began utilizing VSD+TH.

DxE has released nearly 2.5 hours of uncut audio covertly recorded during one of the VSD+TH cycles,[32] as well as video footage of the barn before, during, and after the depopulation. The pitch, volume, and prolonged duration of distressed vocalizations captured on the audio recording leave no room for doubt as to just how agonizing fatal heatstroke caused by VSD is for pigs. This audio recording also cast doubt on the completeness of the video recording apparently presented to Temple Grandin, which she describes as showing "little behavioral reaction from the pigs."[33]

Alternative Methods of Depopulation

The *Guidelines* describe several methods of depopulation that are more rapid and more humane than any form of VSD, including captive bolt, gunshot, electrocution, cervical dislocation (for poultry), foam, and gassing. AWI would like to direct the Panel's attention to additional research that demonstrates either the successful use of more humane methods on a mass scale or the use of novel methods with the potential to be faster and more humane than VSD+.

Electrocution

Electrocution, which causes instantaneous loss of consciousness when properly used, was deployed in the 1990s on-farm in the Netherlands to euthanize 700,000 pigs infected with classical swine fever.[34] Since at least 2014, mobile electrocution units have been contained in the veterinary stockpiles of several European nations.[35]

In line with recommendations by Temple Grandin (see Attachment 2),[36] the National Pork Board recently developed mobile electrocution units for both nursery piglets[37] and pigs weighing between 125 and 600 lbs (these reports are attached in Attachment 3 and 4, respectively).[38] Their research shows that the costs, staffing requirements, and speed of application for these units are equivalent, if not superior, to those described in the VSD+TH report discussed above. They involve minimal handling, would be appropriate in infectious disease settings, and are not protected by patents. The state of Nebraska recently added one such mobile electrocution units to its Veterinary Stockpile.

High-expansion, water-based foam

AWI encourages the Panel to evaluate in great depth the use of high-expansion, water-based anoxic foam, a.k.a., gas-filled dry foam, as a method for depopulation. Such foam is made anoxic by the infusion of CO_2, nitrogen gas (N_2), argon (Ar), or other inert gasses.

Research not referenced in the 2019 Guidelines suggests this foam may be more humane than low- or medium-expansion foam to depopulate birds because it displaces oxygen, causing rapid death via anoxia, rather than airway occlusion.[39] Using high-expansion foam filled with CO_2 or N_2 , average time to unconsciousness in birds is typically 1 to 30 seconds after immersion, with cardiac arrest occurring within approximately three minutes.[40][41] A commercial N_2-filled foam system, appropriate for floor- and multi-tiered rearing systems, has been developed in Europe and provides a more rapid depopulation than VSD+TH, filling a shed housing 30,000 broilers within one hour.[42] A pilot study in pigs with N_2-filled high expansion foam showed that the mean time to unconsciousness was 57 seconds from the start of foam production.[43]

High concentrations of CO_2 may be aversive to animals,[44] and gassing methods like whole house gassing require careful sealing of the building. Thus, high expansion, water-based foam filled with inert gasses may prove better for both animal welfare and efficacy than some of the methods currently classified as “preferred” in the *Guidelines*.

Conversion of slaughterhouses to carcass production

As Grandin recently described (see Attachment 2), slaughterhouses with fewer than half their normal staff can still produce either carcass meat or large cuts of meat.[45] This would allow healthy animals to be depopulated using normal humane slaughter techniques and would ensure that at least some of the resultant meat could be consumed, rather than composted.

Meat Industry Planning and Preparedness

In the 2019 *Guidelines*, the Panel correctly identified the importance and ethical necessity of planning and preparedness, stating, “Proper planning and preparation are important ethical duties that should occur beforehand and must be carried out by the veterinary community and others tasked with responding to the emergency.” Given the options for depopulation currently available or in development, AWI maintains that the continued designation of VSD or VSD + heat and/or humidity as anything other than "not recommended" by the AVMA will deter the efforts to produce, deploy, and utilize more humane depopulation methods.

When the 2019 Guidelines were published, some felt VSD+ had to be included due to concerns about highly pathogenic avian influenza (HPAI) and the need to depopulate within 24 hours of a diagnosis to prevent virus shedding.[46] Other reasons cited for the use of VSD/VSD+ for HPAI have included reducing the time workers are exposed to a zoonotic disease and ending the lives of birds suffering from the disease if other means are not readily accessible.[47] However, records AWI received from the USDA under the Freedom of Information Act indicate that no form of VSD has been used to control HPAI since 2016 (Attachment 5). This suggests that poultry producers, recognizing that there will likely be a recurrent need for depopulation, may have taken measures to ensure preferred methods can be used.

This also illustrates the deficiencies of the AVMA's depopulation "decision tree,"[48] which AVMA leadership highlighted in its response to our previous letter expressing concerns regarding the use of VSD+ for supply chain disruption (see Attachment 6). Decision trees are often based on subjective assumptions, allowing different professionals to arrive at different conclusions in response to the same set of circumstances. Those using the decision tree are often the same individuals responsible for making preparations for an emergency, and their assessment of the situation may be biased.

In contrast to animal disease emergencies like HPAI, the COVID-19 pandemic was not an animal health/welfare emergency requiring action within hours. On the contrary, the recent report on VSD+TH states the farm began planning for depopulation in early March and did not carry out its first VSD+TH operation until April 30th. This time interval is long enough that the AVMA *Guidelines for the Euthanasia of Animals* should have been applied. While the report explained the farm's decision to use VSD+TH by citing lack of access to more preferred methods, such captive bolts, firearms, and carbon dioxide, it is our understanding that a majority of other pig farms facing the same challenge used AVMA-approved euthanasia methods or methods considered "preferred" for depopulation. It is difficult to imagine that the farm could not access *any* of the preferred methods in *any* quantity. This suggests that convenience, cost savings, and inadequate planning and preparation were ultimately the reason VSD+TH was used, and the "decision tree" did little but provide cover for those employing VSD+TH.

High stocking densities

Stocking animals at high densities increases the risk that depopulations will be carried out. As described in the VSD+TH report, the routine practice of allocating growing-finishing pigs only 6.8 sq. ft. per animal meant that within days of slaughterhouse shut-downs, pigs were lying on top of each other; thus, the farm justified the decision to depopulate on animal welfare grounds. If stocking densities had been lower to begin with, welfare concerns severe enough to warrant depopulation would not have developed as rapidly, and perhaps not at all. Furthermore, raising animals in crowded, filthy conditions facilitates the spread and mutation of infectious agents, further increasing the risk of future depopulations due to disease.

By condoning VSD+, the AVMA enables the animal agriculture industry to act irresponsibly. It ensures that the industry will continue to construct massive buildings that confine tens and even hundreds of thousands of animals without consideration of how they will be protected in emergency situations, or humanely killed, if that becomes necessary. If the AVMA takes seriously the importance of planning, it must recognize the dangers of intensive meat production practices and seek to promote more humane, sustainable, and resilient farming systems.

Slaughterhouse workers

Another component of planning, which underscores approaches such as One Health and One Welfare, is addressing the connection between the working conditions of processing plant employees and the risk of future depopulation events caused by supply chain disruption. Industry consolidation means that the same entity now often owns the animals, the farms, and the processing plants. A recent report noted that "low pay, lack of sick leave and affordable healthcare, [and] high density and low quality housing" increased the prevalence of COVID-19 among slaughterhouse workers, the vast majority of whom are migrant or minority workers potentially more vulnerable to exploitation.[49] In addressing the ethical requirement for planning and preparedness, the AVMA should highlight the needs to protect these workers and decrease the risk of future plant closures due to human diseases.

Clarifying "Constrained Circumstances"

Although up to this point our letter has dealt with AWI's opposition to the use of all forms of ventilation shutdown to kill animals, we are also opposed to another method recognized by the *Guidelines* as "permitted in constrained circumstances" for pigs – sodium nitrite (SN). <u>At the time the Panel on Depopulation accepted the use of VSD+ and SN, no published scientific evidence had been offered to demonstrate that the use of these methods in commercial agricultural settings met the standard of more than 95% of animals dead in less than one hour. That was the case at the time of the drafting of the *Guidelines*, and it remains the case today. Both VSD+ and SN either: result in the death of less than 95% of the animals, involve a process that lasts significantly longer than one hour, and/or cause a degree of suffering that is unacceptable.</u>

Scientific research regarding the response of animals to the application of VSD+ was cited earlier. As to sodium nitrite, at least two studies were conducted during the COVID-19 pandemic on the use of the toxicant to kill agricultural animals. In 2020, the USDA Agricultural Research Service studied the effect of SN on laying hens. However, the researchers were unable to determine if SN can be considered a humane method of killing because only one of 32 hens died after consuming SN-laced feed (see Attachment 7). Also in 2020, the National Pork Board commissioned a study of the effect of SN on nursery weight pigs. In this research, only 50-80% of the pigs died, and the earliest instance of mortality was at 90 minutes, with an average time to death of 2 hours and 12 minutes. Moreover, 63% of the pigs in the feed treatment groups experienced retching and vomiting (see Attachment 8).

AWI's position is that ventilation shutdown, in any form, and sodium nitrite should never be used and should be classified as "not recommended" in the AVMA *Guidelines on Depopulation*. Should the Panel elect to continue to recommend VSD+ and/or sodium nitrite for use under "constrained circumstances," we agree with Temple Grandin that the *Guidelines* must clarify exactly what qualifies as constrained circumstances. Supply chain disruption does not immediately cause conditions that require depopulation to avert serious health, welfare, or safety problems. This contrasts with some disease situations in which the suffering caused by VSD+ or sodium nitrite must be weighed against the actual and potential suffering caused by a rapidly spreading disease agent.

The animal agriculture industry now has more than enough experience with supply chain disruption to minimize the need for future depopulations of healthy animals and to ensure that those that are carried out utilize faster, more humane methods. The AVMA has no legal or ethical responsibility to ensure the viability of the meat industry during a supply chain disruption; thus, the economic utility of VSD+ (or sodium nitrite) should receive no weight in the Panel's deliberations. If producers elect to use these demonstrably inhumane methods in response to a supply chain disruption, their decision should not receive cover by a national organization representing the veterinary profession.

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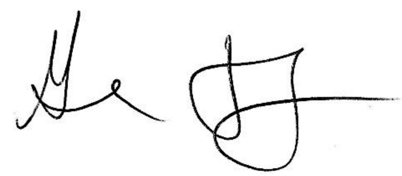
We would welcome the opportunity to discuss this issue with you at your convenience. If you have any questions or would like to arrange a meeting, please contact me via email at cathy@awionline.org or by phone at 202-446-2121.

Sincerely,



Cathy Liss
President

Gwendy Reyes-Illg, DVM, MA
Veterinary Consultant, Farm Animal Program

cc: Janet Donlin, DVM, Chief Executive Officer

Attachments

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Attachment 1

AWI Letter to AVMA on NC State VSD Research, October 2017

Animal Welfare Institute
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awionline.org phone: (202) 337-2332 fax: (202) 446-2131

October 30, 2017

Dr. Janet Donlin
Executive Vice President
American Veterinary Medical Association
1931 North Meacham Road, Suite 100
Schaumburg, IL 60173-4360

Dear Dr. Donlin:

I am writing to express concerns regarding the AVMA's draft guidelines for the depopulation of birds, as well as a study conducted at North Carolina State University on the ventilation shutdown (VSD) method of depopulation that was cited in the guidelines.

As you probably know, the U.S. Department of Agriculture allowed the use of ventilation shutdown during an avian influenza outbreak in 2016, and the AVMA's draft guidelines sanction its use (with heat or carbon dioxide gas) in "constrained circumstances."

The Animal Welfare Institute (AWI) appreciates the distinction between humane euthanasia and depopulation of animals in constrained circumstances. AWI's position on depopulation has been that the method used must be capable of killing animals (or rendering them irreversibly insensible) in less than five minutes with minimal suffering. It is our understanding that containerized gassing and high-expansion gas-filled foam meet these criteria, and although whole-house gassing with CO_2 is slower, proper use also results in minimal distress to birds. AWI has been opposed to the use of ventilation shutdown, with or without heat, and submitted comments on the AVMA guidelines to this effect.

After the comment period on the AVMA guidelines closed, the U.S. poultry industry released a final report regarding a study it funded by Dr. Ken Anderson at North Carolina State University titled "Evaluating hen behavior and physiological stressors during VSD for the development of humane methodologies for mass depopulation during a disease outbreak." AWI reviewed this report and solicited evaluations of the research by several avian welfare experts. Numerous concerns about the study have been identified, the most serious of which are listed below (and further described in an attachment):

- The study has not been peer reviewed. Nonetheless, the AVMA cited it in its depopulation guidelines. During the comment period on the draft guidelines, the report was not public.
- The report is so poorly written and/or edited that it is difficult at times to discern what the author was attempting to communicate. (For example: "Since temperature did not appear to be the primary contributor to hyperthermia in the VSD treatment as the primary component related to the TOD as was the case.")
- Several reporting and mathematical errors call into question the reliability of all of the data. (For example, none of the percentages for the four treatments presented in Table 2 add up to 100; instead, the percentages add up to 109, 119, 90, and 81.)

- The report characterizes certain depopulation methods as "humane" despite the fact that the study does not define "humane."
- The study's primary measure of "humaneness" appears to be Heat Shock Protein (HSP), which has not been validated as a welfare indicator in birds.
- The study reports the duration of time to death and the percentage of time unconscious for the different depopulation methods. However, the length of time birds spent in a conscious state, which is a critical measure, is not provided or discussed, and cannot be calculated from the data.

AWI identified serious problems in all aspects of the ventilation shutdown study, including the methodology, the reporting of findings, and the conclusions. In fact, in our opinion, no conclusions can be drawn from this research, with the possible exception that in some situations birds may survive ventilation shutdown conducted without heat and/or carbon dioxide. The research certainly does not demonstrate that ventilation shutdown with heat—the practical equivalent of baking animals alive—is "humane," and statements making this claim misrepresent the study.

Dr. Dorothy McKeegan, recognized expert in bird depopulation, has said: "VSD is associated with very serious welfare concerns, primarily because death caused by hyperthermia is associated with significant suffering, and the time to death is prolonged." We feel very strongly that this study does not provide any evidence to justify the use of ventilation shutdown to depopulate birds, even under constrained circumstances.

AWI calls on the AVMA and the poultry industry to present a truthful and unbiased account of the research discussed here, and to support the use of methods demonstrated to have lower animal welfare costs for birds, including containerized gassing with argon and CO_2, whole-house gassing using CO_2 or other gases at appropriate concentrations, and high-expansion gas-filled foam.

Further, we urge the AVMA to call out industrialized farming for raising animals in crowded, filthy conditions that facilitate the spread of disease. By proposing inhumane killing methods, the AVMA is enabling the animal agriculture industry to act irresponsibly. It ensures that the industry will continue to construct massive buildings that confine tens and even hundreds of thousands of birds without consideration of how they will be protected in emergency situations, or humanely killed, if that becomes necessary.

We would welcome the opportunity to discuss this issue with you at your convenience.

Sincerely,

Cathy Liss
President

Dena Jones
Director, Farm Animal Program

cc: Dr. Cia Johnson, Director, Animal Welfare Division, AVMA
Dr. Ken Anderson, Professor, North Carolina State University
Dr. John Glisson, Vice President of Research Programs, U.S. Poultry & Egg Association
Mr. Kevin Shea, Administrator, USDA Animal and Plant Health Inspection Service

Attachment

ATTACHMENT

AWI Concerns Regarding Research Conducted by North Carolina State University on the Response of Egg-Laying Hens to Ventilation Shutdown Method of Depopulation

This document briefly describes some of the Animal Welfare Institute's many concerns regarding the methodology of the North Carolina State University study, the interpretation of its findings, and the conclusions drawn from the research.

General

1. The information that is especially pertinent and relevant to the topic—the length of time birds undergoing each treatment spent in a conscious state—is not provided or discussed.

2. The primary measure of animal welfare in the study appears to be Heat Shock Protein (HSP). However, HSP has not been validated as a welfare indicator in birds. HSP is typically used as a measure of heat stress, not as a measure of an animal's conscious experience. Measuring an animal's conscious experience is essential to any discussion of "humaneness" or "animal suffering."

3. Other validated stress indicators, such as glucocorticoids, were not analyzed. Glucocorticoids are regularly measured in birds as indicators of stress and animal welfare.

4. The HSP data is taken from different birds at different time points, not the same birds at different time points, and only two birds per time point. Furthermore, the time points are based on the time to death of just four birds per treatment (in Phase 1). This methodology assumes that all birds respond the same to the treatments, which the research's own data suggests is not the case.

5. AWI knows of no previously published data suggesting that HSP in chickens can rise a significant amount in the very short duration of some of the treatments. Consequently, there are no scientifically valid conclusions that can be drawn from the reported HSP levels.

6. The duration to time of death (TOD) data suggests that ventilation shutdown (VSD) and ventilation shutdown with heat (VSDH) are inappropriate methods of depopulation. Moreover, any acceptability of ventilation shutdown with CO_2—with or without heat (VSDCO, VSDHCO)—hinges on the use of CO_2 at appropriate concentrations as a euthanasia agent. While AWI suspects the methods that include CO_2 may qualify as meeting minimum animal welfare criteria, the current study does not provide substantiation of this.

7. The VSDHCO method was evaluated in Phase 1, but not in Phase 2 or 3, reportedly because the method did not seem to improve upon the VSDH and VSDCO methods. This decision is inappropriate, especially given the extremely small sample size in Phase 1 (four birds per treatment).

