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Implementing Water-Based Foam Depopulation of Floor Reared Poultry

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Abstract

There are six major steps involved in responding to rapidly spreading poultry disease outbreaks including biosecurity, surveillance, quarantine, mass emergency depopulation, mass carcass disposal, and decontamination. Water-based foam is one of the methods used for mass emergency depopulation during severe disease outbreaks. This project evaluated the logistics of foam depopulation in two experiments. In one experiment, the impact of operating in wider poultry barns was assessed. In the second, the logistics of containerized depopulation were evaluated. Foam expansion rate was impacted by the type of equipment used, with foam generators having higher expansion rate than air aspirating nozzles. Foam expansion rate generally improves the longer the system operates. Barn width negatively affected expansion rate and for wider barns, extensions were required for the system to be efficiently operated.

ABBREVIATIONS

ER: Expansion Rate: HPAI: Highly Pathogenic Avian Influenza; AVMA: American Veterinary Medical Association; USDA; APHIS: Animal and Plant Health Inspection Service; ICS: Incident Command System

INTRODUCTION

There are six major steps involved in responding to rapidly spreading poultry disease outbreaks including biosecurity, surveillance, quarantine, mass emergency depopulation, mass carcass disposal, and decontamination. Biosecurity is a preventative step that is used to reduce potential disease exposure for a facility and/or operation. Surveillance is used to locate and track disease spread during an outbreak. Quarantine is used to rapidly limit the movement of people, animals, and equipment to contain potential pathogens and to try to prevent further spread of the disease. Stamping out or depopulation is the primary strategy for dealing with highly pathogenic avian influenza (HPAI) outbreaks for the USDA APHIS [1] and for the World Organization for Animal Health [2]. After depopulation, carcasses, litter, manure, contaminated feed, and other products need to be rapidly disposed of in a biosecure fashion. Wet cleaning and disinfection are the conventional decontamination procedures used to treat personnel, equipment, and facilities prior to movement off-farm or for areturn to normal operations [3].

In North America, an outbreak of H5N2 HPAI resulted in the death or depopulation of 7.5 million turkeys and 42.1 million egg-layer and pullet chickens [3]. The losses to the average US inventory were sector specific, with turkey (7.5%), layers (10.0%) and pullets (6.3%) being most significantly impacted [3]. In the 2014 - 2015 U.S. outbreak, wild bird movements were the likely source of the initial introduction and subsequent spread of HPAI into new areas [4]. However, once HPAI was in a region, poor biosecurity and human activity became an important transmission mechanism [4]. The outbreak resulted in a total economic loss of approximately $3.3 billion, with outbreak control estimated at $850 million [5]. In contrast, the 2016 H7N8 HPAI outbreak was more quickly contained and resulted in one confirmed turkey premises, one dangerous contact layer chickenpremises, and nine low pathogenic avian influenza-affected turkey premises [5].

The approach for dealing with such contagious diseases includes surveillance, quarantine, depopulation, disposal, and decontamination. Depopulation of the diseased flocks minimizes animal suffering and stops virus replication and dissemination. The American Veterinary Medical Association (AVMA) has outlined the animal welfare standards for both general euthanasia and depopulation during outbreaks. Euthanasia methods for poultry (domesticated birds used for egg, meat, or feather production [e.g., chickens, turkeys, quail, pheasants, ducks, geese]) include gas inhalation, manually applied blunt force trauma, cervical dislocation, decapitation, electrocution, gunshot, captive bolt, and injectable agents [6]. Water-based foam is conditionally acceptable for depopulation of floor reared poultry [7].

