The One Health Paradigm: Challenges and Opportunities for Developing Successful Interventions to Improve Poultry and Human Health

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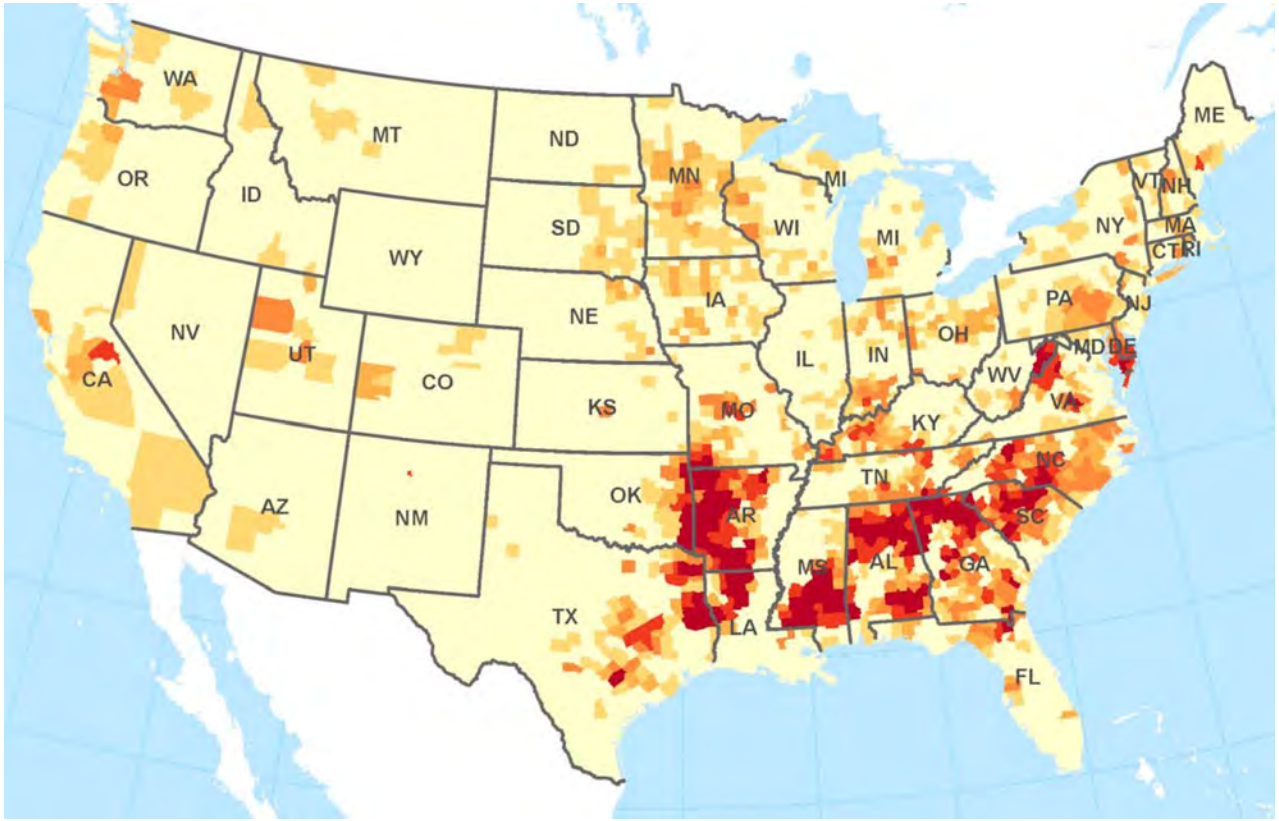
Introduction: Poultry Production



- 32,751 broiler chicken farms
  - USDA, 2017
- 8.56 billion eggs produced annually in the US
  - American Egg Board, 2019