8. Extremely small sample sizes for all Phases, but particularly for Phase 1 (four birds per treatment) and Phase 2 (two birds per time point), qualifies the research as a pre-pilot feasibility study only.

Industry Summary

1. The Summary focuses on duration to TOD for the various treatments; however, from an animal welfare viewpoint, the length of time the birds were conscious is far more important. Moreover, the percentage of time unconscious is of little significance when the time to death is lengthy, as was the case with the VSD method.

2. The Summary reports a hen survivorship of 4 percent for VSD, while the text of the report states 2.8 percent of VSD hens survived.

3. According to the Summary, "The duration to TOD was no different between VSDH and VSDCO." This statement is inaccurate and misleading as the time to death was not reported for Phase 3, and no statistical analysis was conducted (likely due to lack of replication). For Phase 1, time to death was based on only four birds per treatment. If no statistical significance for this Phase was detected, it was likely due to the small sample size and large hen-to-hen variation. This would have been evident if information about variability, such as data ranges, had been provided, but unfortunately it was not.

4. The final statement of the Summary is, "Based upon these field studies, VSDH and VSDCO appear to be the most humane methods of depopulating large numbers of caged he [*sic*]" However, there is no justification for this statement. Given that VSDH hens were conscious four times longer than VSDCO hens, it is inappropriate to suggest that the two methods are equally "humane." From a hen welfare perspective, the difference between 690 seconds and 3202 seconds should be considered important, regardless of statistical significance. The difference must not be disregarded, particularly given the very small sample sizes used in this study.

Phase 1

1. Data for the behavioral observations are not provided.

2. The validity of the different behaviors as measures of loss of consciousness is not established.

3. Because the behaviors studied do not necessarily reflect loss of sensibility or awareness, the amount of time birds were unconscious may have been overstated (or, expressed another way, the amount of time birds were conscious may have been understated).

4. It is not clear how the EEG recordings and the behavioral observations were integrated—did a hen have to display all behaviors listed to be considered unconscious?

5. Maximum carbon dioxide concentrations for Phase 1 are reported as 34% for the VSDCO treatment and 31% for VSDHCO (Table 1 and Figure 3). However, CO^2 concentrations of 40-45% are generally considered necessary to ensure death in chickens. The possibility that lower CO_2 levels may have influenced the duration to TOD for these two treatments is not raised in the report.

6. The percentages of time for each EEG mV range (Table 2) do not add up to 100. For example, the values given for the VSDH treatment add up to 119 percent.

7. Standard error and ranges are not reported for the individual treatments. Therefore, it is not possible to know which treatments had the greatest variation on time to death.

8. Figure 7 reports HSP levels; however, the report does not state that HSP was studied in Phase 1.

Phase 2

1. No explanation is given for why HSP was measured only in the brain and not in the blood of birds. This prevented pre and post measurements in the same animal and prevented measurement while the animal was undergoing treatment. HSP was measured only in dead birds, and all birds at the same time regardless of when the individual birds died.

2. Because brains were used to measure HSP levels, only a subset of the total number of hens could be sampled at each time point (two birds per treatment).

3. Figure 8 is meaningless as the scale masks any difference between the treatments. In addition, Figures 8, 9, and 10 are of very limited usefulness as each value represents different birds, not the same bird over time. Comparing single time points for different animals in different treatments is not a strong method of scientific analysis.

4. The report does not offer an explanation for how HSP levels could be statistically higher in treatments that take significantly less time to unconsciousness or death (Figure 11). The report also does not give an explanation for why the baseline HSP level for the VSD and VSDH treatments in Figure 12 are higher than the sequenced time points (suggesting that heat stress decreased during the ventilation shutdown treatments conducted without CO_2).

5. Conclusions offered for Phase 2 regarding the VSDCO treatment are based on data from just two hens. Since HSP does not respond immediately, it is unlikely that changes in HSP levels would be seen in any birds, except perhaps those in the VSD treatment, where a decrease was actually reported. An adequate explanation of this highly unexpected finding is not offered.

Phase 3

1. The core body temperature data reported in Table 4 is meaningless since the temperature was taken from all birds at the same time, and it is likely that the body temperature would have begun to drop not long after the individual hens died.

2. The text of the report cites a core body temperature of 109.3°F in the VSD survivors, while Table 5 reports a core body temperature of 111.7°F among survivors.

3. Duration to time of death was not reported for Phase 3. It is possible no statistical analysis was conducted because each treatment was applied to all birds at the same time, and therefore there was no replication. In any case, the report should explain the lack of statistical analysis for Phase 3.

4. Conclusions for Phase 3 report that the "speed of the process" for the VSDH and VSDCO methods was similar. This is inaccurate. The time to death was, in fact, very different between VSDH and VSDCO treatments in Phase 3 (if the reported length of environmental monitoring for these treatments can be assumed to represent the total time living birds were being monitored). Whether

the time to death is statistically different cannot be determined as no statistical analysis was conducted (due to lack of replication).

5. If the environmental monitoring times cited for Phase 3 can be interpreted as time to death (see point #4 above), then a large difference was noted between the time to death for Phase 1 and Phase 3. Possible explanations for this difference are not provided.

6. The collection of HSP data in Figure 18 is not described, and this data is not mentioned in the Conclusions for Phase 3.

Attachment 2

Methods to Prevent Future Severe Animal Welfare Problems Caused by COVID-19 in the Pork Industry, Temple Grandin, March 2021

animals

Article

Methods to Prevent Future Severe Animal Welfare Problems Caused by COVID-19 in the Pork Industry

Temple Grandin

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Simple Summary: In the U.S., thousands of pigs had to be destroyed on the farms when illness caused by COVID-19 greatly reduced pork slaughter plant capacity. Some of the methods used to destroy pigs on the farms severely compromised animal welfare. Reliance on a few large slaughter plants created a fragile supply chain. Animal welfare auditing conducted by large meat buyers was also hindered by COVID-19. Many live in-person audits were stopped and replaced by a combination of stationary video cameras and live streamed videos from mobile phones. To insure high standards of animal welfare, video methods should never completely replace in-person visits.

Abstract: In the U.S., the most severe animal welfare problems caused by COViD-19 were in the pork industry. Thousands of pigs had to be destroyed on the farm due to reduced slaughter capacity caused by ill workers. In the future, both short-term and long-term remedies will be needed. In the short-term, a portable electrocution unit that uses scientifically validated electrical parameters for inducing instantaneous unconsciousness, would be preferable to some of the poor killing methods. A second alternative would be converting the slaughter houses to carcass production. This would require fewer people to process the same number of pigs. The pandemic revealed the fragility of large centralized supply chains. A more distributed supply chain with smaller abattoirs would be more robust and less prone to disruption, but the cost of pork would be greater. Small abattoirs can coexist with large slaughter facilities if they process pigs for specialized premium markets such as high welfare pork. The pandemic also had a detrimental effect on animal welfare inspection and third party auditing programs run by large meat buyers. Most in-person audits in the slaughter plants were cancelled and audits were done by video. Video audits should never completely replace in-person audits.

Keywords: COVID-19; pigs; animal welfare; euthanasia; supply chain

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1. Introduction

In the U.S., the most severe farm animal welfare problems due to COVID-19 were in the pork industry. Thousands of pigs had to be destroyed on the farms [1]. This was both a huge animal welfare and food waste issue. There were several reasons why the pork industry had more problems that severely compromised animal welfare compared to poultry or beef. When COVID-19 infected hundreds of slaughter plant employees, the large plants either shut down or ran at decreased capacity. In April and May 2020, plant closures and reduced staffing resulted in the pork slaughterhouses running at 40–45% capacity [2,3]. By the summer, the plants were back running at 90–95% capacity [4]. For a critical two month period in April and May 2020, thousands of pigs were at market ready weights with no place to process them. Since cattle are ruminants, it was much easier to slow down growth and wait for the plants to reopen [5]. They can be switched from a high grain to a high forage diet. Pigs are monogastrics with a digestive tract that is similar to humans. There are rations that can be used to slow down their growth but they are less effective [6]. Adding more fiber and reducing energy in the diet will increase the time for a pig to reach market weight. This may only provide four to seven days of extra time [6]. Poultry have a much shorter life cycle than pigs and it is easier to stop production by hatching fewer eggs.

Data from the Minnesota Pork Producers showed that 350,000 pigs were euthanized and 250,000 were sold at auctions, slaughtered in other facilities or given away [1]. Another variable that contributed to the huge number of pigs that had to be destroyed in the U.S. was the 2018 outbreak of African Swine Fever in China. This greatly reduced China's pig population [7]. At the time that COVID-19 infected many employees in the U.S., large amounts of pork were being exported to China [7–9]. To satisfy a great increase in demand, U.S. producers increased their pig production. This clearly showed that the supply chains in these two countries were intertwined. A disease that killed a large numbers of pigs in one country was a stimulus for another country to increase pork exports. When COVID-19 either shut down or slowed the slaughter lines market, pigs were readily backed up on the farms. Some of the pigs that had to be disposed of were transported to a large commercial slaughter plant where their standard stunning equipment was used to kill them. This required only a small crew of people. All the carcasses were sent to either compost or landfill [2]. From a welfare perspective, this option was preferable to killing pigs on the farm.

On some farms, either a penetrating captive bolt or gunshot was used according to people who were on the farms. This is definitely an approved method that induces instantaneous unconsciousness [10–12]. One of the problems with a captive bolt for large numbers of animals is the guns will overheat. From the author's experience in large slaughter plants, when a handheld cartridge fired captive bolt is used, multiple guns have to be rotated to prevent overheating. The use of a gunshot has worker safety issues due to dangerous projectiles. If firearms have to be used, the pigs should be shot outside. This will reduce ricochet hazards from bullets hitting a concrete floor. One of the problems with having to shoot thousands of animals is distress to the people. Several studies have shown that farmers and the people who have to kill many animals may get distressed and develop mental health problems [13–15]. People who spend their lives raising animals do not like killing them [16]. In the COVID-19 situation, healthy pigs had to be destroyed and all the meat was wasted. This would have made killing them even more stressful because raising the pigs no longer served a useful purpose.

Some of the methods used to depopulate the farms would not have been in compliance with the American Veterinary Medical Association (AVMA) as approved methods of euthanasia [10]. The AVMA does make a distinction between their euthanasia and their depopulation guideline [10,17]. There was a big controversy in the U.S. about the use of ventilation shutdown as a method of killing pigs on the farm. The reference provided in the AVMA depopulation guideline clearly showed that shutting off the ventilation systems with no additional interventions does not work [17,18]. When ventilation shutdown plus is used, the pit of a slatted floor barn is filled in and all fresh air inlets are blocked. Heat and humidity is added with a steamer and strict process control procedures are used to prevent scalding the pigs. The author watched a video of the interior of the barn and there was little behavioral reaction from the pigs. To do it correctly would require considerable engineering expertise. Research is also needed to determine the time of onset of unconsciousness. According to the depopulation guideline, this method should only be used in "constrained" circumstances. The use of this terminology does not provide clear guidance [17]. The author recommends that some examples of constrained circumstances where ventilation shutdown plus may be justified should be added to the AVMA depopulation guideline. One example would be a foreign animal disease. There were many critical articles in the news media about the use of ventilation shutdown plus causing suffering [19,20]. A recent review of the scientific literature on swine depopulation stated that "none of the published studies demonstrated an ideally reliable and safe way to induce rapid unconsciousness in large groups of pigs" [21]. This review missed a paper by Dutch researchers that was published in 1986 [22]. In this paper, Bert Lambooy described a high voltage electrical tunnel that pigs moved through on a moving conveyorized floor. It used 1000 volts and the pigs were killed when their heads hit an electrified curtain of chains. This is the only research study that has been published in the scientific literature [22].

2. Short-Term Easy to Implement Solutions to Reduce Future Severe Welfare Problems

The methods to reduce animal welfare problems discussed in this paper are based both on the scientific literature and practical experience the author has working with the livestock industry. Some of the areas I have worked in are, designing animal handling facilities, solving handling and stunning problems, conducting animal welfare audits, and training auditors. Other areas are writing welfare guidelines and serving on corporate animal welfare advisory committees. The emphasis in this next section is going to be on practical recommendations that would be reasonably easy to implement if a large numbers of pigs have to be depopulated on a farm.

2.1. Portable Electrocution Trailer Is a Viable Method for On-Farm Depopulation

Research studies on electrical stunning methods used in commercial slaughterhouses have shown that when a sufficient current is passed through the brain, pigs, cattle, and sheep will become instantly unconscious [23,24]. There have been two demonstrations that illustrate the potential of a portable electric method to be an economical and humane method for mass euthanasia of pigs on the farm. The demonstrations described below should be used as a starting point for the development of a scientifically verified portable electrical system. In 2011, the system researched by Bert Lambooy was demonstrated to the Canadian Swine Health Board at a Farm in Poland [25]. The system was installed inside a truck so it could be easily transported. There were some problems with getting a reliable electrode contact in the correct position. One of the problems was that pigs stepping onto the moving conveyorized floor were not restrained. They would be able to easily back out. In large commercial abattoirs that use electric stunning, the pigs are held in a conveyor restrainer. For either a manual or an automatic electric stunner, this holds the pig for more accurate placement of the electrodes. Large-scale existing electrical stunning systems have either a V-conveyor restrainer or a center track (belly) (monorail) conveyor system. These systems have been used commercially for many years.

Research has shown that a properly designed belly conveyor is a low stress way to restrain an animal [26]. To assess the stressfulness of restraint or problems with stunning, there should be a low percentage of pigs vocalizing with high pitched squeals [27] or cattle vocalizing [28]. These are easy-to-use outcome measures. Each animal scored as either vocalizing or silent.

A prototype trailer is being developed by Ruth Woiwode and Benny Mote at the Department of Animal Science, University of Nebraska. It consists of a V-conveyor restrainer from a commercial pork slaughter plant mounted on a trailer. It is equipped with electrode paddles, per the design in the expired patent by Grandin (1999) [29]. This design is simple to build and the author wants to make it very clear that the patent has expired. The design is now in the public domain. Anyone can use it. The pig's forehead is in firm contact with the paddles before the pig's front leg contacts the ground electrode. This provides the electrode position of forehead to upper foreleg. About fifty cull pigs, ranging from 220 (100 kg) to 600 (272 kg), have been successfully euthanized with the prototype. Since meat quality and prevention of petechial hemorrhages is not an issue, higher voltages and amperages can be used to insure death. Low frequency 50 cycle (Europe) or 60 cycle (North America) electric currents should be used. Low frequencies of 50–60 cycles are more effective for inducing both cardiac arrest and instant unconsciousness [30,31]. To insure instantaneous unconsciousness, an electric stunner must induce a grand mal epileptic seizure [32,33]. When really high voltages are used, such as 1000 volts in the Dutch apparatus, the seizure may not be visible because the spinal cord neurons are disrupted. The head electrode must never be applied to the neck because the current will bypass the brain [34]. For electrical safety, the unit can be housed in an enclosed trailer.

2.2. Slaughter Plant with Reduced Staff Can Produce Carcass Pork

A method that could be used to reduce both the number of pigs that had to be destroyed on the farm and the tremendous waste of food would be the production of either carcass pork or large cuts, such as loins, hams, shoulders, or bellies [35]. Before COVID-19 infected the U.S., there was at least one large pork slaughter plant that was exporting whole hog carcasses to China [36]. This clearly shows that this option is feasible. Producing these large cuts could probably be accomplished with less than half of the abattoir employees. When the meat cutting floor is shut down, the plant would still be able to run its slaughter line at maximum capacity. This does not require retooling of the plant, but to switch over quickly would require some advance planning. Portable conveyor equipment may be required to bypass the packaging equipment. The question that many people have asked is, "How would these carcasses or large pieces of pork be distributed and sold?". There are many places that have industrial-size kitchens that could be used to cut the meat up. Some of the examples are hotels, military bases, college dining services, and prisons. Many communities in the U.S., such as cattle ranchers would know how to cut up a carcass. Limited numbers of truckloads of meat could be sold to them. This could be accomplished with high standards of food safety. The carcasses would all be inspected by FSIS/USDA (Food Safety Inspection Service United States Department of Agriculture) because the pigs would be slaughtered in the large slaughter plant that already has FSIS/USDA inspection. In the U.S. and many other countries, chilled carcasses or large primal cuts are shipped all the time. Primal cuts are often transported in large plastic-lined boxes (combos) that fit on a forklift pallet.

3. The Big Is Centralized Supply Chain Fragile?

Many people will say big is bad. The real problem is that big is fragile [35]. The author has visited many large centralized pork slaughter plants. They can have excellent standards for both animal welfare and food safety. However, when a large pork slaughter plant is suddenly shut down there is a tremendous disruption of the supply chain [2]. The advantage of a large centralized supply chain is that it is extremely efficient [37]. When it is working correctly, the meat can be produced at a much lower cost [37]. The meat industry is not the only industry that has been disrupted by either COVID-19, bad weather, or some other disruptive event. Pharmaceutical supply chains are also very concentrated [38]. A disruption may have an effect on obtaining common generic medications. Container ships is another area where there are concerns about big being fragile. The largest ships can transport the equivalent of 10,000 truckloads of freight [39]. If something goes wrong, delays could be greater compared to several shipments on smaller ships. Telecommunications and internet infrastructure can also be damaged by floods, fires, or deliberate attacks. In the U.S., there was a recent bombing of a building housing centralized telecommunications equipment [40]. It housed landline, emergency, cellular, and internet services. Emergency communication and other services were disrupted up to 159 km away [40].