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The AVMA supports the use of water-based foam as a method of mass depopulation in accord with the conditions and performance standards outlined by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS) [7]. The conditions are as follows: 1) Appropriate method of depopulation for floor-reared poultry, 2) Animals are potentially infected with a zoonotic disease, 3) Animals are experiencing an outbreak of a rapidly spreading infectious disease that, in the opinion of state or federal regulatory officials, cannot be contained by conventional or currently accepted means of depopulation, and 4) Animals are housed in structurally unsound buildings that would be hazardous for human entry, such as those that may result from natural disaster [7]. Foam depopulation methods currently available include foam generator and air aspirating nozzle systems or a combination of both. With a foam generator, foam concentrate and water are sprayed into the airstream from a water-powered fan motor, resulting in medium to high expansion rates (ER). With an air aspirating nozzle, foam is produced by drawing air into a stream of surfactant solution inside the nozzle [8].

Foam depopulation equipment and protocols for mass emergency depopulation of floor reared poultry have been developed and shown to be effective for broilers, turkeys, table egg layers, and ducks [9-16]. An example of a commercial foam generator system is the Kifco Avi-Foam Guard, which was designed for use in large, commercial-scale broiler barns and turkey barns. At the time the system was developed, typical new construction broiler barns were 12.2 - 12.8 m x 153 m. The poultry industry has generally moved towards larger barns as a result of economies of scale. For example, newer construction broiler barns are typically 20.1 x 183 and turkey barns can be up to 28.0 m x 280 m. Most testing and development of the foam generator system was performed on smaller, older barns. Experience shows that the current generations of equipment may be limited in effectiveness for barns greater than 15.3 m wide. Penning may be used to reduce the length and/or width of the area to be treated. In particular, for long barns, penning is used to split the barn lengthwise and foaming performed from each end.

An outbreak of HPAI in caged layers as occurred in 2014 - 2015 represents one of the worst-case scenarios for the poultry industry. The recent outbreak in laying hens in the US decreased the national table egg flock by 7% compared to the previous year [17]. Depopulation in layer houses can be extremely difficult due to the fact that multiple birds are kept in a cage as well as the high population within a given building and complex. When depopulating birds in cages, birds must be (a) removed before death, (b) immediately after death and before the onset of rigor mortis, or (c) after death and rigor mortis pass, but before decomposition begins. Removing the birds prior to depopulation requires significant human handling of infected poultry, which places personnel at a greater risk and increases bird handling stress. Removing the carcasses prior to rigor mortis is ideal in order to avoid the carcasses becoming stiff and thus difficult to remove from the cage. The faster the carcasses can be removed, the quicker the disposal and decontamination processes can be completed. Most layer hen facilities have large numbers of birds in rows of cages 5 to 10 cages high. Laying hen facilities can range in size from approximately 100,000 to 4 million hens on one farm. The processes of catching the birds can take weeks to complete and in a disease situation, birds may die to disease prior to completing the catching process. This is a significant problem whether birds are removed from the cages first and then depopulated or depopulated in the cages and then removed.

Depopulating the birds in the cages effects which methods are most appropriate. Unfortunately, the cages represent a barrier for current foam depopulation systems. Currently approved methods such as nozzle based and generator based foam depopulation systems can effectively kill layer hens outside of cages, however, the foam cannot effectively penetrate and provide sufficient retention time within a cage [10,18]. Currently, there are no approved foam depopulation methods that are effective, and suitable for depopulating birds while still in cages.

Water resources are a significant concern as the size of the barn or farm increases. ER has a significant impact on the amount of water required for depopulation. A single foam generator or air aspirating nozzle requires approximately 320 lpm and most commercial systems can supply two devices, such as two generators or one generator and one nozzle.

During an outbreak, water resources will often have to be brought on to the farm, often in the form of a tanker (also called a water tender in ICS terminology) relay. In a tanker relay or water shuttle, water tenders are rapidly and repeatedly filled and brought to a site, dumped, refilled, and returned to service or for another water delivery [19]. Water shuttles are routinely used during rural fire fighting, where water resources can be limited. Biosecurity is a critical component of emergency poultry disease management and the simplest method to maintain biosecurity is to avoid contaminating equipment. Any equipment brought onto the farm needs to be appropriately cleaned and disinfected prior to departing the farm. The need to repeatedly clean and disinfect the water tenders during a water shuttle will slow the operation considerably.