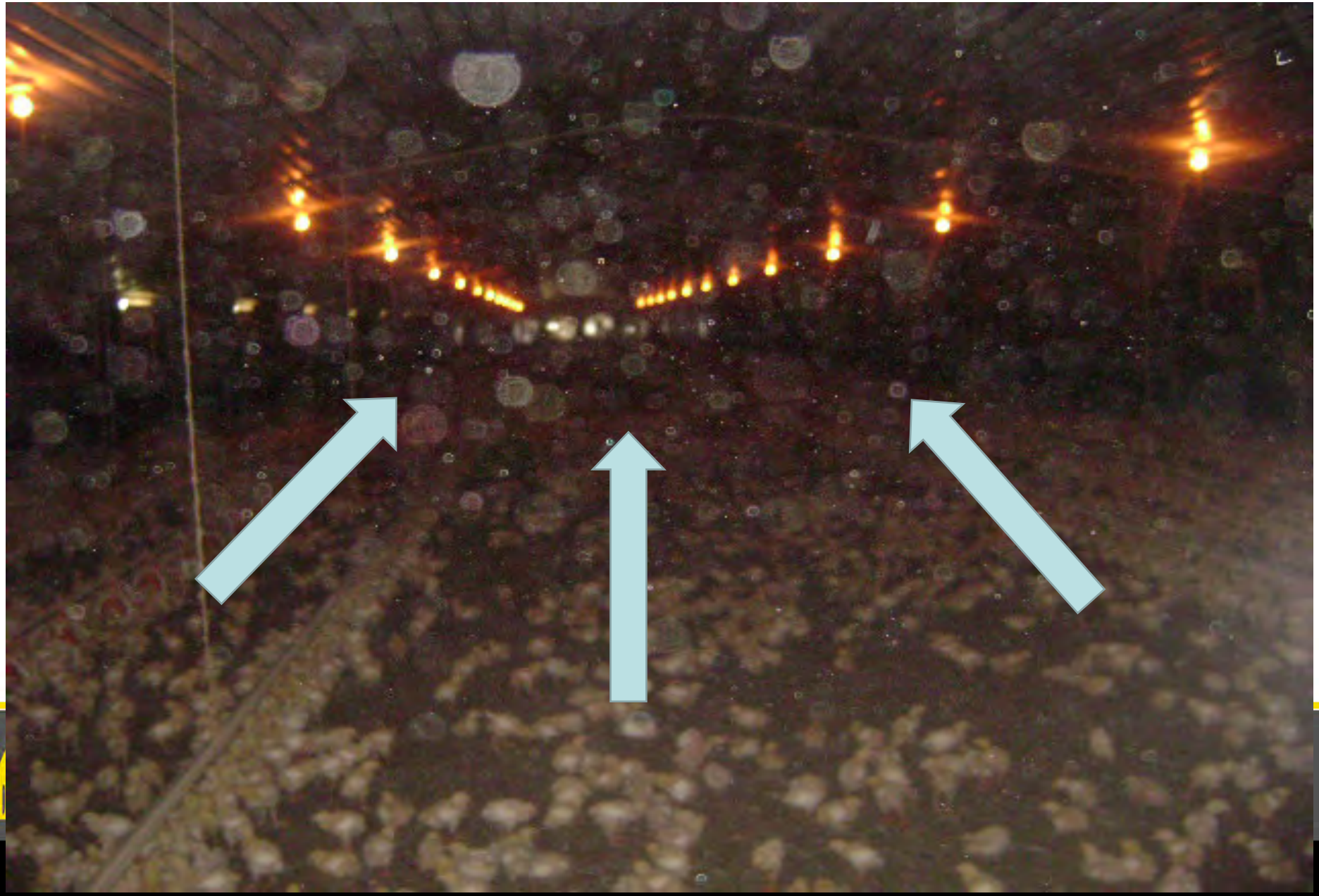
https://www.agcensus.usda.gov/Publications/2012/Online_Resources/Ag_Census_Web_Maps/