4. A Long-Term Solution Is the Creation of a More Distributed Supply Chain

COVID-19 has made many business leaders and producers realize that it may be wise to have a more distributed supply chains for many products. There have been numerous articles in the U.S. livestock and meat industry trade press about the need for more small slaughter plants [41,42]. Unfortunately, some of these articles are in livestock industry publications that are not readily available online. The demand for either modular or mobile slaughter facilities has greatly increased [41,42]. Consumers want more local food and producers need more small processing facilities [43]. In 2020, three or four groups of cattle producers have either started construction or have already built small and medium-sized plants [44,45]. These prefabricated units can also be expanded as the business increases. The units enable a group of pork or beef producers to more economically get a meat business started. There are two types of facilities for constructing smaller slaughter plants. They are the small prefabricated modular units and larger facilities that are built on site.

The modular units can process a few hundred animals per week. The large medium-sized new facilities could handle 100–900 animals per day [46]. This is still small compared to a large U.S. plant that processes 20,000 pigs or 5000 cattle per day. To achieve these high numbers, they work two shifts each day.

It is easier for the cattle ranchers to adopt a more distributed supply chain than large modern swine finishers that have large numbers of pigs reaching market weight each day. For the swine industry, the most practical emergency option would be processing whole hog carcasses. Outlets for the carcasses need to be determined in advance. One possibility would be to use the services of meat science students and volunteers to cut them up for distribution to emergency food programs. People were going hungry during the COVID-19 pandemic and the meat from these animals could be used in these programs.

Small Slaughter Houses Have to Have a Specialized Market to Be Profitable

To be profitable, small slaughter plants cannot compete on a cost basis with the largest slaughter plants. They need a specialized market where they can charge a higher price for a premium product. Some of the niche markets are grass-fed beef, high welfare outdoor pigs, pork produced on family farms, special sustainable practices, or a specific breed of animal [47,48]. Another niche is ethical local meat. In the U.S., Niman Ranch is a very successful niche market of high welfare pigs [49]. Many consumers are also concerned about the number of people that got sick and died in the large plants. This welfare of people is also an issue in the minds of consumers.

The author has been in the U.S. livestock industry for almost fifty years. In the 1980s and 1990s, she observed the sad fate of many medium-sized slaughter plants when they attempted to directly compete for the same customers with the larger plants. Plants in California, Colorado, Arizona, and Texas went out of business because they could not achieve the low per animal costs of the huge plants. There is a tradeoff. A centralized huge supplier is really economical but fragile when it is disrupted by a pandemic or storms. A more distributed supply chain is more robust, but the products will be more expensive. In the U.S. a combination of COVID-19, forest fires, and storms that cause severe flooding have made many consumers more concerned about their food security [50]. This may motivate more consumers to buy local.

5. Effect of COVID-19 on Animal Welfare Audits Conducted by Large Meat Buyers

For the last twenty years, large buyers of meat in the U.S. have been inspecting and auditing animal welfare at their suppliers. Large retailers are increasingly putting an increasing emphasis on the importance of regular welfare audits [51]. The author assisted in the development of some of the first audits of large U.S. slaughter houses [52]. The audits were started in 1999 and they resulted in huge reductions in electric prod use, and improvements of both handling and stunning. Captive bolt stunning was greatly improved by better stunner maintenance [53]. Handling of both cattle and pigs was also improved by repairs of handling equipment, installation of non-slip flooring, employee training, and other simple changes such as illuminating the entrance of a restrainer to facilitate animal entry [53]. In the U.S., the largest improvements occurred when large meat buyers demanded them [52]. Over the years, more and more buyers have started inspections and industry organizations have responded by both writing guidelines and starting training programs.

The next step in the early 2000s was the formation of PAACO (Professional Animal Auditor Certification Organization) [54]. PAACO is a consortium of meat buyers, academics, professional, industry, and veterinary organizations. Its purpose is to provide training and certification of animal welfare auditors. Another function is reviewing animal welfare guidelines that are written by livestock industry associations. The author is a PAACO instructor on animal welfare at slaughter. When COVID-19 stopped almost all the business travel in the U.S. PAACO auditor training was instantly converted to virtual on-line. The author has participated in these virtual programs. The two slaughter plant visits, which were originally part of these classes, were cancelled and replaced with video tours. This was the definite downside of switching to digital. There were some advantages. Previously, a typical PAACO animal welfare auditor training class for either slaughter or welfare on the farm had about 20 students. The classes were kept small to facilitate in-person training at farms and slaughter plants. When the training classes were switched to digital, the size of the classes tripled. More students enrolled from other countries. Online classes made animal welfare training available for more people. COVID-19 problems in the U.S. have kept PAACO classes online through the time of writing this article in January 2021.

In April and May 2020, third party independent welfare audits and audits by meat buyers were forced to convert to online virtual [55]. The large slaughter plants banned outside visitors to prevent the spread of COVID-19. Some people in the meat industry have told the author that welfare audits of farms and slaughter plants can be kept entirely virtual. The author does not agree with this. From her extensive experiences with being an animal welfare auditor, she has learned that there are too many ways to cheat. Some cheating methods that the author has personally observed are falsified scores where they were "too good", electric prodding of cattle just outside the view of the video camera and fake electrical meters on a pig stunner. This was done to mask the use of low electrical amperages that were not effective. It is the author's opinion that the audits could be made partially digital. This would be especially true for a farm or slaughter plant that an auditor has visited many times. The auditor could have a plant or farm employee walk around with a smart phone and livestream video of the parts that needed to be assessed. For an initial visit, an in-person visit would be essential to help prevent either livestock producers or slaughter managers from hiding hidden areas. Since 2008, a commercial auditing company in the U.S. has been using remotely viewed cameras installed in the abattoirs to monitor handling and stunning [56]. These cameras are connected with a hard wired internet connection. Due to COVID-19, some plant managers have now become more open to allowing buyers and customers access these video feeds.

When it works, the high quality of some of the video is amazing. The author has had the opportunity to do some consultation on both pig handling and determining if an animal was unconscious over an internet connected video link. It worked surprisingly well. Videos of pigs moving through a handling facility showed both really good low stress handling of pigs and poorer methods when the number of pigs moved at one time was too large. These videos would also be really useful for training employees. The downside is that in some rural areas of North America, internet service is poor and live streaming video from either a slaughter plant or farm either works intermittently or completely fails. This is especially a problem when auditing is done by having a plant employee walk through a plant with a mobile phone on cellular service. The video will often stop due to either a poor cellular signal or failure of the cellular signal to penetrate areas of the plant constructed from thick concrete or steel.

The author would be really concerned about welfare if there was an attempt to replace all in-person auditor visits with video. This would be especially a problem for welfare auditors and inspectors who have had little or no experience out on farms or in the plants. COVID-19 has forced both slaughter plant and farm management to become more cooperative about having video cameras in their facilities. The author predicts that the number of in-person audits could be reduced by the use of remote video. Total replacement of in-person visits would be a grave mistake.

6. Long-Range Thoughts on Food Supply Chains

There is a tendency for networks to form hubs, whether they are in Gingko trees, ferns, airline hub airports, or supply chains for the distribution of goods [57]. Ruth DeFries, a professor of ecology at Columbia University, explains that primitive plants, such as the Gingko, rely on a system of veins that depend on the minimum number veins to supply water to the leaves [56]. This system is fragile and the supply of water and nutrients can be easily cut off when the leaf is damaged. Modern plants have a "loopy network", which has more redundancy because there is more than one pathway through the vein network. Modern plants evolved this more expensive network with extra veins to make the leaves less vulnerable to vein damage. In the airline industry, a hub and spoke system is efficient, but when a snowstorm disables a major airport, a large part of the entire system will have delays. We should learn from the evolution of plants and develop more distributed food supply chains. A recent editorial in the journal Nature states that the majority of scientific research is not relevant to insure food security to small farmers [58]. The editor concludes that research is needed to support small farmers. There is also a need to support both small farmers and small processing facilities to create a robust food production network. This principle applies to all foods.

Willy C. Shih wrote in the Harvard Business Review that to make supply chains for any product more robust requires either a diversity of sources or warehousing of key components [59,60]. Pigs are not electronics or industrial components that can be stored. The only sensible solution to prevent a repeat of an animal welfare and food waste disaster is a more diversified supply chain.

7. Conclusions

It is essential to develop programs so that large numbers of healthy pigs will not have to be destroyed on the farm due to a loss of slaughter capacity. If large numbers of pigs have to be euthanized on the farm, a portable electrical stunning system may be the best option. It can maintain the same high welfare standards that are required for electric stunning in a slaughter plant. From both a sustainability and animal welfare standpoint COVID-19 was a disaster for the pork industry. One solution is to develop a less centralized, more diversified options for pig slaughter and processing. The U.S. beef and poultry industries were less affected because it is easier to slow down the growth of cattle and chickens have a shorter life cycle. COVID-19 also revealed how international supply chains are dependent on each other.

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Conflicts of Interest: None directly related to this paper. The author does work as a consultant to the livestock industry and for a video auditing company.

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Attachment 3

Pork Board Research Report on Electrocution for Depopulation of Piglets, July 2020

RESEARCH REPORT

ANIMAL WELFARE

Title: Application of Electrocution in Suckling Pigs for Mass Depopulation, **- NPB #20-117**

Investigator: Clayton Johnson, DVM

Institution: Carthage Veterinary Services, LTD

Date Submitted: July 31, 2020

Industry Summary: Project Objective #1 evaluated the effectiveness of the Best & Donovan Hog Stunner ESS for depopulation of weaned pigs from a commercial breed to wean facility. Within this evaluation a feed cart was utilized as a temporary holding area taking advantage of this commonly found piece of equipment's' plastic walls and floor along with rubber tires to minimize the risk of human safety. We found the "V-shaped" position of the probe works excellently for positioning the probe directly behind to the pig's ears and found this placement to be 100% effective at immediately rendering the pig insensible and ~99% effective at simultaneous euthanasia. While attempts were made to place the stunner probe simultaneously to the head and chest area, we found this positioning to be difficult at best and impossible for most medium to large sized weaned pigs given the fixed position of the probes. Electricity was delivered to piglets at the lowest possible voltage of 360 volts for a period of 3-8 seconds per attempt with no noticeable difference in effective euthanasia rates at any different periods of application. Pigs which were well wetted down prior to electrocution had minimal electrical arcing and its associated burning of skin and hair, but failure to adequately wet down the pigs will result in the smell of burnt hair due to electrical arcing. Using this procedure, we were able to successfully euthanize ~5 piglets/minute or ~300 piglets/hour using a team of 3 individuals. There is no blood associated with the procedure and it is much more worker friendly than alternative piglet depopulation methods with which our team has personal experience.

Project Objective #2 is to develop a list of Best Practices to share with the industry, please find this document listed as Appendix 1 with this Final report.

For additional information regarding this project, please contact Dr. Clayton Johnson at johnson@hogvet.com.

Key Findings:

- Electrocution is an effective, safe and welfare friendly means of mass euthanasia of due to wean piglets at a Breed to Wean farm.
- The Hog Stunner ESS machine is easy to use, portable and quick to set up at any pig farm using an existing 110 volt outlet.
- Piglet restraint can be easily accomplished using commonly found equipment and supplies including a feed or piglet cart.
- Electrocution using commercial stunning machines is an effective and safe means of mass piglet euthanasia with easy set up using commonly found barn supplies and equipment.

Keywords: Piglet, Euthanasia, Depopulation, Electrocution, Hog Stunner ESS

Scientific Abstract: Commercial electrocution equipment is commonly utilized to render market pigs insensible at packing facilities. This same equipment is available for purchase by pig producers and can be used on farm in depopulation situations. The Hog Stunner ESS from Best and Donovan was acquired and utilized to depopulate due to wean piglets from a commercial Breed to Wean farm. Our observations were that electrocution using the Hog Stunner ESS was a safe and rapid way to conduct mass euthanasia, requiring minimal training and only supplies and equipment already commonly found on most U.S. pig farms.

Introduction: The pork supply chain relies on moving pigs from one phase of production to the next. Regular movement of pigs is critically important for Breed to Wean farms which have limited space to house their piglets. As growing pig farms have been forced to hold pigs due to COVID-19 induced marketing disruptions, some Breed to Wean farms have been forced to mass depopulate due to wean pigs to create farrowing space for incoming pregnant sows. While there are several approved methods of mass depopulation of due to wean piglets, very few are practical for on-farm application. Electrocution is an approved method and while commercial electrocution equipment is not available on most Breed to Wean farms, it can be easily purchased and rapidly set up for use in farm.

Objectives: While commercial equipment is available, best practices for use in mass piglet euthanasia are lacking. Our proposal has 2 primary objectives:

1. Evaluate the effectiveness of a commercially available electrical stunner (Best and Donovan Hog Stunner ES) for euthanizing due to wean piglets in a commercial breed to wean facility. Euthanasia effectiveness along with throughput metrics will be evaluated and recorded.
2. Develop a set of recommended Best Practices for dissemination to the commercial industry that can serve a guide for implementing electrical stunning as a mass euthanasia method for due to wean piglets.

Materials & Methods: A field trial was performed at a 6400 head commercial Breed to Wean facility using the Hog Stunner ESS to electrocute ~4000 due to wean piglets. Within this facility a temporary holding alley was utilized using a feed cart with plastic walls and floors. Piglets were euthanized by a licensed veterinarian using attempts with both the one step method of passing electricity through the brain and heart simultaneously as well as the two-step method of passing electricity through the brain initially and heart secondarily as needed based on the need for a secondary step to complete euthanasia. For the 1 step method the probe of this stunner was be applied simultaneously to the head area and approximately 6” behind the head, near the level of the thoracic/lumbar spine for no less than three seconds and within 15 seconds of stunning per AVMA Guidelines for Depopulation of Animals. A minimum of 0.5 amps and 110 volts at a 60 hertz current frequency was utilized, consistent with AASV recommendations for On Farm Euthanasia of Swine. Assessment of efficacy in stunning and euthanasia was made by the absence or presence of tonic and clonic movements. If the one-step method was not effective, then alterations were be made to employ a two-step method of stunning via electricity through the brain then euthanasia via electricity through the heart for piglets not euthanized passing electricity through the brain alone. Additionally, all piglets will be wetted down with a fan tip and low-pressure hose prior to euthanasia. Time metrics were tracked regarding the number of piglets that can be euthanized per minute utilizing this method and number of personnel required. Pictures and video were be recorded to support further education regarding these procedures.

Results: While the consistent application of the one step method passing electricity through the brain and heart simultaneously was deemed to be impractical if not impossible early in the field trial, the two step method was extremely effective with ~1% of piglets needing a secondary electrocution attempt of the thoracic region to complete euthanasia. The process was perceived to be extremely humane by all involved and an improvement relative to our collective experiences using alternative techniques for mass depopulation of due to wean piglets. The Hog Stunner ESS was able to be used leveraging only the instructions and training materials supplied by the manufacturer, and worked consistently throughout each depopulation event. A team of three was able to effectively euthanize piglets at a rate of 5 piglets/minute or 300 piglets/hour. A set of recommended best practices was developed and is presented in Appendix 1 of this document for industry utilization.

Discussion: Electrocution is a humane and approved method of both euthanasia and mass depopulation of swine. Commercial euthanasia equipment is readily available for purchase and can be utilized with minimal training and without need for additional outside supplies or equipment. Assuming biosecurity is acceptable, the commercial euthanasia equipment is portable and could be leveraged across multiple farms if needed. Electrocution using the Hog Stunner ESS is a viable, practical and safe form of mass depopulation for due to wean piglets.