During the 2014 - 2015 HPAIV outbreak, some water tenders were brought into the biosecurity hot zone to directly supply water to the foam depopulation units. Water supply hoses need to be matched to ensure compatibility between the water tender and foam depopulation units. During the outbreak, equipment became fouled with sediment and oil residue when directly drafting from a water tender which drew sediment or contaminants from the tank into the foam system. Petroleum residue is a particular concern because it will negatively alter the foaming characteristics of the system. As an alternative, two portable tanks can be used, one tank located near the foam depopulation system and a second tank can be placed outside the biosecurity hot zone as near to the road as possible. The water tenders discharge their water into the tank near the road and the water is pumped on site to the portable tank near the foam depopulation system. Discharging into a portable tank allows sediment to settle out of solution and some types of contamination will be visible. In addition, the depopulation team only needs to have matching fittings to draft from the portable tank, regardless of the hose fittings on the water tender. More importantly, this approach maintains biosecurity by keeping the water tenders off the farm.

MATERIALS AND METHODS

Two experiments were conducted to evaluate the logistics of foam depopulation. Experiment 1 evaluated the impact of barn width, foam concentrate, and duration of operation on ER. Experiment 2 evaluated the logistics of large scale containerized foam depopulation.

Experiment 1

In Experiment 1, A Kifco (Havana, IL) Avi-Foam Guard trolley cart equipped with two foam generators and an air aspirating foam nozzle (AWG medium expansion foam nozzle, AWG Fittings, Ballenborf, Germany) was modified to include foam generator boom extensions. A Kifco Avi-Foam Guard AV-ST3 IRR depopulation system was used for foam production. Multiple commercially available foam concentrates including Ansul (Marinette, WI) Silvex (Concentrate A), ICL Performance Products (Rancho Cucamonga, CA) Phos-Chek First Response (Concentrate B), and Phos-Chek WD881 (Concentrate C) were tested. Foam concentrate was maintained at 1% using a foam proportioner (Dostec-40, I.T.C. Dosing Pumps, Barcelona, Spain).

Extension booms for the foam generators were developed to provide greater width between generators to provide better distribution of foam in the wider pen. Without extensions, the two foam generators were located approximately 3.7 m apart. The extensions allowed the foam generators to be moved to achieve up to a 9.0 m separation between the generators. The extensions, as shown in (Figure 1), were intended for research purposes only and would need to be improved for field use. Tension cables were used to provide support for the extensions. The foam nozzle was mounted on the front of the trolley cart as shown in (Figure 1).

Two different open-air pens, one 15.3 m wide x 62.3 m long and one 23.7 m wide x 62.3 m long, were constructed using 0.9 m silt fence on level ground. The lengths of the pens were chosen to allow the system to reach operating configuration and avoid endeffects due to starting or stopping. The foam generators were used to fill the pen starting from the back wall forward and operated as normal. The generator cart mounted nozzle was used as required to move foam or fill areas in the corners and sides of the pens not reached by the generators. Measurements were initiated after water and foam concentrate reached the foam generator. Water consumption was recorded every 7.6 m using a flow totalizer. The foam height goal was 0.9 m, however, under open air conditions, there was some variability in resulting foam height.

Experiment 2

In Experiment 2, foam was created using a single generator or a single foam nozzle as shown in (Figure 2). The foam nozzle used was a Spumifermodel AG-1 (Spumifer, Ridgefield Park, NJ). A Darley (Itasca, IL) 2-1/2AGE 31BS pump driven by a 23 kW Briggs & Stratton (Milwaukee, WI) Vanguard gasoline engine provided a rated water delivery performance of 1136 L/min at 586 kPa was used. A commercial 30.5 m^3 trash dumpster was filled to a height of 1.2 m - 2.1 m to determine ER. Foam concentrates A and C were used in the experiment at 1% using the foam proportioner as in Experiment 1.