Introduction

- Inhalation hazards in poultry production:
  - Dust, NH_3, H_2S, CH_4, CO_2, microorganisms (e.g., influenza), components of microorganisms (e.g., peptidoglycan, endotoxins), bedding, feed, dander, respiratory secretions
  - Greatest concentrations in the winter months due to lower ventilation rates
  - Exposures are typically well below Permissible OSHA Exposure Limits
  - OSHA PEL Particles Not Otherwise Regulated (PNOR) – 8hr - TWA
    - Total dust - 15 mg/m^3
    - Respirable dust – 5 mg/m^3
  - Recommended exposure concentrations (Donham et al.,2000)
    - Total dust - 2.4 mg/m^3
    - Ammonia, 7ppm
    - 614 Endotoxin units/m^3
    - $l0^4$ microorganisms/m^3

Broiler House

Broiler House



Broiler House

Broiler House

Grower Major Work Tasks

Daily Tasks

- Mortality collection
- Checking feed and water lines
- Monitoring computer system

Non-daily Tasks

- Place Chicks
- Inspection
- Caking out top layer of litter for next flock
- Catch crews
- Power Washing

Labor Required to Operate Broiler Farm

Number of houses	Weekly hours: Primary operator	Weekly hours: All operators	Labor inputs to production: Unpaid hours	Labor inputs to production: Paid labor compensation ($)
			Per 1,000 pounds produced	
1-2	25	30	1.72	0.00
2-4	35	40	0.97	0.09
5-6	40	49	0.67	1.01
7-8	40	50	0.53	2.44
9-10	45	45	0.41	2.65
11-12	45	50	0.35	4.42
13-18	45	45	0.27	5.97
All farms	32	40	0.96	0.15

Note: Estimates are median values in each size class (half of farms in a class have greater values and half have smaller).

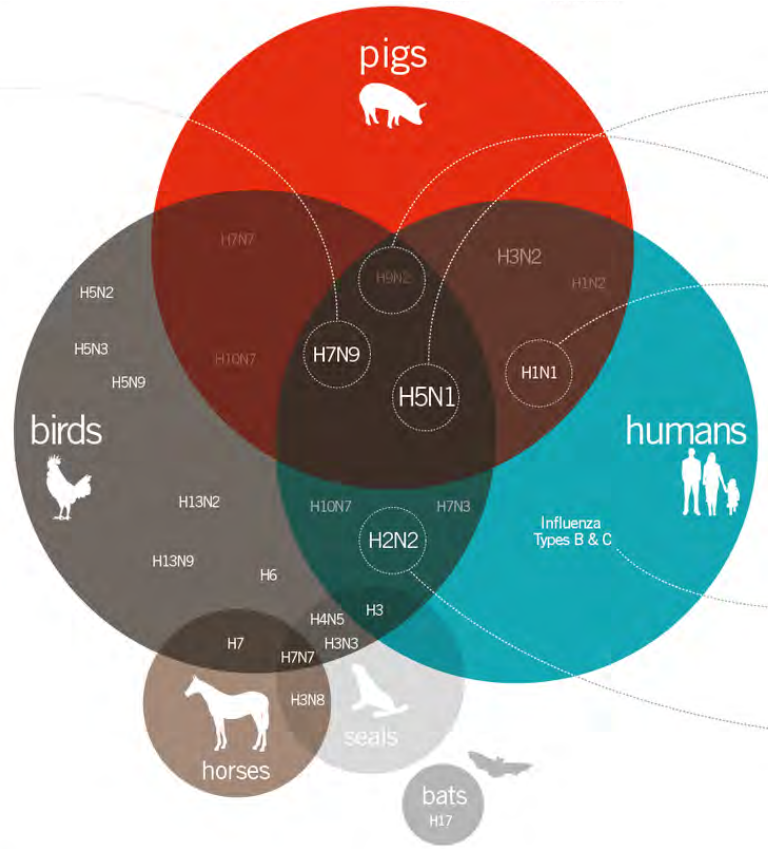
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.