Appendix 1: Best Practices

Supplies & Equipment Required:

- Commercial Stunning Transformer & Wand
  - Hog Stunner ES & ESS is a viable option, Manufactured by Best & Donovan, 5570 Creek Road, Cincinnati, OH 45242, 1-800-553-2378
- Heavy Duty Electrical Drop Cord (if no outlet within 10 feet of Depopulation Location)
- Heavy Duty Hose & Wand with "Shower" Setting
- 4 x Feed/Pig Moving Carts

Personnel Required:

- 3 People Total Working in an Assembly Line Flow
  - 1 People gathering and delivering pigs to Depopulation location
  - 1 Person operating equipment and performing the Euthanasia
  - 1 Person confirming insensibility and death, removing dead pigs from carts

Depopulation Area Setup:

- Clean the area to allow easy movement of Feed/Pig Moving Carts into within and out of the area
- Connect the hose to the nearest available water outlet and attach the wand
  - Set wand to "Shower" setting
- Plug in the Commercial Stunning Transformer & Wand into a regular 110 outlet
  - Turn Voltage setting to lowest setting
  - Ensure timer is set for a minimum of 3 seconds

Procedure:

- Gather piglets into Feed/Pig Moving Cart not to exceed 0.67 sq ft/pig stocking rate (no piling of pigs, maximum 1 layer deep)
- Move piglets in Feed/Pig Moving Cart to Depopulation area
- Wet pigs down using "Shower" setting immediately prior to euthanasia
- Identify the pig who's head and neck are located furthest from other pigs in the cart, place the "V-shaped" end of the prod directly behind the pig's ears, sliding the prod down until it is fully in contact with the pig's head and neck
- Press the button on the wand to allow electricity to flow uninterrupted for a minimum of 3 seconds, repeat this process for all pigs in the cart
- Pass the cart to the person in charge of confirming insensibility and death, if any pigs are deemed to need a second attempt, remove them from this cart return the cart to the person actively performing electrocution for a second attempt
- When all euthanasia is complete, completely unplug the wand and transformer, storing them in separate locations until the next depopulation event

ESS Electrical Stunner: A Tool for Wean Pig Depopulation

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- Manufactured by Best & Donovan
- 40lbs total, 3lb wand
- Designed for market hogs as well as sheep/other animals
- Requires standard residential 110V grounded outlet

Current SOP

Staffing

- 1 people inside farm, one outside person running tractor
- 1 people filling carts with wean pigs from holding room, farrowing room
- 1 person running machine-veterinarian or senior production staff
- 1 person confirming insensibility and death, removing dead pigs from carts to tractor

Current SOP

<u>Process</u>

- Assembly line approach
- Feed carts loaded with one layer of pigs (~6-7 depending on size)
- Pigs sprayed with water prior to euthanasia using garden hose
- Prod placed behind ears to ensure electricity flows through the brain rapidly inducing insensibility
- Pigs electrocuted for 3-5 seconds individually avoiding contact with remaining sensible pigs

Current SOP

Process

- Piglets left in cart for ~5 minutes post euthanasia until agonal breathing has ceased
- Post euthanasia monitoring performed by trained, dedicated worker to ensure insensibility
- Pigs with signs of sensibility are returned to previous step for additional application
- Pigs handled twice: placed in cart on front end, removed as last step

Current SOP

1. Pre Loading Carts (2 people)

2. Application of Electrocution (one person)

4. Removal (one person)

3. Post Application Monitoring (one person)

Process Timeline

- Preload carts- 5 minutes
- Application of electrical stunning- 3-5 seconds
- Post application monitoring- 5 minutes
- Time to stop vocalization- immediately post application
- Time to stop movement- 1-5 minutes, coordinated movements stop immediately when applied correctly
- Removal of cart- 20-30 seconds
- Total time: ~10 seconds per pig
- 300 pigs/hour peak efficiency

Efficiency

- Can euthanize up to 2000 pigs per day, two shifts recommended
- Percent survivability- about 1% require additional application of electricity, not necessarily sensible
- Utilizes hose, feed carts already found on farm, only additional equipment is device itself

Lessons learned

- Best time to do is evening/late afternoon after regular farm staff have completed sow movements/weaning
- Rate limiting steps are application of electricity and filling carts

Cost Per Pig

- ~$3100 for Device
- Electricity usage is negligible
- Main cost is labor to administer device

Human Safety Concerns

- Device designed to kill
- No touching of applicator end of wand at any time while plugged in
- Completely unplugged when not in use, wand stored separately
- All-in all-out of feed cards during process

CVS

Human Welfare/Mental Health

- Subjectively better than blunt force trauma
- Minimal blood (also good for FAD applications)
- Smoking an issue if pigs are not properly wetted down prior to application
- Additional fans for ventilation
- Music for participants?

Attachment 4

Pork Board Research Report on Electrocution for Depopulation of Pigs (125-600 lbs.), December 2020

RESEARCHREPORT

ANIMAL WELFARE

Title: Validation of a Mobile Electrocution System for Humane Mass Depopulation of Swine – **NPB #20-123**

Investigator: Benny Mote

Institution: University of Nebraska-Lincoln

Date Submitted: December 31, 2020

Industry Summary: During the Spring of 2020, the US Pork industry experienced unprecedented supply chain interruption because of packing plant closures and slowdowns. While the industry quickly adapted feed rations to slow pigs' growth rate, some producers ran out of time and space and were forced to euthanize pigs. This crisis revealed the fact that other than sending pigs to harvest, the US was unprepared for humane mass depopulation of pigs on farm. Therefore, humane and approved methods are needed that can operate on-farm with high throughput capacity, that would allow for sites to be depopulated quickly. To this end, we proposed to adapt electrical stunning techniques once utilized in harvest plants into an automated, single step electrical euthanasia system that is fully mobile. The objectives of the project were: 1) To validate an AVMA-approved method of humane euthanasia for on-farm application, to ensure the same standard of welfare is met during mass depopulation events that is provided under federally regulated conditions in slaughter plants. 2) To provide real-time industry assistance with mass depopulation while gathering data that will be used to develop SOPs and infrastructure for future crises. 3) To develop a unit that can be replicated for national preparedness and response to catastrophic events on farm that may be considered for addition to the USDA stockpile. The investigators used an expired patent for an auto-stunner that had been designed for slaughter plant use as the starting point for the project. Under slaughter conditions, electrical stunning is accepted as a humane method of rendering swine immediately unconscious, but a second step is required to prevent return to sensibility and ensure death. The aim of this project was to validate automated electrocution as a humane, single step method for on-farm euthanasia on a large scale.

A brief description of the mobile unit is as follows. A v-belt restrainer was mounted onto a 30' flatbed gooseneck trailer. At the rear of the trailer is a lead up chute that is chute/dock height. The electric components and the electric drive unit for the hydraulic are mounted to the front of the trailer and powered by connecting to a 3 phase 220-volt power source with 30

amps. A negative contact was positioned to make contact with the left legs of the pigs as the restrainer moved them through the unit. An insulated paddle is lined on one side with a steel contact plate for the hot positive contact point. The pigs enter the unit via the lead up chute, transition into the restrainer which carries them forward to make contact with the negative contact bar followed by the hot paddle. When the pigs are in contact with both the negative contact bar and the hot paddle, head to heart electrical euthanasia occurs with a single step. By introducing the current across the head, instantaneous unconsciousness occurs, and the body contact achieves fibrillation (cardiac arrest). Pigs maintain the contacts for a minimum of 3 seconds. The restrainer carries the pigs to the end of the restrainer where they transition onto the exit slide and are discharged from the trailer.

The unit was not completed in time to assist with depopulation, which was objective #2. Sixty pigs ranging in weight from 125 pounds to ~600 pounds were processed through the unit for validation. 56 of the 60 pigs were euthanized with the single step automated electrocution as designed. The four pigs that required the use of a secondary method to ensure death pointed to size limitations (lower limit) or the need for a lower hold down apparatus, not a design issue with the use of automated single step electrical euthanasia. The investigators were extremely pleased with the ability of the electrical contacts to apply and maintain good electrical contact as the pigs were transported on the restrainer, even on mature Duroc boars with thick coarse hair. The above leads investigators to be extremely pleased with progress towards objectives 1 and 3. Farm staff that observed the use of the mobile unit all preferred its use vs their standard farm protocols of euthanasia.

The most important contribution this project has to pork producers is the validation of hands-free single step electrical euthanasia in a mobile unit on pigs ranging from 125 pound to ~600 pounds. While pork producers now have access to one operation unit, the process that has been undertaken on this project ensures the unit can be copied by other companies/government agencies to make their own unit(s). The fact that it does not require a human to apply the euthanasia holds great promise for worker mental health. Additionally, as it is extremely quick and bloodless, the visual aspects are also of importance for worker mental health. The unit also is designed in such a way to minimize the number of workers needed on site and greatly reduces the need for workers to move animals. All told, this is a safe, highly effective mobile unit that can perform hands free single step electrical euthanasia with minimal staff needed and to perform a necessary task in the most humane and mentally acceptable manner possible.

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Key Findings:

- Single-step electrocution may be considered for humane euthanasia
- The emotional impact of euthanasia on animal caretakers may be reduced in this system
- Anecdotal feedback from personnel trained to perform captive-bolt euthanasia suggests their preference for this method over HHCB

Keywords: auto-stunner, electrocution, euthanasia, depopulation, swine

Scientific Abstract:
During the Spring of 2020, the US Pork industry experienced an unprecedented supply chain interruption because of packing plant closures and slowdowns. This crisis revealed the fact that other than sending pigs to harvest, the US was unprepared for humane mass depopulation of pigs on farm. If the US were to experience a foreign animal disease outbreak such as ASF or FMD, livestock would not be allowed to be transported off the farm for euthanasia. The challenges encountered by the industry pointed to the need for more work developing humane methods of depopulation specifically for on-farm use, that can accommodate large numbers of animals. Therefore, humane and approved methods are needed that can occur on-farm with high throughput capacity, to allow for sites to be depopulated quickly. To this end, we proposed to adapt electrical stunning techniques once utilized in harvest plants into an automated, single step electrical euthanasia system that is fully mobile.
The investigators used an expired patent for an auto-stunner that had been designed for slaughter plant use as the starting point for the project. A brief description of the mobile unit is as follows. A v-belt restrainer was mounted onto a 30' flatbed gooseneck trailer. At the rear of the trailer is a lead up chute that is chute/dock height. The electric components and the electric drive unit for the hydraulic is mounted to the front of the trailer and is powered by connecting to a 3 phase 220-volt power source with 30 amps. A negative contact was positioned to make contact with the left legs of the pigs as the restrainer moved them through the unit. An insulated paddle is lined on one side with a steel contact plate for the hot positive contact point. The pigs enter the unit via the lead up chute, transition into the restrainer which transports them forward to make contact with the negative contact bar followed by the hot paddle. When the pigs are in contact with bot the negative contact bar and the hot paddle, head to heart electrical euthanasia occurs with a single step. Pigs maintain the contacts for a minimum of 3 seconds. The restrainer continues to transport the carcasses to the end of the restrainer where they transition onto the exit slide to be discharged from the trailer.
Sixty pigs ranging in weight from 56 kg to ~272 kg was processed through the unit for validation. 56 of the 60 pigs were euthanized with the single step automated electrocution as designed. Four pigs required the use of a secondary method to ensure death. The four pigs that required the use of a secondary method to ensure death pointed to size limitations (lower limit) or the need for a lower hold down apparatus. The electrical contacts applied

and maintained sufficient electrical contact as the pigs were transported on the restrainer, even on mature Duroc boars with thick coarse hair. Though not a measurable outcome, farm staff that observed the use of the mobile unit all preferred its use versus their standard farm protocols of euthanasia. The mobile unit was found to be effective in performing hands free single step electrical euthanasia with minimal staff needed and to perform a necessary task in the most humane and mentally acceptable manner possible.

Introduction:

Lambooy and van Voorst (1986) conducted electrocution experiments under laboratory conditions, where a chain curtain served as electrodes, and a metal floor was the negative contact. One limitation identified was that pigs could turn around, and if the chains initiated contact with the hindquarters of the pig rather than the head, insensibility was not immediately achieved, and pigs were left recumbent but not euthanized. Preliminary work in the US (Probst-Miller, 2010) provided the framework for on-farm electrocution as a humane method of depopulation of neonate pigs. Shortly after this, Douma, et al. (2012) described testing of a mobile unit for electrocution of market-weight hogs. This study cited gaps in ensuring consistent delivery of electrical current to pigs entering the system, including the introduction of electrical current to locations other than the head initially, resulting in a failure of this system to reliably render pigs immediately unconscious. A recent systematic review of existing methods of swine depopulation refers to depopulation by electrocution when approximately 700,000 pigs were eradicated in the Netherlands during a CSF outbreak. While the articles included in the review (Arruda, et al., 2020) do not include a description of the euthanasia device, it was described as an automated system mounted on a truck, consistent with the features of the original Lambooy and van Voorst system. Despite this successful testing and use, electrocution as an option for humane depopulation has not been adopted for wide on-farm use in the United States.

During the Spring of 2020, the US Pork industry experienced an unprecedented supply chain interruption because of packing plant closures and slowdowns. Hundreds of thousands of pigs were market weight and ready to harvest, but the plants were not able to take them. While the industry quickly adapted feed rations to slow pigs' growth rate, some producers ran out of time and space and were forced to euthanize pigs. This crisis revealed the fact that other than sending pigs to harvest, the US was unprepared for humane mass depopulation of pigs on farm. Not only were producers unprepared, but the USDA stockpile resources for producer support only included hand-held captive bolt guns, which is not a practical solution for FAD response. During the 2020 crisis, documented depopulation methods used by the industry include ventilation shutdown plus, captive bolt, and gunshot, though many additional methods were explored. In some instances, pigs were transported offsite for euthanasia in plants that operated only for emergency euthanasia and did not harvest pigs euthanized under those circumstances. If the US were to experience a foreign animal disease outbreak such as ASF or FMD, livestock would not be allowed to be transported off the farm for euthanasia. The challenges encountered by the industry pointed to the need for more work developing humane methods of depopulation specifically for on-farm use, that can accommodate large numbers of animals. Therefore, humane and approved methods are needed that can operate on-farm with high throughput capacity, that would allow for sites to be depopulated quickly. To this end, we proposed to adapt electrical stunning techniques once utilized in harvest plants into an automated, single step electrical euthanasia system that is fully mobile.

Objectives:
The objectives of the project were:

- To validate an AVMA-approved method of humane euthanasia for on-farm application, to ensure the same standard of welfare is met during mass depopulation events that occurs under federally regulated conditions in slaughter plants
- To provide real-time industry assistance with mass depopulation while gathering data that will be used to develop SOPs and infrastructure for future crises.
- To develop a unit that can be replicated for national preparedness and response to catastrophic events on farm that may be considered for addition to the USDA stockpile.

Materials and Methods:
The investigators used an expired patent for an auto-stunner that had been designed for slaughter plant use as the starting point for the project. Under slaughter conditions, electrical stunning is accepted as a humane method of rendering swine immediately unconscious, but a second step is required to prevent return to sensibility and ensure death. The aim of this project was to validate automated electrocution as a humane, single step method for on-farm euthanasia on a large scale. To accomplish this, the unit needed to be mobile and versatile. The investigators decided to build the unit on a new 30-foot tandem axle (15,680 GVW) classic flatbed trailer, which can be pulled by a ¾ ton or 1 ton pickup, making it easily deployable should the need arise for its use. This allows for onsite euthanasia in the event of a foreign animal disease outbreak or it can be set up at a regional site. A reconditioned v-belt restrainer was mounted on the flatbed trailer, and an 8-foot single-file lead up chute was constructed on the back of the trailer. The chute entrance is 48 inches from the ground to accommodate most loading docks. The positive contact of the auto stunner is a stainless-steel plated, insulated swinging paddle suspended at head-height over the v-belt restrainer. The negative contact is stainless steel pipe, 1.5 inches in diameter and 36 inches long that is fixed an inch below the bottom of the belt on the stationary side of the restrainer and protrudes ¾ inch into the center of the restrainer. Having the negative contact a set length where full contact occurs allows for the restrainer speed to be adjusted up or down to allow the operator to precisely control the amount of time that pigs maintain contact with the complete circuit.

The unit can be operated by wiring into a three-phase, 220-volt power on site, or a 20kw generator capable of producing 30 amps can be rented. It is critical to ensure when using on-site power, that 220 volts are delivered since it is not guaranteed to produce 220 volts. Additionally, pigs must be wet down prior to entry into the restrainer to ensure maximum electrical conductivity, so having access to water is mandatory.

Trailer setup: The trailer should be backed into place (loading chute, facility dock, or site for semis to back up to). The electrical contacts for the “hot paddle” and the negative bar should be checked to ensure they are tight. The metal plate on the hot paddle and the negative leg bar should be cleaned with wire brush to ensure they are clean and rust free to maximize electrical conductivity. The trailer should be disconnected from the pickup so that the trailer can be stabilized with the dual 12,000-pound jacks up front. Jacks are also in the storage compartment under the lead up chute to be placed at the rear of the trailer for extra stability. The unit should be grounded for extra security by connecting the copper ground wire to the ground lug on the restrainer leg to the copper ground rod that should be driven into the ground a minimum of three feet. Note, if operating the unit in the winter with frozen ground, it is suggested to drill a 0.5” hole to a point below the frost line to make it easier to drive the ground rod into the ground. The ground around the ground rod should be fully wet down prior to energizing the unit. With all breakers on the trailer turned to the off position, the 5 wire electrical leads (3 hot, 1 neutral, and 1 ground) should be connected by a qualified person to either the power source (3 phase 220-volt generator or on-site power supply). Using the supplied voltage testers, multiple spots on the trailer should be checked for stray voltage prior to turning on the breakers or anyone being on the unit. The unit should be checked for stray voltage again once the breakers for the hydraulic motor/pump are flipped on. The motor on the hydraulic drive unit has arrows labeled on it to indicate the proper direction for the motor to rotate. Should the motor rotate in the opposite direction, any 2 of the 3 hot wires can be switched to make the motor rotate in the proper direction. The restrainer belts should be turned on and allowed to move for a few minutes to warm up. Each side of the belt should be timed to ensure the belts are running at the same speed to ensure the pigs move through the unit smoothly. If the speed of the belts are different, it should be adjusted. The speed of the restrainer should be set such that it ensures the pigs maintain a complete electrical circuit for a minimum of 3 seconds. The minimum and maximum speed will therefore be different depending on the length of the pigs with smaller pigs needing a slower speed to ensure a 3 second contact. Once these steps are complete, the unit is ready to run.

Trailer operation: It is recommended to have one person loading pigs into the lead up chute on the trailer. The pigs can either be wet down in the lead up ramp by a person or hoses/sprinklers can be set up to do this step automatically. Ideal pig flow into the restrainer should be such that pigs do not try to stack on top of each other. One person located on the trailer can control both the flow of pigs into the restrainer and the controls to the restrainer and the electricity for the euthanasia. This person should/can immediately stop the unit if a pig is not fully electrocuted prior to discharge from the restrainer. Ideally another person should be stationed at the front of the trailer to check for proper euthanasia and they can stop the unit via the breaker box should they identify a need to stop the unit. Further personnel/vehicle needs are for the removal of the carcasses once they exit the trailer. This can be accomplished either by using loader buckets placed to catch/scoop carcasses and place them into rendering trucks. If mass depopulation is occurring, efficiency of the operation will be increased by placing a portable conveyor belt under the discharge slide to catch the carcasses and deposit them directly into waiting rendering trucks.