Expanded foam volume and expansion rate were calculated from the recorded data and the actual foam height was used as part of the calculations for resulting volume and ER.

DATA ANALYSIS

Data was analyzed in Microsoft Excel and statistical analysis was performed using JMP 13.0 (SAS Institute, Inc., Cary, NC). ER was calculated using the formula below.

$$ER = \frac{(L \times W \times H)}{V}$$

Where ER is the expansion rate, V is the volume of water in m^3; L, W, and H are the length, width, and height in m of the foam filled area.

Figure 1 The modified foam depopulation trolley cart, showing the extensions used with the foam generators. The air aspirating foam nozzle was used to aid in foam distribution.

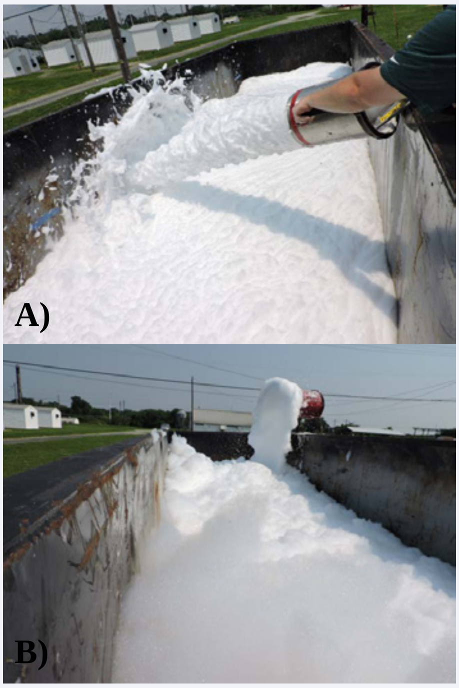

Figure 2 In Experiment 2, nozzle (a, top) and foam generator systems (b) were used to fill a portable dumpster and expansion rates were calculated.

Table 1: Foam generator system expansion rate as analyzed by foam concentrate.

Foam Concentrate	Mean Expansion Rate (ER)	
	Experiment 1	Experiment 2
Concentrate A	79.5^{a}	111.1^{a}
Concentrate B	71.6^{ab}	97.6^{a}
Concentrate C	65.2^{b}	

Mean values for the same columns with different superscript letters are statistically different at ($p < 0.05$).

RESULTS AND DISCUSSION

ER was calculated with different combinations of barn width, barn length, and foam concentrate as shown in (Figure 3) and (Figure 6). In Experiment 1, using combinations two generators and a nozzle produced a mean ER of 64.9, with a range of 28.7 to 106.9. In Experiment 2, mean ER for a single foam generator of 103.7, with a range of 49.6 to 136.9, while the mean ER for the single air aspirating nozzle of 55.3, with a range of 47.3 to 68.9. These ER values are within the USDA guidelines for floor reared poultry, however, they are lower than typically referenced for foam generator or nozzle use. The manufacturer's listed ER for the foam generator is 100:1 [20] and the AWG nozzle is 60:1 [21]. In these tests, the nozzle was used to help move foam and/or fill areas that did not have complete coverage. Experiment 2 showed that nozzle use can and did significantly affect overall ER. Nozzle ER was approximately half (55.3) versus the foam generator (103.7). In some circumstances, the use of the nozzle, even though it has a lower ER, when used efficiently in conjunction with the foam generators can reduce the time to foam a large barn.

The type of foam concentrate did not have a consistenteffect on foam ER as shown in (Table 1). In Experiment 1, Concentrate A (ER = 79.5) was higher than Concentrate C (ER = 65.2), but could not be distinguished from Concentrate B (ER = 71.6). In Experiment 2, the differences between Concentrate A (ER = 111.1) and Concentrate B (ER = 97.6) were not significant. This is important since Concentrate C is one of the standard foam concentrates recommended for emergency use. Concentrate C was used for the majority of the wider barn tests.