Aerosol and Gas Exposures in Poultry Production Facilities

- Associations between dust exposure and chronic respiratory diseases
- Associations between endotoxin exposure and a decrease in lung function
- However, the personal exposure to dust, endotoxin and bioaerosols have not been well characterized among US workers

Introduction: Avian Influenza

- Highly pathogenic avian influenza (HPAI) or low pathogenicity avian influenza (LPAI)
  - based on pathogenicity in poultry
  - both LPAI and HPAI viruses have caused illness in humans
- AI viruses rarely infect people
  - subtypes that have infected humans
    - H5, H7 and H9 viruses
  - Infections occur when eyes, nose or mouth is exposed or the virus is inhaled
  - Viral exposures or control technologies have not been well characterized



Objectives

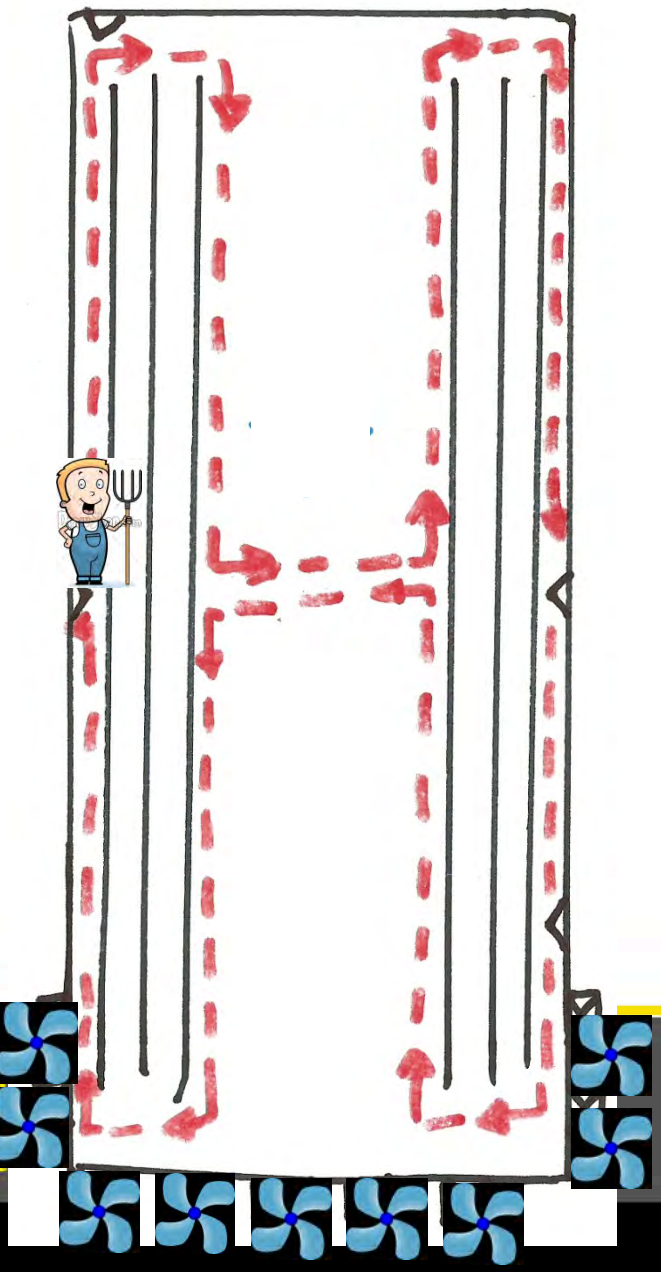
- Study 1 – Task-based exposure assessment of inhalable dust during work in broiler chicken production
  - Determine personal exposure to inhalable dust
- Study 2 - Task modification – “dead bird pickup” during work in broiler chicken production
  - Compare exposures across “traditional” and “modified” task
- Study 3 – Exposure assessment during the composting of birds euthanized during an outbreak of avian influenza
  - Measure NH_3 concentrations during composting of euthanized birds
- Study 4 - Evaluate the effectiveness of a water sprinkler system to reduce inhalable dust and ammonia concentrations in a broiler chicken house