Validation of unit: All pigs were monitored for vocalization, gasping/agonal breathing, corneal reflex, and menace test to aid in confirmation of insensibility and death. Further, ECG leads were applied to each pig following discharge from the restrainer with a hand-held ECT monitor used to monitor for the absence of the QRS complex to aid in the confirmation of death. The unit was placed into operation on four occasions as modifications were made to the unit. The first three deployments were at UNL’s swine research facility and the fourth deployment was at a commercial cooperator site. During the first deployment, six pigs were euthanized with size ranging from 125 pounds to 440 pounds. Each pig was placed into the unit one at a time to allow for confirmation of insensibility and death and to allow for ongoing analysis after each pig. Modifications were made as necessary after each pig. As the first pig did not make sufficient contact with the electrical contacts, captive bolt was used as a secondary euthanasia method. Adjustments were made to the height and resistance of the hot paddles for better contact. All other pigs did not need a secondary method of euthanasia. Modifications made during/after this run included adding straps to ensure a “tighter” contact with electrical paddles, removal of plastic at the bottom of the hot paddles to help maintain a better electrical contact as pigs moved through/under the paddles, wrapping the bottom of the hot paddles with stainless steel to ensure contact as pigs moved through the unit/under the paddles, designed and installed the 36" bar for negative electrical contact, and reduced the height of the exit ramp to allow the pigs to not hang up upon exit. The second deployment was tested on 5 pigs ranging in weight from 135 pounds to 550 pounds. All pigs were euthanized with the single step hands free electrocution process as designed. Modifications suggested from this deployment included moving the negative contact bar slightly further under the restrainer, from being 1.25" of the pipe exposed to 0.75" exposed. Additional modification was needed on the exit slide to keep carcasses from hanging up on the ramp and a transition slide was needed. Replacement of the hydraulic motor on the driver side of the restrainer was needed as a seal went out during this test. Deployment of the trailer for a third time was for a single boar weighing 500 pounds to validate the placement of the negative contact bar and the exit of the carcasses from the unit. The boar was euthanized with the single step hands free electrocution process as designed and the boar exited the unit without hanging up. The fourth deployment of the trailer was the largest conducted with 48 pigs. No weights were gathered but were estimated to have a weight range of 140 pounds up to approximately 600 pounds. Set up time was roughly one hour to have the unit fully operational. Forty-five pigs were euthanized with the single step hands free electrocution as designed including all pigs weighing over 300 pounds. The three pigs that were not euthanized with the single step process did not ride in the restrainer as designed. Two of the pigs jumped up on the side of the restrainer belt prior to losing contact with the floor with their front legs and thus did not make a complete head to heart electrical circuit. Modification to the hold down bars and a shortened decline ramp into the restrainer will prevent this from happening in the future. The third pig that was not euthanized with the single step electrocution was a "bloater pig." The large belly on this pig caused the pig to rock forward and not come in contact with the electrical contacts properly. This indicated the lower size limit of the unit to be more based on the natural width of the pigs rather than actual weight.

The width between the two restrainer sides should be set to 6" (minimum current distance of the unit) for pigs weighing between 125 pounds and ~400 pounds. Pigs at the bottom end of this weight range should be put into the unit with caution as the width of the pig is important to keep them from falling through. For pigs over ~400 pounds, the restrainer should be widened to 8" for the larger pigs to "ride" lower in the v-belt. Large (width) sows and boars tend to "ride" higher in the restrainer thus changing the angle of the contact with the hot paddle. The hot paddle is adjustable in both the distance from the negative contact bar and the height up and down in the restrainer. For animals weighing less than ~350 pounds, the hot paddle should be slid as close to the negative contact bar as possible. For animals weighing over ~350 pounds, the negative contact bar should be slid as far away from the negative contact bar as possible ensuring the larger animals are in sufficient contact with the negative contact bar prior to engaging the hot paddle and thus decreasing the incidence of "hot wanding." The ideal height of the hot paddle should be set such that it first contacts the bridge of the nose vs the nose itself. This ensures a more stable contact as pigs tend to go rigid when electricity is applied and that motion pushes the hot paddle causing a momentary loss of contact with the hot paddle if the hot paddle touches the tip of the nose first.

Results:

Due to complications with university policy on payments (amount of time to make payments typically in the range of 3 weeks) and the university slowdowns with almost all accounting personnel working remotely due to COVID-19, the mobile unit did not get completed for its first trial run to occur until October 12, 2020. COVID-19 slowdowns also held up the replacement hydraulic motor for a month after it was noted that the blown seal had no replacement part available. Therefore, the unit was not completed in time to assist producers that needed to euthanize pigs due to COVID-19 packing plant slowdown/closures (0bjective 2.) While short, at this time, of testing 302 pigs for objective 1: "validate an AVMA-approved method of humane euthanasia for on-farm application, to ensure the same standard of welfare is met during mass depopulation events that is provided under federally regulated conditions in slaughter plants," the 60 pigs that the unit has been validated on shows that the mobile unit is fully capable of single step hands free euthanasia on pigs ranging in size from 125 pounds to up to the ~600 pounds tested thus far. Most encouraging to the investigators is the ability of the electrical contacts to maintain good contact on moving pigs as indicated by the unit's ability to even make good contact through thick coarse hair of several Duroc boars. Additionally, given the validation to date, the investigators fully believe the mobile unit can be copied by other companies and government agencies to aid in mass depopulation events of swine to meet objective 3. The Nebraska Department of Agriculture has been so thoroughly impressed with the operation of the unit that they are purchasing the unit from the National Pork Board to keep in state for depopulation emergencies. This means that the checkoff dollars that funded the project will be returned in full to the National Pork Board for funding additional projects while having a fully operational unit ready should the need arise.

Comments from farm staff at both locations were highly positive. Staff at both locations noted how humane the process is for the animal with the pigs being rendered instantly insensible and dead with this method and the lack of blood, kicking, squealing as compared to their current methods of captive bolt/gunshot. Staff at both locations preferred this hands-free single step electrical euthanasia to their current methods. We have open invitations to return to either location to perform further validation of the unit.

Discussion:

The most important contribution this project has to pork producers is the validation of hands-free single step electrical euthanasia in a mobile unit on pigs ranging from 125 pound to ~600 pounds. The lower limit of the unit is dependent on the width of the restrainer belts and thus with closer widths future trailers and have a lower weight limit. The upper weight limit is determined by the width of the animal and their ability to fit into the restrainer. While pork producers now have access to one operation unit, the process that has been undertaken on this project ensures the unit can be copied by other companies/government agencies to make their own unit(s). The unit being fully mobile, weighs just 13,040 pounds fully operational, and can be pulled by a ¾ ton or 1 ton pickup, making it easily deployable should the need arise for its use. This allows for onsite euthanasia in the event of a foreign animal disease outbreak or it can be set up at a regional site. The fact that it does not require a human to apply the euthanasia holds great promise for worker mental health. Additionally, as it is extremely quick and bloodless, the visual aspects are also of importance for worker mental health. The unit also is designed in such a way to minimize the number of workers needed on site and reduces the need for workers to move animals. In a mass depopulation situation where the unit has a conveyor belt set up to offload the pigs into waiting rendering trucks, humans will not have to handle the carcasses and will only need to get live pigs onto the unit much the same as they do when loading a truck to transport animals to a harvest plant. All told, this is a safe, highly effective mobile unit that can perform hands free single step electrical euthanasia with minimal staff needed and to perform a necessary task in the most humane and mentally acceptable manner possible.

Figure 1. The complete unit ready for transport.

Figure 2. View from under the restrainer showing the negative contact bar for the left legs and the hot paddles suspended in the center of the restrainer.

Figure 3. Top view of the negative contact bar with the original negative paddle still in place.

Attachment 5

USDA-APHIS Records on Depopulation of Birds for Avian Influenza and Newcastle Disease, January 2015 - March 2021

Premises	Incident Site	Special ID (Investigation)	Production Type (Animal Business)	Incident	Euthanasia Method	Euthanasia Completed
(b)(3) Section 1619 of the Farm bill	Iowa	Adair 01	Commercial Table Egg Layer	HPAI 2015	Foam	6/11/2015
	Wisconsin	Barron 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/21/2015
	Wisconsin	Barron 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/25/2015
	Wisconsin	Barron 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/29/2015
	Wisconsin	Barron 04	Commercial Breeder Operation	HPAI 2015	Foam	5/3/2015
	Wisconsin	Barron 05	Commercial Breeder Operation	HPAI 2015	Foam	5/6/2015
	South Dakota	Beadle 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/8/2015
	Washington	Benton 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	1/5/2015
	Washington	Benton 02	Backyard Producer	HPAI 2015	CO2 Gart/Container	1/6/2015
	Minnesota	Blue Earth 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/31/2015
	Arkansas	Boone 01	Commercial Broiler Production	HPAI 2015	Foam	3/11/2015
	Minnesota	Brown 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/28/2015
	Minnesota	Brown 02	Commercial Breeder Operation	HPAI 2015	Captive Bolt/ TEDS	5/28/2015
	Minnesota	Brown 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/31/2015
	Minnesota	Brown 04	Commercial Breeder Operation	HPAI 2015	Foam	6/1/2015
	Minnesota	Brown 05	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/5/2015
	Iowa	Buena Vista 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/20/2015
	Iowa	Buena Vista 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/4/2015
	Iowa	Buena Vista 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/5/2015
	Iowa	Buena Vista 04	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/5/2015
	Iowa	Buena Vista 05	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/28/2015
	Iowa	Buena Vista 06	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/5/2015
	Iowa	Buena Vista 07	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/13/2015
	Iowa	Buena Vista 08	Commercial Turkey Meat Bird	HPAI 2015	CO2 Gart/Container	5/10/2015
	Iowa	Buena Vista 09	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/12/2015
	Iowa	Buena Vista 11	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/14/2015
	Iowa	Buena Vista 12	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/14/2015
	Iowa	Buena Vista 13	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/12/2015
	Iowa	Buena Vista 14	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/3/2015
	Iowa	Buena Vista 15	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/14/2015
	Iowa	Buena Vista 16	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/24/2015
	Iowa	Calhoun 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/23/2015
	Iowa	Calhoun 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/2/2015
	Idaho	Canyon 02	Backyard Producer	HPAI 2015	CO2 Gart/Container	1/19/2015
	Iowa	Cherokee 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/10/2015
	Iowa	Cherokee 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/9/2015
	Iowa	Cherokee 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/14/2015
	Iowa	Cherokee 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/14/2015
	Iowa	Cherokee 05	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/15/2015
	Minnesota	Chippewa 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/29/2015
	Wisconsin	Chippewa 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/24/2015

Premises	Incident Site	Special ID (Investigation)	Production Type (Animal Business)	Incident	Euthanasia Method	Euthanasia Completed
(b)(3) Section 1619 of the Farm bill	Washington	Clallam 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	1/18/2015
	Minnesota	Clay 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/7/2015
	Iowa	Clay 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/8/2015
	Iowa	Clay 02	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/10/2015
	Minnesota	Cottonwood 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/13/2015
	Minnesota	Cottonwood 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/20/2015
	Oregon	Deschutes 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	2/17/2015
	North Dakota	Dickey 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/12/2015
	Nebraska	Dixon 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/5/2015
	Nebraska	Dixon 02	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/21/2015
	Nebraska	Dixon 03	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/2/2015
	Nebraska	Dixon 04	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/23/2015
	Nebraska	Dixon 05	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/19/2015
	Nebraska	Dixon 06	Backyard Producer	HPAI 2015	Other	6/6/2015
	Oregon	Douglas 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	12/21/2014
	Iowa	Hamilton 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/28/2015
	Iowa	Hamilton 02	Commercial Turkey Meat Bird	HPAI 2015	Other	5/31/2015
	Iowa	Hamilton 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/3/2015
	Iowa	Hamilton 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/4/2015
	South Dakota	Hutchinson 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/13/2015
	Missouri	Jasper 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	3/12/2015
	Wisconsin	Jefferson 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	4/26/2015
	Wisconsin	Jefferson 02	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/14/2015
	Wisconsin	Jefferson 03	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/8/2015
	Montana	Judith Basin 01	Backyard Producer	HPAI 2015	Other	4/3/2015
	Wisconsin	Juneau 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	4/16/2015
	Minnesota	Kandiyohi 01	Commercial Breeder Operation	HPAI 2015	Foam	4/10/2015
	Minnesota	Kandiyohi 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/13/2015
	Minnesota	Kandiyohi 03	Commercial Breeder Operation	HPAI 2015	Foam	4/16/2015
	Minnesota	Kandiyohi 04	Commercial Breeder Operation	HPAI 2015	Foam	4/20/2015
	Minnesota	Kandiyohi 05	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/23/2015
	Minnesota	Kandiyohi 06	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/22/2015
	Minnesota	Kandiyohi 07	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/22/2015
	Minnesota	Kandiyohi 08	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/21/2015
	Minnesota	Kandiyohi 09	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/24/2015
	Minnesota	Kandiyohi 10	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/26/2015
	Minnesota	Kandiyohi 11	Commercial Breeder Operation	HPAI 2015	Foam	4/25/2015
	Minnesota	Kandiyohi 12	Commercial Breeder Operation	HPAI 2015	Foam	4/24/2015
	Minnesota	Kandiyohi 13	Commercial Breeder Operation	HPAI 2015	Foam	4/25/2015
	Minnesota	Kandiyohi 14	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/26/2015
	Minnesota	Kandiyohi 15	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/28/2015

Premises	Incident Site	Special ID (Investigation)	Production Type (Animal Business)	Incident	Euthanasia Method	Euthanasia Completed
(b)(3) Section 1619 of the Farm bill	Minnesota	Kandiyohi 16	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/26/2015
	Minnesota	Kandiyohi 17	Commercial Breeder Operation	HPAI 2015	Foam	4/27/2015
	Minnesota	Kandiyohi 18	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/27/2015
	Minnesota	Kandiyohi 19	Commercial Breeder Operation	HPAI 2015	Foam	4/29/2015
	Minnesota	Kandiyohi 20	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/28/2015
	Minnesota	Kandiyohi 21	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/27/2015
	Minnesota	Kandiyohi 22	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/29/2015
	Minnesota	Kandiyohi 23	Commercial Breeder Operation	HPAI 2015	Foam	4/29/2015
	Minnesota	Kandiyohi 24	Commercial Turkey Meat Bird	HPAI 2015	Other	4/30/2015
	Minnesota	Kandiyohi 25	Commercial Breeder Operation	HPAI 2015	Captive Bolt/ TEDS	5/1/2015
	Minnesota	Kandiyohi 26	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/2/2015
	Minnesota	Kandiyohi 27	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/3/2015
	Minnesota	Kandiyohi 28	Commercial Turkey Meat Bird	HPAI 2015	Other	5/2/2015
	Minnesota	Kandiyohi 29	Commercial Breeder Operation	HPAI 2015	Foam	5/3/2015
	Minnesota	Kandiyohi 30	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/6/2015
	Minnesota	Kandiyohi 31	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/5/2015
	Minnesota	Kandiyohi 32	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/9/2015
	Minnesota	Kandiyohi 33	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/17/2015
	Minnesota	Kandiyohi 34	Commercial Breeder Operation	HPAI 2015	Foam	5/29/2015
	Minnesota	Kandiyohi 35	Commercial Breeder Operation	HPAI 2015	Foam	5/26/2015
	Minnesota	Kandiyohi 36	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/29/2015
	Minnesota	Kandiyohi 37	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/28/2015
	Minnesota	Kandiyohi 38	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/28/2015
	Minnesota	Kandiyohi 39	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/2/2015
	Minnesota	Kandiyohi 40	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/6/2015
	California-Tulare	Kings 01	Commercial Broiler Production	HPAI 2015	Foam	2/18/2015
	South Dakota	Kingsbury 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/10/2015
	Iowa	Kossuth 01	Commercial Breeder Operation	HPAI 2015	CO2 Gart/Container	5/8/2015
	Minnesota	Lac Qui Parle 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	3/29/2015
	North Dakota	LaMoure 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/23/2015
	Minnesota	Le Sueur 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/14/2015
	Kansas- Basehor	Leavenworth 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	3/14/2015
	Missouri	Lewis 01	Backyard Producer	HPAI 2015	Other	5/3/2015
	Minnesota	Lyon 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/12/2015
	Iowa	Lyon 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/29/2015
	Iowa	Madison 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/16/2015
	South Dakota	McCook 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/13/2015
	South Dakota	McPherson 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/15/2015
	Minnesota	Meeker 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/14/2015
	Minnesota	Meeker 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/21/2015
	Minnesota	Meeker 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/19/2015