ER generally improves with the distance that the system operates as shown in (Figure 3) ($p < 0.0001$). Tests were conducted up to 60.9 min length, which is less than the capacity of the equipment (200 m). Foam depopulation systems take some time before the equipment reaches operating conditions. In addition, foam depopulation systems are more efficient when they remain operational because it avoids decreased ER during transition phases such as start up. The transition phases partially explain the lower ER for shorter travel distances.

Barn width negatively affected ER ($p < 0.0001$) as shown in (Figure 4). Without extensions, the foam generator system provided sufficient depth of foam for barns 15.3 m to 18.3 m wide. At barn widths of 15.3 m to 18.3 m, an air aspirating nozzle on the foam generator cart was required to help redistribute the foam towards the outside edges of the barn. Many of the generator carts are equipped with an air aspirating nozzle, which allows backfilling areas of low height foam, around posts or obstacles, and to assist in moving foam towards the outside of the structure. The units have the capacity to operate two devices (for example, one air aspirating nozzle and one foam generator or two foam generators). The required use of the nozzle in conjunction with the foam generators for the wider width barns tested contributed to the decreased expansion rate. This increased overall foam and water consumption as expected.

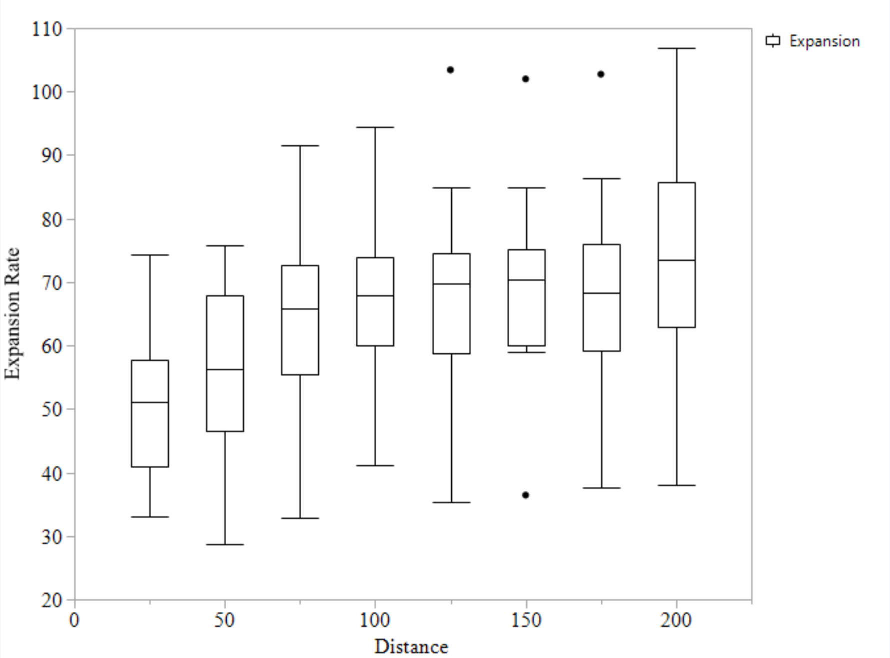

Figure 3 In Experiment 1, foam expansion rate increases with the length of operation. Outliers shown exceed the upper or lower bound of the box plot by at least 1.5 times the inter quartile range.