Study 1: Experimental Design

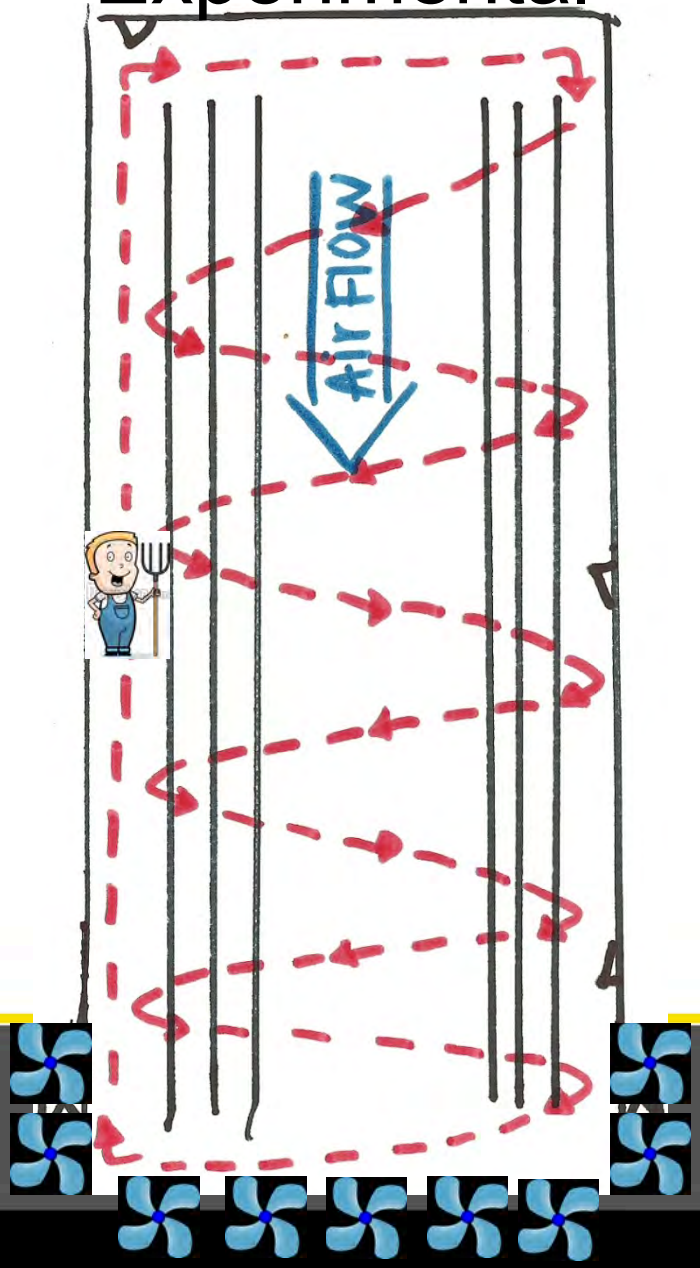
- Personal Exposure to Inhalable Dust
  - Button Sampler (SKC, Inc.)
    - Sample Flow Rate: 4 Liters per min (LPM)
    - Collection Media: Polyvinyl chloride filters, (5 um pore size, SKC Inc.)
  - Tasks
    - Study 1: Litter Sampling
      - » Dust Concentration (n=69)
      - » Endotoxin Concentration – rFC Assay (n=69)
      - » Microbial Composition (n=15)
    - Study 2: Mortality Collection (n=38)
      - » Microbial Composition (n=3)
- Settled Dust
  - Curtains and Side walls
    - Microbial Composition (n=3)