Premises	Incident Site	Special ID (Investigation)	Production Type (Animal Business)	Incident	Euthanasia Method	Euthanasia Completed
(b)(3) Section 1619 of the Farm bill	Minnesota	Meeker 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/23/2015
	Minnesota	Meeker 05	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/26/2015
	Minnesota	Meeker 06	Commercial Breeder Operation	HPAI 2015	Foam	4/26/2015
	Minnesota	Meeker 07	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/25/2015
	Minnesota	Meeker 08	Commercial Breeder Operation	HPAI 2015	Foam	5/2/2015
	Minnesota	Meeker 09	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/16/2015
	Minnesota	Meeker 10	Commercial Breeder Operation	HPAI 2015	Foam	5/29/2015
	Missouri	Moniteau 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	3/10/2015
	South Dakota	Moody 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/12/2015
	South Dakota	Moody 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/30/2015
	Minnesota	Nicollet 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/22/2015
	Minnesota	Nobles 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/3/2015
	Iowa	O'Brien 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/6/2015
	Iowa	O'Brien 02	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/2/2015
	Iowa	O'Brien 03	Backyard Producer	HPAI 2015	Other	5/9/2015
	Washington	Okanogan 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	2/3/2015
	Washington	Okanogan 02	Backyard Producer	HPAI 2015	CO2 Gart/Container	2/4/2015
	Iowa	Osceola 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/7/2015
	Iowa	Osceola 02	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/20/2015
	Iowa	Osceola 03	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/15/2015
	Iowa	Osceola 04	Backyard Producer	HPAI 2015	Other	5/22/2015
	Minnesota	Otter Tail 01	Commercial Breeder Operation	HPAI 2015	Foam	4/22/2015
	Minnesota	Otter Tail 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/24/2015
	Minnesota	Otter Tail 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/1/2015
	Minnesota	Otter Tail 04	Commercial Breeder Operation	HPAI 2015	Foam	4/22/2015
	Iowa	Palo Alto 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/15/2015
	Minnesota	Pipestone 01	Backyard Producer	HPAI 2015	Foam	4/20/2015
	Minnesota	Pipestone 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/4/2015
	Iowa	Plymouth 01	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/5/2015
	Iowa	Pocahontas 01	Commercial Turkey Meat Bird	HPAI 2015	CO2 Gart/Container	5/6/2015
	Iowa	Pocahontas 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/12/2015
	Iowa	Pocahontas 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/24/2015
	Minnesota	Pope 01	Commercial Breeder Operation	HPAI 2015	Foam	3/7/2015
	Minnesota	Pope 02	Commercial Breeder Operation	HPAI 2015	Foam	3/7/2015
	Minnesota	Redwood 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/16/2015
	Minnesota	Redwood 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/21/2015
	Minnesota	Redwood 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/16/2015
	Minnesota	Redwood 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/21/2015
	Minnesota	Renville 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/4/2015
	Minnesota	Renville 02	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/1/2015
	Minnesota	Renville 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/28/2015

Premises	Incident Site	Special ID (Investigation)	Production Type (Animal Business)	Incident	Euthanasia Method	Euthanasia Completed
(b)(3) Section 1619 of the Farm bill	Minnesota	Renville 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/31/2015
	Minnesota	Renville 05	Commercial Breeder Operation	HPAI 2015	Foam	6/2/2015
	Minnesota	Renville 06	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/30/2015
	Minnesota	Renville 07	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/10/2015
	Minnesota	Renville 08	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/4/2015
	South Dakota	Roberts 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/16/2015
	Minnesota	Roseau 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/20/2015
	Iowa	Sac 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/30/2015
	Iowa	Sac 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/10/2015
	Iowa	Sac 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/15/2015
	Iowa	Sac 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/20/2015
	Iowa	Sac 05	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/19/2015
	Iowa	Sac 06	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/22/2015
	Iowa	Sac 07	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/31/2015
	Iowa	Sac 08	Commercial Turkey Meat Bird	HPAI 2015	Foam	6/5/2015
	Iowa	Sioux 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/12/2015
	Iowa	Sioux 02	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/20/2015
	Iowa	Sioux 03	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/13/2015
	Iowa	Sioux 04	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/11/2015
	Iowa	Sioux 05	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/23/2015
	Iowa	Sioux 06	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/19/2015
	Iowa	Sioux 07	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/15/2015
	Iowa	Sioux 08	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/28/2015
	Iowa	Sioux 09	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/16/2015
	Iowa	Sioux 10	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/29/2015
	Iowa	Sioux 13	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/23/2015
	Iowa	Sioux 14	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/29/2015
	Iowa	Sioux 15	Backyard Producer	HPAI 2015	Other	6/3/2015
	Iowa	Sioux 16	Backyard Producer	HPAI 2015	Other	6/4/2015
	Iowa	Sioux 17	Backyard Producer	HPAI 2015	CO2 Gart/Container	5/30/2015
	Iowa	Sioux 18	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	5/31/2015
	Iowa	Sioux 19	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/1/2015
	Iowa	Sioux 20	Mail Order Hatchery	HPAI 2015	CO2 Gart/Container	6/12/2015
	South Dakota	Spink 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/21/2015
	California	Stanislaus 01	Commercial Turkey Meat Bird	HPAI 2015	Other	1/30/2015
	Minnesota	Stearns 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	3/30/2015
	Minnesota	Stearns 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/5/2015
	Minnesota	Stearns 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/8/2015
	Minnesota	Stearns 04	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/14/2015
	Minnesota	Stearns 05	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/15/2015
	Minnesota	Stearns 06	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/19/2015

Premises	Incident Site	Special ID (Investigation)	Production Type (Animal Business)	Incident	Euthanasia Method	Euthanasia Completed
(b)(3) Section 1619 of the Farm bill	Minnesota	Stearns 07	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/26/2015
	Minnesota	Stearns 08	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/24/2015
	Minnesota	Stearns 09	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/26/2015
	Minnesota	Stearns 10	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/27/2015
	Minnesota	Stearns 11	Commercial Breeder Operation	HPAI 2015	Foam	4/27/2015
	Minnesota	Stearns 12	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/11/2015
	Minnesota	Stearns 13	Commercial Breeder Operation	HPAI 2015	Foam	4/27/2015
	Minnesota	Stearns 14	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/1/2015
	Minnesota	Steele 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/29/2015
	Minnesota	Swift 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/16/2015
	Minnesota	Swift 02	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/19/2015
	Minnesota	Swift 03	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/29/2015
	Minnesota	Swift 04	Commercial Turkey Meat Bird	HPAI 2015	Captive Bolt/ TEDS	5/4/2015
	Minnesota	Swift 05	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/5/2015
	Minnesota	Swift 06	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/9/2015
	Minnesota	Swift 07	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/12/2015
	Minnesota	Wadena 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/25/2015
	Minnesota	Watonwan 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	4/12/2015
	Iowa	Webster 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/6/2015
	Indiana	Whitley 01	Backyard Producer	HPAI 2015	CO2 Gart/Container	5/9/2015
	Iowa	Wright 01	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/12/2015
	Iowa	Wright 02	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/2/2015
	Iowa	Wright 03	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/6/2015
	Iowa	Wright 04	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	5/31/2015
	Iowa	Wright 05	Commercial Table Egg Pullets	HPAI 2015	CO2 Gart/Container	6/12/2015
	Iowa	Wright 06	Commercial Table Egg Layer	HPAI 2015	CO2 Gart/Container	6/20/2015
	South Dakota	Yankton 01	Commercial Turkey Meat Bird	HPAI 2015	Foam	5/13/2015
	Indiana	Dubois 01	Commercial Turkey Meat Bird	HPAI 2016	Foam	1/16/2016
	Indiana	Dubois 01a	Commercial Turkey Meat Bird	HPAI 2016	Foam	1/15/2016
	Indiana	Dubois 02	Commercial Turkey Meat Bird	HPAI 2016	Ventilation Shutdown	1/17/2016
	Indiana	Dubois 03	Commercial Turkey Meat Bird	HPAI 2016	Foam	1/20/2016
	Indiana	Dubois 04	Commercial Turkey Meat Bird	HPAI 2016	Ventilation Shutdown	1/16/2016
	Indiana	Dubois 05	Commercial Turkey Meat Bird	HPAI 2016	Foam	1/16/2016
	Indiana	Dubois 05a	Commercial Table Egg Layer	HPAI 2016	Ventilation Shutdown	1/19/2016
	Indiana	Dubois 06	Commercial Turkey Meat Bird	HPAI 2016	Ventilation Shutdown	1/16/2016
	Indiana	Dubois 07	Commercial Turkey Meat Bird	HPAI 2016	Other	1/20/2016
	Indiana	Dubois 08	Commercial Turkey Meat Bird	HPAI 2016	Captive Bolt/ TEDS	1/19/2016
	Indiana	Dubois 09	Commercial Turkey Meat Bird	HPAI 2016	Other	1/17/2016
	Indiana	Dubois 10	Commercial Turkey Meat Bird	HPAI 2016	Other	1/18/2016

Incident	Incident Site	County (Premises)	Premises	Indemnity Request Requested	Euth Complete	Euthanasia Method	Euthanasia Party	Disp Complete	Disposal Method	Disinfect Complete	Control Zone Open	Control Zone Close	Quarantine Release	Restock Approved?
LPAI 2017	Alabama	CULLMAN	(b)(3)	n/a	3/23/2017	Foam	Company	3/25/2017	Burial	pending	n/a	n/a	No	
LPAI 2017	Alabama	JACKSON	(b)(3)	n/a	3/16/2017	Cervical dislocation	State/Federal Personnel	3/16/2017	Burial	pending	n/a	n/a	4/7/2017	
LPAI 2017	Alabama	LAUDERDA LE	(b)(3) Section 1619 of the Farm bill	n/a	3/10/2017	Cervical dislocation	Company	3/11/2017	Burial	3/22/2017	n/a	n/a	4/6/2017	Restock Approved
HPAI 2017	Alabama	MADISON		n/a	3/11/2017	Cervical dislocation	State/Federal Personnel	3/11/2017	Burial	pending	n/a	n/a	No	
LPAI 2017	Alabama	MADISON		n/a	3/21/2017	Cervical dislocation	State/Federal Personnel	3/21/2017	Burial	3/21/2017	n/a	n/a	No	
LPAI 2017	Alabama	PICKENS		n/a	3/21/2017	Foam and CO2	Company	3/22/2017	Burial	pending	n/a	n/a	No	
LPAI 2017	Georgia	CHATTOOG A		n/a	3/24/2017	Foam	State/Federal Personnel	3/25/2017	Burial	pending	n/a	n/a	No	
LPAI 2017	Kentucky	CHRISTIAN		n/a	3/23/2017	Cervical dislocation	Producer	3/23/2017	Burial	pending	n/a	n/a	No	
LPAI 2017	Kentucky	CHRISTIAN		n/a	3/17/2017	Foam	Company	3/18/2017	Burial	pending	n/a	n/a	No	
LPAI 2017	Tennesse e	GILES		n/a	3/6/2017	KEDS	Company	3/6/2017	Burial	4/3/2017	n/a	n/a	4/10/2017	
HPAI 2017	**Tennesse e**	**LINCOLN**	(b)(3) Section 1619 of the Farm bill	**3/4/2017**	**3/5/2017**	**Foam**	**Multiple Parties**	**3/8/2017**	**Burial**	**No**	**3/4/2017**	**4/11/2017**	**No**	
HPAI 2017	Tennesse e	LINCOLN		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4/11/2017	
HPAI 2017	**Tennesse e**	**LINCOLN**		**3/15/2017**	**3/17/2017**	**Foam**	**Contractor**	**3/17/2017**	**Burial**	**No**	**3/14/2017**	**4/11/2017**	**No**	
HPAI 2017	Tennesse e	LINCOLN		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4/11/2017	
AI WI LP 0317	Wisconsin	BARRON		n/a	n/a	n/a	n/a	n/a	Controlled Market	n/a	n/a	n/a	4/5/2017	

Incident	Incident Site	Start Date (Ir	Special ID	Species	Production Type	Euth Comple	Euthanasia Method	Other
HPAI 2017	Tennessee	3/3/2017	none	Chicken	Commercial Broiler Breeder	3/5/2017	Foam	
LPAI 2017	Tennessee	3/9/2017	none	Chicken	Commercial Broiler Breeder	3/6/2017	KEDS	
LPAI 2017	Alabama	3/11/2017	none	Chicken	Commercial Broiler Breeder	3/10/2017	Other	Cervical Dislocation
HPAI 2017	Alabama	3/11/2017	none	Poultry	Backyard Producer	3/11/2017	Other	Cervical Dislocation
LPAI 2018	Missouri	3/2/2018	none	Turkey	Commercial Turkey Meat Bird	3/23/2018	Humane/Controlled Slaughter	
HPAI 2017	Tennessee	3/5/2017	none	Chicken	Commercial Broiler Breeder	3/17/2017	Foam	
LPAI 2018	Texas	3/6/2018	none	Chicken	Commercial Broiler Breeder	3/8/2018	Foam	
LPAI 2017	Alabama	3/15/2017	none	Chicken	Commercial Broiler Breeder	3/21/2017	Combination-see comments	Foam / CO2 Gas
LPAI 2017	Kentucky	3/16/2017	none	Chicken	Commercial Broiler Breeder	3/17/2017	Foam	
LPAI 2017	Alabama	3/18/2017	none	Chicken	Commercial Broiler Breeder	3/23/2017	Foam	
LPAI 2017	Kentucky	3/17/2017	none	Chicken	Backyard Producer	3/23/2017	Other	Cervical Dislocation
AI WI LP 0317	Wisconsin	3/3/2017	none	Turkey	Commercial Turkey Meat Bird	4/14/2017	Humane/Controlled Slaughter	
LPAI 2017	Georgia	3/24/2017	none	Chicken	Commercial Broiler Breeder	3/24/2017	Foam	
LPAI 2018	California	10/4/2018	Stanislaus 05	Turkey	Commercial Turkey Meat Bird	11/14/2018	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	10/19/2018	Kandiyohi 01	Turkey	Commercial Turkey Meat Bird	11/30/2018	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	10/30/2018	Stearns 01	Turkey	Commercial Turkey Meat Bird	11/16/2018	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	11/1/2018	Stearns 02	Turkey	Commercial Turkey Meat Bird	11/15/2018	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	10/20/2018	Kandiyohi 02	Turkey	Commercial Turkey Meat Bird	12/7/2018	Humane/Controlled Slaughter	
LPAI 2018	California	9/4/2018	Stanislaus 01	Turkey	Commercial Turkey Meat Bird	9/8/2018	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	11/1/2018	Stearns 03	Turkey	Commercial Turkey Meat Bird	12/7/2018	Humane/Controlled Slaughter	
LPAI 2018	California	9/6/2018	Stanislaus 02	Turkey	Commercial Turkey Meat Bird	9/21/2018	CO2 Whole House	
LPAI 2019	Minnesota	11/2/2018	Stearns 04	Turkey	Commercial Turkey Meat Bird	12/7/2018	Humane/Controlled Slaughter	
LPAI 2018	California	9/6/2018	Stanislaus 03	Poultry	Other	10/5/2018	CO2 Cart/Container	
LPAI 2018	California	9/6/2018	Stanislaus 04	Turkey	Commercial Turkey Meat Bird	11/6/2018	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	10/22/2018	Kandiyohi 03	Turkey	Commercial Turkey Meat Bird	12/28/2018	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	10/22/2018	Kandiyohi 04	Turkey	Commercial Turkey Meat Bird	1/11/2019	Humane/Controlled Slaughter	
LPAI 2019	Minnesota	1/25/2019	Chippewa 01	Turkey	Commercial Turkey Meat Bird	2/8/2019	Humane/Controlled Slaughter	
LPAI 2019	California	4/16/2019	Monterey 01	Duck	Commercial Duck Breeder	4/25/2019	CO2 Cart/Container	
LPAI 2019	California	6/25/2019	Merced 01	Duck	Backyard Producer	8/14/2019	Humane/Controlled Slaughter	

Incident Site	Special ID	Production Type	Euthanasia Method	Incident	Euth Complete
California	Riverside 285	Commercial Table Egg Pullets	CO2 Cart/Container	CA VND 2018	12/16/2018 14:00
California	Riverside 351	Commercial Table Egg Layer	CO2 Whole House	CA VND 2018	1/19/2019 19:00
California	Riverside 372	Commercial Table Egg Layer	CO2 Cart/Container	CA VND 2018	1/21/2019 19:00
California	Riverside 455	Commercial Table Egg Layer	CO2 Cart/Container	CA VND 2018	

2019-2020 HPAI events

NC- SC Combined Incident H7N3 HPAI and H7N3 LPAI (Commercial Turkey Flocks),

March-April 2020

Depopulation and Disposal

Disease	Incident Site	Special ID	Euthanasia Method	# Euth to Date	Euth Complete	Euthanasia Party
LPAI	**North Carolina**	Anson 01	Foam	16,372	3/16/2020	State Personnel
LPAI	**North Carolina**	Anson 02	Foam	24,068	3/16/2020	State Personnel
LPAI	**North Carolina**	Union 01	Foam	12,900	3/15/2020	State Personnel
LPAI	**North Carolina**	Union 02	Other	65,071	3/15/2020	Company
LPAI	**North Carolina**	Union 03	Foam	7091	3/15/2020	State Personnel
LPAI	**North Carolina**	Union 04	Foam	17,877	3/15/2020	State Personnel
LPAI	**North Carolina**	Union 05	Foam	16,974	3/16/2020	State Personnel
LPAI	**North Carolina**	Union 06	Foam	15,590	3/18/2020	State Personnel
LPAI	**North Carolina**	Union 07	Foam	20,070	3/18/2020	State Personnel
LPAI	**North Carolina**	Union 08	Combination	45,974	3/22/2020	Company
LPAI	**North Carolina**	Union 09	Foam	26,149	4/2/2020	State Personnel
LPAI	**South Carolina**	Chesterfield 01	Foam	36,649	3/15/2020	State Personnel
HPAI	**South Carolina**	Chesterfield 02	Foam	32,577	4/8/2020	State Personnel

2020 NC/SC LPAI/HPAI incident

On March 10, a North Carolina NALHN laboratory detected H7 low pathogenicity avian influenza in pre-slaughter surveillance samples from two commercial meat-type turkey operations. No clinical signs disease or abnormal production parameters were noticed in either of these flocks, which were located in an area of dense poultry production. Also on March 10, the same NAHLN lab detected H7 LPAI in samples collected from one breeder turkey operation in a neighboring county. The producer reported a slight drop in egg production in this flock. NVSL confirmed H7N3 LPAI in all three flocks on March 12.