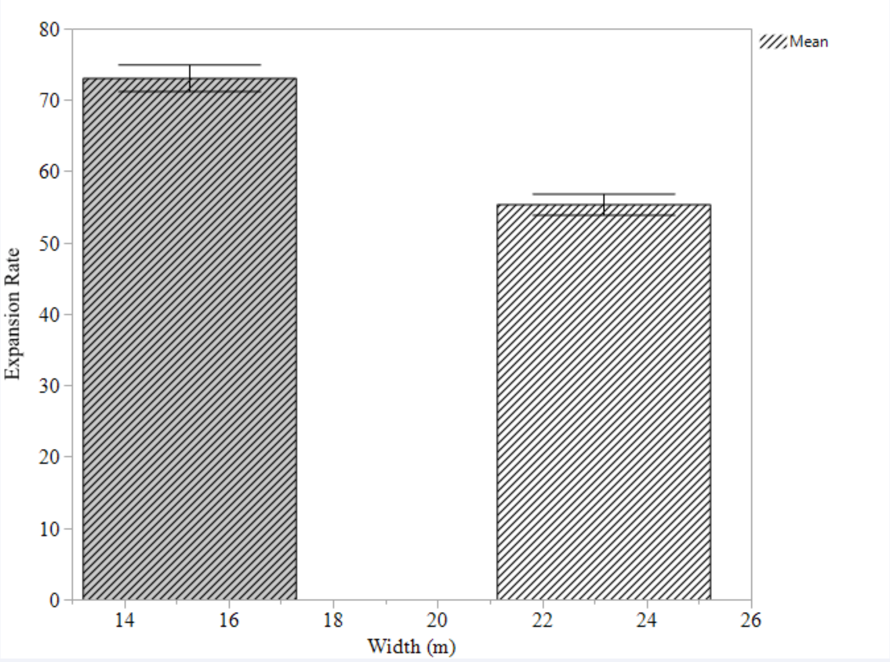

Figure 4 In Experiment 1, expansion ratio was negatively affected by barn width. Error bars show one standard error from the mean.

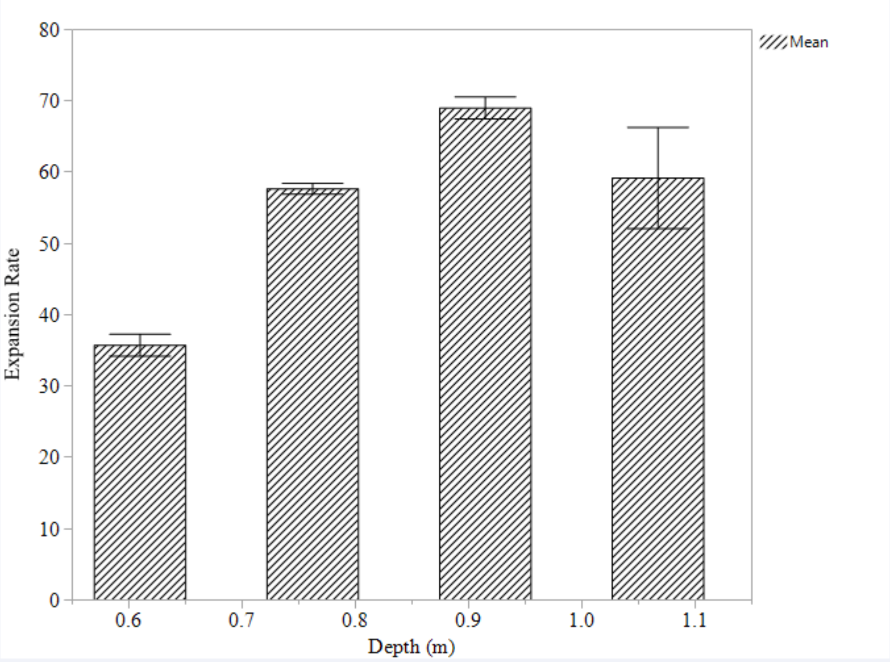

Figure 5 Foam expansion rate versus depth for Experiment 1. Error bars show one standard error from the mean.

Without extensions, it is difficult to reliably make high quality foam at widths greater than 18.3 m. Generator extensions allow the generators to be moved further out and gain additional barn width capability. The extensions negatively impacted foam generator cart stability. Support poles or structures will limit the use of extensions. The extensions should be purpose designed to ensure appropriate stability and durability.

Experiment 1 was primarily conducted with a controlled depth, 0.9 m as shown in (Figure 5) ($p < 0.0001$). Experiment 2 was conducted at depths 1.2 m to 2.1 m, which is an important consideration both for containerized depopulation and larger floor reared birds. ER can be impacted by depth (Figure 5) and nozzle use (Figure 6). When compared directly, foam generators alone will have a higher ER than nozzle and foam generator for the same depth. As the required depth increases, the wetter

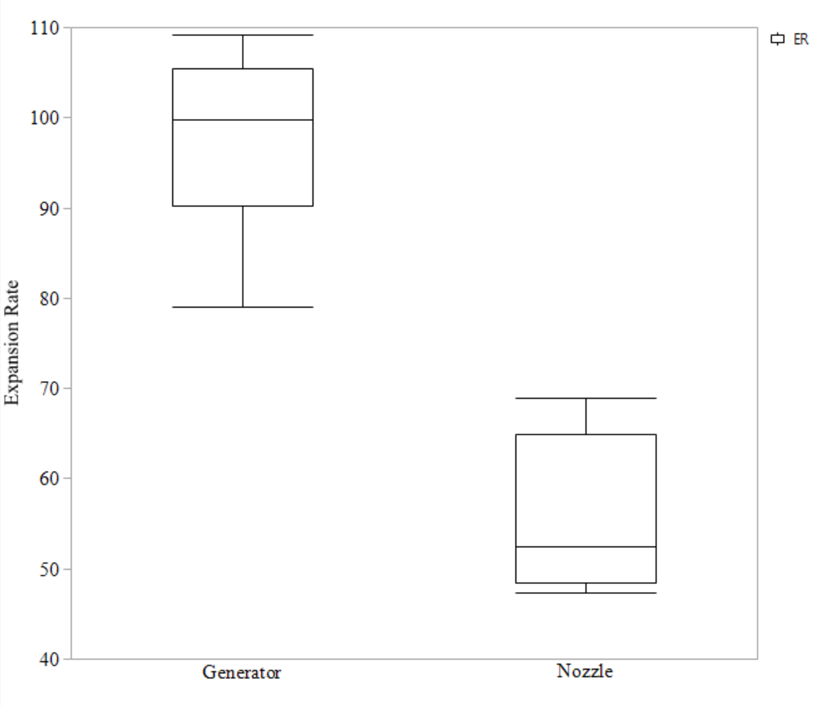

Figure 6 In Experiment 2, foam generator expansion rate was significantly greater than air aspirating nozzle expansion rate.

foam from the nozzle does not build depth at the same rate as for the foam generator, resulting in a lower ER. In addition, the weight of foam tends to cause the foam at the top to break down the bubbles at the bottom, making it more difficult to reach the required depth. Barn length greater than 183 m is a concern for foam depopulation due to equipment limitations. There is some variation in available hose length for the foam generator systems and it is not practical to add additional hose to an existing foam generator system in the field.

ER is one of the most significant drivers for USDA approved foam depopulation [7]. ER should be kept in the ratio of 30:1 to 120:1. At ER higher than 120:1, foam will not flow into the trachea of the bird. At ER less than 30:1, it will be difficult to build a sufficient depth of foam to cover the birds.

CONCLUSION

A number of factors were found to impact foam expansion rate and this is important because foam expansion rate is the primary factor affecting water and foam requirements in the field. Foam concentrate, foam depth, barn width, nozzle and generator usage all impacted expansion rate. Allowing the system to remain operational without transitions positively affected expansion rate, resulting in more effective use of the foam depopulation system.

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CONFLICT OF INTEREST

Benson and Alphin are named inventors on US Patent 7,435,166 (“Foam based equipment and procedure for emergency euthanasia”).