On March 13, a North Carolina incident command team began surveillance for commercial flocks in control zones established around all three positive premises. As a result of control zone surveillance, eight additional H7 LPAI affected premises were found in North Carolina and one in South Carolina. The team expanded surveillance testing as a result of these detections, and South Carolina established an incident command team.

On April 7, 2020, South Carolina officials investigated a grower's report of respiratory signs and mortality in a commercial meat-type turkey flock in Chesterfield County. The South Carolina NAHLN lab detected H7 avian influenza virus in samples from this flock, and on April 8, NVSL confirmed the detection and reported that sequence results are consistent with H7N3 highly pathogenic avian influenza virus.

For all H7N3 NC and SC cases, data supports a single introduction followed by secondary spread. Mutation of the LPAI virus to HPAI occurred in one house on a single premises. Other houses on that premises had LPAI virus.

The H7N3 LPAI NC/SC viruses are:

- North American wild bird-origin viruses
- distinct from other recent H7 events in poultry, and have not previously been detected in poultry
- similar to other wild bird viruses, sharing a common hemagglutinin ancestry with those from 2016-2018
- Initially LPAI
- NOT related to the H7N3 HPAI event in Mexico

Depopulation and disposal have been completed at all 13 affected premises. Slightly more than 300,000 turkeys were depopulated due to LPAI, and almost 33,000 turkeys were depopulated on the HPAI affected premises. Composting was used to dispose of carcasses in North Carolina, and South Carolina buried bird carcasses. Cleaning and disinfection is in progress for most of the affected premises, three have completed C&D, and one has been released from quarantine.

North Carolina completed two rounds of surveillance in the LPAI control zones, plus additional network-based surveillance within the State, with negative results. South Carolina completed four rounds of surveillance associated with the HPAI control area. In-depth epidemiologic investigation of the cases is well underway.

APHIS notified the OIE about the H7N3 LPAI incident on March 16, 2020, and notified the OIE about the H7N3 HPAI on April 09. Individual trading partners were notified according to our individual agreements with those countries. You can find updated detailed information about exporting meat and meat products under FSIS certification on the FSIS website, and the APHIS IREGS website is a source for detailed country-specific information for live animal exports.

Incident	Incident Site	Special ID	Production Type	Euthanasia Method	Euth Complete
LPAI 2021	California	NorCal 001	Live Bird Sales / Non-Slaughter	CO2 Cart/Container	3/27/2021
LPAI 2021	California	NorCal 002	Backyard Producer	CO2 Cart/Container	3/28/2021
LPAI 2021	Missouri	Webster 01	Backyard Producer	CO2 Cart/Container	11/11/2020

Attachment 6

AVMA Response to AWI on Depopulation During COVID-19 Pandemic, September 2020

September 28, 2020

Cathy Liss
President, Animal Welfare Institute
900 Pennsylvania Avenue, SE
Washington, DC 20003

RE: Use of AVMA Guidelines for the Depopulation of Animals During the COVID-19 Pandemic

Dear Ms. Liss:

Thank you for reaching out to the American Veterinary Medical Association (AVMA) regarding our shared concerns around the welfare of animals. We appreciate your recognition of the challenges that COVID-19 has presented for the United States regarding disruptions in the food supply chain[1] and wholeheartedly agree that decisions about when and (if needed) how to depopulate animals in response to such disruptions must be made exceedingly thoughtfully. We also understand that, given the AVMA's reputation for care and expertise surrounding end-of-life decision making, many will seek to apply the AVMA's guidance as they make their own choices. This includes turning to the *AVMA Guidelines for the Depopulation of Animals*[2] in the case of emergencies.

Recognizing that our depopulation guidelines apply specifically to such emergency situations, the AVMA expects that any decision to depopulate animals will be made only after an exhaustive search for alternatives. Similar care must be taken when selecting the method that will be used to depopulate those animals, including recognition that the circumstances surrounding euthanasia and depopulation are fundamentally different. In addition, those implementing the method chosen must be absolutely certain the appropriate conditions, equipment, personnel, training, and oversight are available so that the AVMA's performance standard for that method, as specified in our guidelines, is met.

The AVMA believes animals should NOT be depopulated unless required by an emergency and all other reasonable alternatives to managing the affected animals have been explored and been found to not be viable. In emergency situations (e.g., natural disasters like floods, fires, and earthquakes; non-natural disasters, such as terrorism, war, or toxic chemical spills; contagious animal diseases; and zoonotic or pandemic disease) advance planning is absolutely essential to ensure that the best decisions, resulting in as little animal suffering as possible, are made.

If depopulation is determined to be the appropriate course of action, then meticulous attention also must be paid to selecting the method of depopulation that is best for that species of animal in that situation. We hope those who find themselves needing to make such recommendations and/or decisions will utilize the decision tree[3] that the AVMA developed and provides in conjunction with its guidelines as a resource.

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[1] https://www.avma.org/resources-tools/animal-health-and-welfare/covid-19/covid-19-impacts-food-production-medicine
[2] https://www.avma.org/resources-tools/avma-policies/avma-guidelines-depopulation-animals
[3] https://www.avma.org/sites/default/files/2020-04/Humane-Endings-flowchart-2020.pdf

Preferred methods, which include the use of modified euthanasia and slaughter techniques described within the *AVMA Guidelines for the Euthanasia of Animals*[4] and the *AVMA Guidelines for the Humane Slaughter of Animals*,[5] should be always be considered first.

The AVMA's responses to the Animal Welfare Institute's specific recommendations follow.

Use of Ventilation Shutdown

Ventilation Shutdown (VSD) Plus is considered a last resort option for depopulation of swine and is NOT a preferred method for depopulating pigs or poultry. Ventilation Shutdown (VSD) is a method of killing that involves closing the facility, shutting inlets, and turning off the fans associated with the ventilation system. Importantly, VSD is not the same as VSD Plus. VSD Plus incorporates additional components (e.g., heat, humidity, CO2) to cause the death of pigs or poultry. Appropriate implementation of VSD Plus requires a scientifically validated protocol and strict engineering process control to ensure death occurs as rapidly as possible. Further, any depopulation plan should include a protocol for confirmation of death.

As you are aware, the AVMA is not a regulatory agency. The facilities that chose to use VSD Plus for depopulation did not reach out to us to discuss their situation or their decision. Therefore, it's difficult for us to discern whether all feasible alternatives to depopulation were explored prior to the facilities making the decision to depopulate animals during COVID-19. However, after the use of VSD Plus to depopulate swine in Iowa was made public, the AVMA received some information regarding implementation of the method. It was shared that VSD Plus was implemented in a converted facility using temperature and humidity sensors, external heaters, and steam generators. The air temperature was increased to 120°F within 30 minutes and steam was added to maintain 80% relative humidity. It was also reported to us that 99% mortality was achieved with 60 minutes. Assuming this was the case, the AVMA performance criteria of greater than 95% mortality within 60 minutes would have been met.

Dr. Temple Grandin is a member of the AVMA Panel on Depopulation's Working Groups. She told us that she observed video of the application of VSD Plus during the COVID-19 pandemic and commented: *"I watched a video that showed how the pigs behaved during the application of controlled heat and humidity according to a very precise protocol. Strict process control and engineering is required. The pigs were in a specially retro-fitted building that had significant cost. To prevent suffering, this method requires highly trained people and it is difficult to do correctly. The parameters for this method are being researched. The video showed that the pigs remained calm until they lost posture and the ability to stand. They walked around and there was NO piling or escape attempts. The pig's behavior was calmer than the behavior I have observed in a CO2 chamber."*

In poultry, the USDA Response Guide[6] currently states that when using VSD in poultry the temperature of the house must be raised to 104°F or higher as quickly as possible, and preferably within 30 minutes, maintaining a temperature between 104°F and 110°F for a minimum of three hours.

Further research is needed to fully understand the physiological processes associated with hyperthermia in the pig and all types of poultry, and how the pig and different types of poultry are affected prior to becoming insensible. Additionally, research is needed to better define the appropriate environmental parameters that must be met when administering VSD Plus.

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[4] https://www.avma.org/resources-tools/avma-policies/avma-guidelines-euthanasia-animals

[5] https://www.avma.org/resources-tools/avma-policies/guidelines-humane-slaughter-animals

[6] https://minnesotaturkey.com/wp-content/uploads/2015/03/USDA-NEW-Using-VSD-1.15.2016_V2.pdf

Alternative Methods of Mass Euthanasia and Depopulation

In publishing its guidelines, the AVMA expects those who use them will do so with the utmost attention to thoughtful decision-making and careful execution on the very rare occasions when their use may be necessary. Depopulation of animals is ONLY to be carried out in response to serious emergencies or crises; animals should NOT be depopulated under ordinary circumstances.

Alternatives that the AVMA depopulation guidelines suggest should be explored prior to depopulation include (but are not limited to) the ability to move animals to a different slaughter facility; keeping animals on farm (or moving them to another location) without negative impact on their welfare or creating biosecurity concerns; and use of an AVMA acceptable or acceptable with conditions method of euthanasia or modified slaughter technique.

Overall, the AVMA expects that any decision to depopulate animals will be made ONLY after a careful search for alternatives and great deliberation.

Use of Water-based or Dry Foam

Preliminary data on 'dry' nitrogen-based foam as a depopulation method suggest that nitrogen-based foam appears to be efficacious and humane for killing poultry. Despite this finding, there are factors one must consider regarding application, suitability, and safety between widely available CO2 water-based foam and newly developed nitrogen-based foam in the United States.

Currently it is unclear whether nitrogen-based foam is resource-practical (i.e., manufacturing, equipment, gas) in the United States for very large systems. This may limit its use as a depopulation method. Furthermore, issues such as carcass residues and safety to the individual(s) applying the foam need further evaluation and consideration before adopting nitrogen-based foam as a depopulation method.

Overall, there is agreement that this method should be considered during the next revision of the *AVMA Guidelines for the Depopulation of Animals*. Until that time, the current guidelines do provide flexibility in choice of depopulation method. Methods that are not covered specifically by the guidelines may still be used, based on a veterinarian's professional judgement and sound reasoning regarding why methods currently included in the guidelines would not fit a particular situation. An explanation of how one might consider alternative methods is included on page eight of the guidelines as follows: "*These Guidelines do not address every contingency. In circumstances that are not clearly covered by these Guidelines, a veterinarian experienced with the species in question should apply professional judgment and knowledge of clinically acceptable techniques in selecting a method of depopulation or euthanasia (if required). Reaching out to colleagues with relevant experience may be necessary. Veterinarians will be working with other members of a crisis management team and in some cases may not have jurisdiction or the capacity to carry out their professional activities. When exercising their professional responsibilities, veterinarians should consider whether 1) the procedure results in the best outcome for the animal; 2) their actions conform to acceptable standards of veterinary practice and are consistent with applicable federal, state, and local regulations; and 3) the choice of depopulation or euthanasia technique is consistent with the veterinarians' professional obligations and adheres to sound ethical grounding."*

The AVMA will continue to collect, review and evaluate new published literature on foam-based depopulation methods, as it becomes available, to determine appropriate updates to the *AVMA Guidelines for the Depopulation of Animals*. Pending the next review cycle, the information in the current edition of the guidelines provides veterinarians with the flexibility needed to implement emergency plans and make difficult decisions when called for in times of crisis.

National Veterinary Stockpile
The AVMA agrees that the USDA should continue to work with state animal health officials, industry veterinarians, producers, and other stakeholders to secure appropriate depopulation and disposal resources and equipment for the National Veterinary Stockpile. The AVMA recognizes there is a wide range of needs and circumstances that influence the content of the stockpile and will continue to support measures that ensure appropriate supply and access to resources and equipment for all veterinary emergency and disaster needs, including needs for euthanasia and depopulation of animals.

Again, thank you for sharing your concerns. We hope our comments have been helpful in responding to the questions you had regarding the AVMA's approach and perspective.

Sincerely,

Douglas D. Kratt, DVM
President

Lori Teller, DVM, DABVP (canine/feline), CVJ
Chair, Board of Directors

Janet D. Donlin, DVM, CAE
Chief Executive Officer

CLJ/NK/GCG

As one of the oldest and largest veterinary medical organizations in the world, with more than 95,000 member veterinarians worldwide engaged in a wide variety of professional activities and dedicated to the art and science of veterinary medicine, the mission of the AVMA is to lead the profession by advocating for its members and advancing the science and practice of veterinary medicine to improve animal health and welfare and public health. The Association has a long-term concern for, and commitment to, the welfare and humane treatment of animals.

Attachment 7

USDA-ARS Study on Use of Sodium Nitrite for Depopulation of Poultry, May 2020

USDA Agricultural Research Service

https://www.ars.usda.gov/research/publications/publication/?seqNo115=374545

Research Project: Protecting the Welfare of Food Producing Animals

Location: **Livestock Behavior Research**

Title: Exploring the use of sodium nitrite as a humane method for mass euthanasia of poultry.

Author

- Lay, Jr, Donald - *Don*
- Enneking, Stacey

Submitted to: Meeting Abstract
Publication Type: Abstract Only
Publication Acceptance Date: 5/12/2020
Publication Date: N/A
Citation: N/A

Interpretive Summary: When disease outbreaks that threaten the poultry industry require mass euthanasia, it is imperative to ensure humane methods of euthanasia. Current methods are not practical on a large scale. Sodium nitrite ingested at high concentrations prevents the transport of oxygen in the blood and thereby renders the animal unconscious and then dead. Laying hens (n=8 per treatment, 18 wk of age) were subjected to 1 of 4 treatments: A, 75 mg/kg BW; B, 150 mg/kg BW; C, 300 mg/kg BW; or D, 600 mg/kg BW of sodium nitrite in feed. Behavior was recorded via direct observation and video recording. The D hens spent more time lying/sitting, less time standing, and more time inactive alert then C hens ($P < 0.03$), but not A and B hens. However, A, B, and C hens spent more time standing compared to lying/sitting ($P < 0.01$), whereas D hens spent equal time in both behaviors. The D hens spent less time eating and drinking, and had fewer drinking events compared to the A, B, and C hens ($P < 0.04$). Only 1 hen, a D hen, died. She stopped eating 1 min after eating, was lying on her side by 2 min, had total loss of posture and feather erection at 2.5 min, and tremors and wing flapping 5 s later, with subsequent (1 s later) lack of a palpebral reflex. The greatest dose of sodium nitrite caused hens to be lethargic and eat and drink less. This could be due to sedation and aversion to the taste of sodium nitrite. The hen that died did so in an apparently humane manner. However, with only 1 hen dying it is not possible to say if sodium nitrite is a humane method of euthanasia and future research should investigate feeding in an encapsulated form.

Technical Abstract: When disease outbreaks that threaten the poultry industry require mass euthanasia, it is imperative to ensure humane methods of euthanasia. Current methods are not practical on a large scale. Sodium nitrite ingested at high concentrations prevents the transport of oxygen in the blood and thereby renders the animal unconscious and then dead. Laying hens (n=8 per treatment, 18 wk of age) were subjected to 1 of 4 treatments: A, 75 mg/kg BW; B, 150 mg/kg BW; C, 300 mg/kg BW; or D, 600 mg/kg BW of sodium nitrite in feed. Behavior was

recorded via direct observation and video recording. The D hens spent more time lying/sitting, less time standing, and more time inactive alert then C hens ($P < 0.03$), but not A and B hens. However, A, B, and C hens spent more time standing compared to lying/sitting ($P < 0.01$), whereas D hens spent equal time in both behaviors. The D hens spent less time eating and drinking, and had fewer drinking events compared to the A, B, and C hens ($P < 0.04$). Only 1 hen, a D hen, died. She stopped eating 1 min after eating, was lying on her side by 2 min, had total loss of posture and feather erection at 2.5 min, and tremors and wing flapping 5 s later, with subsequent (1 s later) lack of a palpebral reflex. The greatest dose of sodium nitrite caused hens to be lethargic and eat and drink less. This could be due to sedation and aversion to the taste of sodium nitrite. The hen that died did so in an apparently humane manner. However, with only 1 hen dying it is not possible to say if sodium nitrite is a humane method of euthanasia and future research should investigate feeding in an encapsulated form.

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Attachment 8

Pork Board Research Report on the Evaluation of Sodium Nitrite for Mass Depopulation of Pigs, November 2020

RESEARCH REPORT

ANIMAL WELFARE

Title: Evaluation of Sodium Nitrite for mass euthanasia of commercial pigs – **NPB #20-118**

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Institution: Carthage Veterinary Service, Ltd.

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Date Received: November 4, 2020

Industry Summary:
It is critical to develop feasible mass euthanasia technology that is humane, economical, safe, and less labor intensive. Microencapsulated sodium nitrite (meSN) feral swine bait has been developed and marketed by Animal Control Technologies Australia (ACTA) as a feed-based toxicant for feral swine control. This technology has not been applied to commercial swine in confinement barns, just feral swine. Sodium nitrite is a chemical commonly used in low concentrations as a preservative in processed meats. If consumed at high doses, sodium nitrite can convert hemoglobin to methemoglobin that is unable to transport oxygen in the blood. The reduced oxygen carrying capacity of the blood depletes the brain and tissues of oxygen, causing unconsciousness and death. Previous pilot trials showed that SN can effectively euthanize swine, however, has been difficult to achieve reliable ingestion when SN is added to commercial feed due to palatability issues.

110 early nursery weight pigs (6.2 kg average weight) were randomly allotted to one of the 11 treatments (one treatment per pen, 10 pigs per pen). Granular form SN (un-encapsulated) salt and microencapsulated SN were the two sources of SN used in the feeds. There were three different feed flavors or taste suppressor combinations. Dried molasses at 4.4% inclusion was the first feed flavor. Vanilla at 0.1% inclusion was utilized as the second flavor. A bitterness taste suppressor at 0.2% inclusion was utilized as the third treatment. The dosage of SN was targeted at 20 grams of SN/100kg of pig at 2 lbs offered per pig. The resulting concentration was 2.2% SN per kg of feed. The dosage of SN in the water was targeted for an intake of 20g of SN per pig with an intake estimation of 0.25 gallons per pig.

1	Feed
2	Feed + SN
3	Feed + SN + Molasses
4	Feed + SN + Taste suppressor
5	Feed + SN + Flavor
6	Feed + meSN
7	Feed + meSN + Molasses
8	Feed + meSN + Taste suppressor
9	Feed + meSN + Flavor
10	Water
11	Water + SN

Feed was removed 24 hours prior to offering treatments. The water treatment pens had water removed also 24 hours to trial start. Pigs were offered their respective treatments for 3 hours of ab libitum consumption.

Of the feed treatment groups, 53 of 80 pigs (66%) were euthanized by SN. Each feed treatment resulted in a range of 50-80% mortality regardless of treatment. 63% of the pigs vomited during the feed treatment. The average time to death was 2 hours and 12 minutes. The earliest pig died at 1 hour and 13 minutes and latest pig at 3 hours. The water treatment group (Group 11) failed to induce clinical signs or mortality. Average feed consumption was 0.14 kg/pig. Pigs on averaged consumed 0.49 g of SN per kg of body weight with a range of 0.20 to 1.09 g of SN per kg.

General timeline of clinical signs:

- 0-45 minutes: good feed intake
- 45-75 minutes: stop eating and huddle
- 75 minutes: start to observe vomiting. Progresses to ataxia and palor and then lateral recumbency.
- 90 minutes: earliest mortality. Most were 90-180 minutes.

All feed formulations performed similarly, with only a 30% mortality rate range between treatments. This method of euthanasia is promising for use in constrained circumstances for depopulation, however, it did not achieve 100% mortality in this trial. It is imperative that pigs receive a bolus of SN for a lethal amount. Increasing the inclusion rate may increase the mortality rate but at the risk of pigs being averse to consume the product. It would also be recommended that pigs have uncompetitive access to consume feed when SN feed is administered.

There were minor differences in intake and mortality between the following groups (meSN versus SN, molasses versus vanilla versus taste blocker groups, unflavored meSN and SN versus flavored and taste blocker). The flavorings and taste blockers did not improve intake and mortality in comparison to feed with meSN and SN by itself.

Pigs were averse to consuming water with SN solubilized. There was minimal intake and no clinical signs.

Sodium nitrite is a viable option for mass depopulation in constrained circumstances. It euthanized between 50-80% of the pigs when offered to commercial swine in this study. Further development is needed to increase the euthanasia rate of pigs, speed up time to death, and decrease the percentage of pigs that vomit.

For further questions or information on this study, please contact:
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Key Findings:

- Sodium nitrite euthanized 50-80% of the pigs per treatment regardless SN formulation used (microencapsulated SN or free form SN) or feed treatment (molasses flavor, vanilla flavor, bitterness taste blocker)
- Administration of sodium nitrite through the water did not achieve sufficient intake to induce mortality

Keywords: Euthanasia, depopulation, sodium nitrite, methemoglobinemia, feed

Scientific Abstract:
It is critical to develop feasible mass euthanasia technology that is humane, economical, safe, and less labor intensive. Microencapsulated sodium nitrite (meSN) feral swine bait has been developed and marketed by Animal Control Technologies Australia (ACTA) as a feed-based toxicant for feral swine control. This technology has not been applied to commercial swine in confinement barns, just feral swine.

110 early nursery weight pigs (6.2 kg average weight) were randomly allotted to one of the 11 treatments. Granular form SN (un-encapsulated) salt and microencapsulated SN were included at a dosage of SN targeted at 20 grams of SN/100kg of pig at 2 lbs offered per pig. The resulting concentration was 2.2% SN per kg of feed. Three different feed flavors or taste suppressor combinations were utilized including dried molasses at 4.4% inclusion, vanilla at 0.1% inclusion, and a bitterness taste suppressor at 0.2% inclusion. The dosage of SN in the water was targeted for an intake of 20g of SN per pig with an intake estimation of 0.25 gallons per pig.

Of the feed treatment groups, 53 of 80 pigs (66%) were euthanized by SN. Each feed treatment resulted in a range of 50-80% mortality regardless of treatment. 63% of the pigs vomited during the feed treatment. The average time to death was 2 hours and 12 minutes. The earliest pig died at 1 hour and 13 minutes and latest pig at 3 hours. Average feed consumption was 0.14 kg/pig. Pigs on averaged consumed 0.49 g of SN per kg of body weight with a range of 0.20 to 1.09 g of SN per kg.

All feed formulations performed similarly, with only a 30% mortality rate range between treatments. The flavorings and taste blockers did not improve intake and mortality in

comparison to feed with meSN and SN by itself. Pigs were averse to consuming water with SN solubilized.

Sodium nitrite is a viable option for mass depopulation in constrained circumstances. It euthanized between 50-80% of the pigs when offered to commercial swine in this study. Further development is needed to increase the euthanasia rate of pigs, speed up time to death, and decrease the percentage of pigs that vomit.

Introduction:
There is an urgent need for mass euthanasia technology in the US swine industry. In the spring of 2020, COVID19 disrupted pig production flows resulting in growing pig space shortages. Additionally, foreign animal diseases like African Swine Fever, if introduced domestically, will similarly disrupt market channels or require depopulation of infected premises. It is critical to develop feasible mass euthanasia technology that is humane, economical, safe, and less labor intensive. Microencapsulated sodium nitrite (meSN) feral swine bait has been developed and marketed by Animal Control Technologies Australia (ACTA) as a feed-based toxicant for feral swine control. This technology has not been applied to commercial swine in confinement barns, just feral swine. Sodium nitrite is a chemical commonly used in low concentrations as a preservative in processed meats. If consumed at high doses, sodium nitrite can convert hemoglobin to methemoglobin that is unable to transport oxygen in the blood. The reduced oxygen carrying capacity of the blood depletes the brain and tissues of oxygen, causing unconsciousness and death. Pigs are highly susceptible to methemoglobinemia as they have low levels of methemoglobin reductase (Smith et al., 1966), an enzyme that can reverse methemoglobin formation.

SN has several attractive features as a euthanasia method in depopulation strategies. The AVMA has previously approved SN as a mass euthanasia technique in constrained circumstances (AVMA Guidelines for the Depopulation of Animals: 2019 Edition). SN breaks down quickly, making it environmentally safe (USDA, 2017). There are low carcass residues limiting the risk to scavengers and allowing multiple carcass disposal options (Snow et al., 2018).

Little research has been conducted utilizing SN as a euthanasia method for domestic swine. The researchers involved in this study have completed in 2018, multiple pilot studies with commercial swine (unpublished). The results of those pilot trials showed that SN can effectively euthanize swine, however, has been difficult to achieve reliable ingestion when SN is added to commercial feed due to palatability issues. Flavoring or taste blocking agents may improve the ingestion by commercial swine when SN is added, resulting in predictable intake and death.

The aim is to identify the hog feed blend(s) including SN to encourage sufficient voluntary ingestion by commercial swine for a humane euthanasia technology.

Objectives:

1. Evaluate consumption and mortality of pigs consuming meSN (micro-encapsulated sodium nitrite) versus non-encapsulated SN without and with the addition of flavoring and bitterness taste blockers.

2. Evaluate the mortality of pigs consuming non-encapsulated SN through the water.

Materials & Methods

Animals:

A total of 110 early nursery weight pigs (6.2 kg average weight) were sourced and housed at the Carthage Innovative Swine Solutions, Veterinary Research Farm. Pigs were randomly allotted to one of the 11 treatments listed above in Tables 1 and 2 (one treatment per pen, 10 pigs per pen).

Materials:

A commercial feed composed of corn and soy was used as a base feed. Granular form SN (un-encapsulated) salt (Duda Energy, 99.9% pure food grade SN) and microencapsulated SN (Animal Control Technologies (Australia) Pty Ltd 46-50 Freight Drive, Somerton, VIC, 3062, Australia +61 3 9308 9688) were the two sources of SN used in the feeds.

There were three different feed flavors or taste suppressor combinations. Dried molasses at 4.4% inclusion was the first feed flavor. Vanilla at 0.1% inclusion (Lucta, Luctarom 32619Z) was utilized as the second flavor. A bitterness taste suppressor (Lucta, Luctarom Bitteroff "S" 5413Z) at 0.2% inclusion was utilized as the third treatment. The vanilla flavor and taste suppressor inclusion rate were added per the recommended by the manufacturer (Lucta). The molasses inclusion rate was based on recommendation from Dr. Youngsoo Lee, University of Illinois, Dept of Food Science and Human Nutrition, and targeted to be two times the inclusion rate of SN.

The dosage of SN was targeted at 20 grams of SN/100kg of pig at 2 lbs offered per pig. The resulting concentration as 2.2% SN per kg of feed. The sample preparation was completed at Integrated Bioprocessing Research Laboratory (IBRL, https://ibrl.aces.illinois.edu/) pilot plant at the University of Illinois, Urbana-Champaign.

Table 1:

In Feed — Weight in *grams* for 10 pigs

	Sample	Sample codes	Feed	SN	meSN	Molasses	Taste Supressor	Flavor	%SN
1	Feed	Con	9091						
2	Feed + SN	SN	8891	200					2.2%
3	Feed + SN + Molasses	SN+ML	8491	200		400			2.2%
4	Feed + SN + Taste suppressor	SN+TS	8891	200			18.2		2.2%
5	Feed + SN + Flavor	SN+FL	8891	200				9.1	2.2%
6	Feed + meSN	meSN	8871		220				2.2%
7	Feed + meSN + Molasses	meSN+ML	8471		220	400			2.2%
8	Feed + meSN + Taste suppressor	meSN+TS	8871		220		18.2		2.2%
9	Feed + meSN + Flavor	meSN+FL	8871		220			9.1	2.2%
		Total	79338	800	880	800	36	18	

Number of pigs		10	
	lb/pig	g/pig	
Feed intake	2	909.1	
	lb	g	
Base feed	20	9091	
		g SN/pig	
SN dose		20	
		g meSN/pig	
meSN dose		22	90% SN in meSN
Molasses (82 Brix)	x2 of SN		
		% of feed	
Taste supressor		0.2	
		% of feed	
Flavor		0.1	

*SN – free sodium nitrite; meSN – microencapsulated sodium nitrite; Taste suppressor – taste suppressor from a commercial partner; Flavor – vanilla flavored feed additive

The dosage of SN in the water was targeted for an intake of 20g of SN per pig with an intake estimation of 0.25 gallons per pig.

Table 2:

	In Drinking Water		For 10 pigs		
	Sample	Sample codes	Water (gal)	SN (g)	Water intake per pig estimation
10	Water	W Con	2.5		0.25 gal/pig
11	Water + SN	WSN	2.5	200	

This concentration is base on 20g SN/pig.
The test done by Swine Vet Center, P.A. used 1800g SN/ gal water with either 24 or 72 hours of offered water.
Soluble up to 84g SN/100g water (3000 g SN/1 gal water) at 25 C (77 F).

Administration:
Nursery feed and water were offered to all pens on a continuous basis for 48 hours to allow for acclimation. At 24 hours prior to offering treatment diets and water, feeders were emptied for all groups. The feed treatment groups were offered water, the water treatment pens had water removed. At the start of the trial, pigs were offered their respective treatments for 3 hours of ab libitum consumption. 20 lbs of feed were offered per treatment in a two hole feeder with 14'' wide holes. Water was offered through 1 cup per pen.

Measurements:
Pigs were individually numbered and weighed in each treatment. Treatments were monitored for feed intake at a group level, death, time to death, and vomiting

Results:
Control pigs (Group 1 – feed control and Group 10 – water control) did not show any clinical signs or mortality during the treatment.

Of the feed treatment groups, 53 of 80 pigs (66%) were euthanized by SN. Each feed treatment resulted in a range of 50-80% mortality regardless of treatment. 63% of the pigs vomited during the feed treatment. The average time to death was 2 hours and 12 minutes. The earliest pig died at 1 hour and 13 minutes and latest pig at 3 hours.

The water treatment group (Group 11) failed to induce clinical signs or mortality.

Table 3:

Treatment	Sample	Vomit	Mortality	Feed Consumed per pig (kg)	SN consumed per pig (g)	SN/kg	Average Time to Death	Range
1	Feed	0%	0%		Invalid Data			
2	Feed + SN	70%	60%	0.21	4.57	0.76	1:57	1:37 - 2:39
3	Feed + SN + Molasses	70%	60%	0.06	1.26	0.20	2:08	1:38 - 2:18
4	Feed + SN + Taste suppressor	70%	80%	0.31	6.77	1.09	2:01	1:13 - 2:49
5	Feed + SN + Flavor	60%	60%		Invalid Data		2:11	1:53 - 2:51
6	Feed + meSN	40%	60%	0.11	2.36	0.37	2:32	1:50 - 3:00
7	Feed + meSN + Molasses	70%	50%	0.06	1.26	0.21	1:59	1:40 - 2:25
8	Feed + meSN + Taste suppressor	60%	80%	0.11	2.36	0.36	2:19	1:40 - 3:00
9	Feed + meSN + Flavor	60%	80%	0.11	2.36	0.40	2:27	2:01 - 2:48
10	Water	0%	0%					
11	Water + SN	0%	0%					

*SN – free sodium nitrite; meSN – microencapsulated sodium nitrite; Taste suppressor – taste suppressor from a commercial partner; Flavor – vanilla flavored feed additive

Treatment 1 (Control) did not have feed offered during the trial period, so no consumption data is available. Treatment 5 (Feed + SN + Flavor) had invalid data from the feeder weights taken to determine pen consumption. Average feed consumption was 0.14 kg/pig. Pigs on averaged consumed 0.49 g of SN per kg of body weight with a range of 0.20 to 1.09 g of SN per kg.

Discussion:

The timeline of clinical signs is predictable with ab libitum feed intake of SN in commercial swine.

Timeline:

- 0-45 minutes: good feed intake
- 45-75 minutes: stop eating and huddle
- 75 minutes: start to observe vomiting. Progresses to ataxia and palor and then lateral recumbency.
- 90 minutes: earliest mortality. Most were 90-180 minutes.

In previous pilot projects, intake of meSN was low and inconsistent resulting in a mortality rate of less than 10%. The feed treatments of flavoring and taste blocking were to improve consumption of SN. Feed intake during this trial was much improved for all treatments, even those with just SN added to the feeds. All feed formulations performed similarly, with only a 30% mortality rate range between treatments. The rate of vomiting and retching is high (63%). An antiemetic, in combination with SN, should be evaluated.

This method of euthanasia is promising for use in constrained circumstances for depopulation, however, it did not achieve 100% mortality in this trial. It is imperative that pigs receive a bolus of SN for a lethal amount. When pigs begin to experience clinical signs, there will be no further consumption of SN feed. Dosing in this study was at 2.2% inclusion rate. In an effort to overcome the intake concerns in previous work, we used a lower inclusion rate. The feral swine product has used formulations of 10% and moved to 5% inclusion rate. Increasing the inclusion rate may increase the mortality rate but at the risk of pigs being averse to consume the product. Work needs to be done to determine correct dose titration. Current information is based on group intake and weights to determine dosage. Additionally, increasing the feeder space will also have a positive impact on the bolus of SN consumed. In this trial, there were 5 pigs per feed space hole (14''). Effectively, there were 2 pigs eating out of the feeder space at a time. It would be recommended that pigs have uncompetitive access to consume feed when SN feed is administered.

There were minor differences in intake and mortality between the following groups:

- meSN versus SN
- Molasses versus vanilla versus taste blocker groups
- Unflavored meSN and SN versus flavored and taste blocker

It is interesting that there was not an appreciable difference in mortality rate between any of these groups. The flavorings and taste blockers did not improve intake and mortality in comparison to feed with meSN and SN by itself.

Pigs were averse to consuming water with SN solubilized. There was minimal intake and no clinical signs.

Sodium nitrite is a viable option for mass depopulation in constrained circumstances. It euthanized between 50-80% of the pigs when offered to commercial swine in this study. Further development is needed to increase the euthanasia rate of pigs, speed up time to death, and decrease the percentage of pigs that vomit.

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