REFERENCES

1. United States Department of Agriculture. Animal and Plant Health Inspection Service. Foreign Animal Disease. The Red Book. 2017.
2. World Organization for Animal Health (OIE). Terrestrial Animal Health Code. 2017.
3. United States Department of Agriculture. Animal and Plant Health Inspection Service. 2016 HPAI preparedness and response plan. 2017.
4. Garber L, Bjork K, Patyk K, Rawdon T, Antognoli M, Delgado A, et al. Factors associated with Highly Pathogenic Avian Influenza H5N2 infection on table-egg layer farms in the Midwestern United States. Avian Dis. 2016; 60: 460-466.
5. Swayne DE, Hill RE, Clifford J. Safe application of regionalization for trade in poultry and poultry products during highly pathogenic avian influenza outbreaks in the USA. Avian Pathol. 2017; 46: 125-130.
6. American Veterinary Medical Association. AVMA Guidelines for the Euthanasia of Animals: 2013 Edition. Am Vet Med Assoc.
7. American Veterinary Medical Association. Poultry depopulation. 2015. https://www.avma.org/KB/Policies/Pages/Poultry-Depopulation.aspx Accessed 5/25/2015.
8. Laundess AJ, Rayson MS, Dlugogorski BZ, Kennedy EM. Suppression performance comparison for aspirated, compressed-air and in situ chemically generated Class B foams. Fire Technol. 2012; 48: 625-640.
9. Alphin RL, Rankin MK, Johnson KJ, Benson ER. Comparison of water-based foam and inert-gas mass emergency depopulation methods. Avian Dis. 2010; 54: 757-762.

10. Benson ER, Alphin RL, Rankin MK, Caputo MP. Mass emergency foam depopulation of poultry. Avian Dis. 2012; 56: 891-896.

11. Benson ER, Malone GW, Dawson MD, Alphin RL. Use of water-based foam to depopulate ducks and other species. Poult Sci. 2009; 88: 904-910.

12. Benson E, Pope CR, Van Wicklen GL, Dawson MD, Malone GW, Alphin RL. Foam-based mass emergency depopulation of floor-reared meat-type poultry operations. Poult Sci. 2007; 86: 219-224.

13. Caputo MP, Alphin RL, Pritchett EM, Hougentogler DP, Johnson AL, Benson ER, et al. Evaluation of the diving reflex in response to non-terminal submersion of White Pekin ducks in water-based foam. Poult Sci. 2013; 92: 412-417.

14. Caputo MP, Benson ER, Pritchett EM, Hougentogler DP, Jain P, Patil C, et al. Comparison of water-based foam and carbon dioxide gas mass emergency depopulation of White Pekin Ducks. Poult Sci. 2012; 91: 3057-3064.

15. Flory GA, Peer RW. Verification of poultry carcass composting research through application during actual avian influenza outbreaks. ILAR J. 2010; 51: 149-157.

16. Rankin MK, Alphin RL, Benson ER, Johnson AL, Hougentogler DP, Mohankumar P. Comparison of water-based foam and carbon dioxide gas emergency depopulation methods of turkeys. Poult Sci. 2013; 92: 3144-3148.

17. Mathews K, Haley M. Livestock, Dairy, and Poultry Outlook. USDA ERS. No. (LDP-M-253) 11 pp. July 16, 2015. www.ers.usda.gov/media/1871909/ldpm253.pdf.

18. Federal Emergency Management Agency US Fire Administration. Safe operations of fire tankers. 2003.

19. Alphin RL, ER Benson, DP Hougentogler. Is foam an option for addressing the challenges associated with the depopulation of caged layers? 2015. 5th International Symposium on Animal Mortality Management. Lancaster, Pennsylvania. 2015; 28-30.

20. Kifco. Kifco Avi-Foam Guard. 2016.

21. AWG Fittings, Ltd. Catalogue 2015. 2015.

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