Study 2

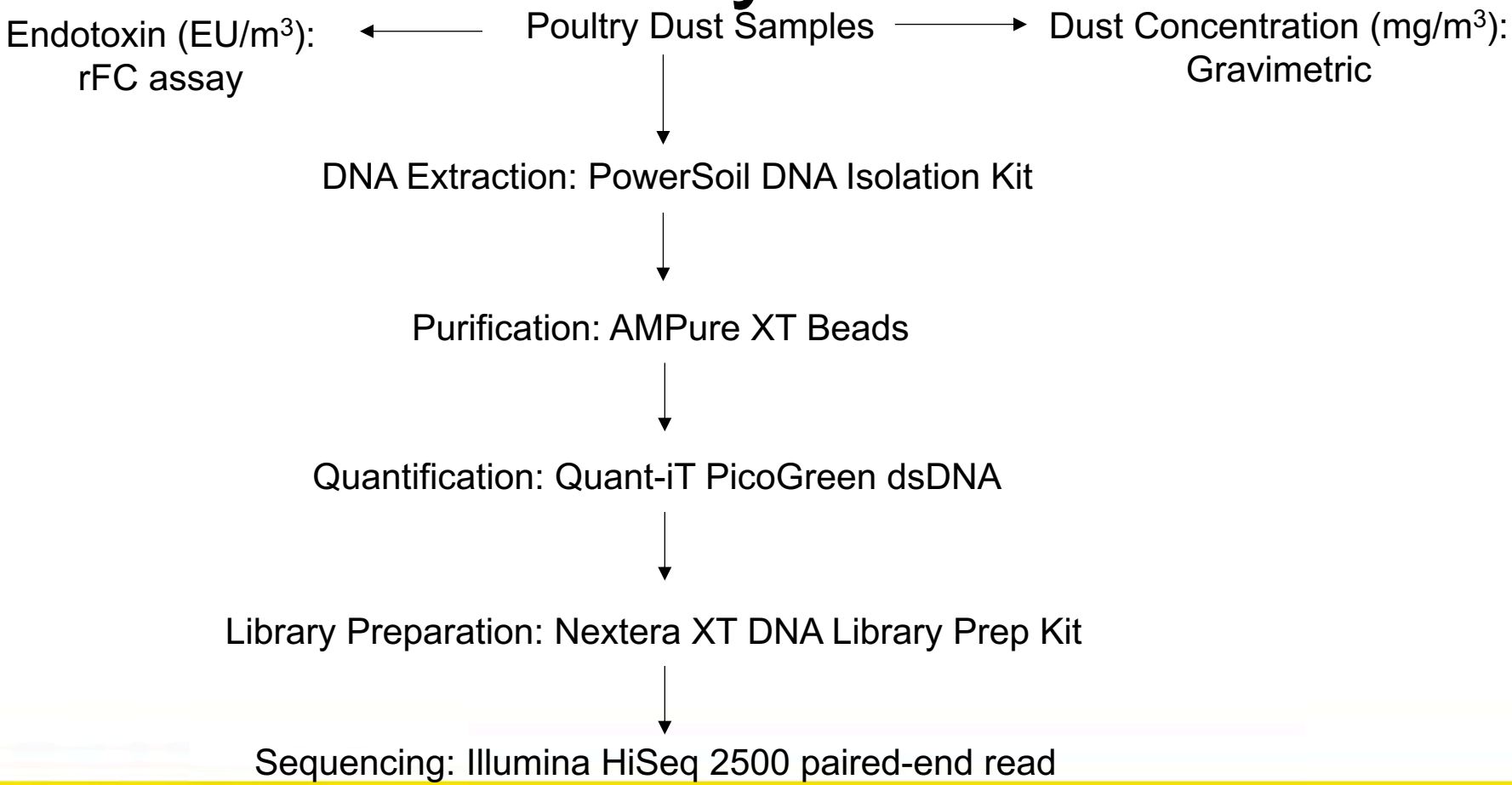
Traditional



Experimental



Study 1 and 2: Dust Sample Analyses

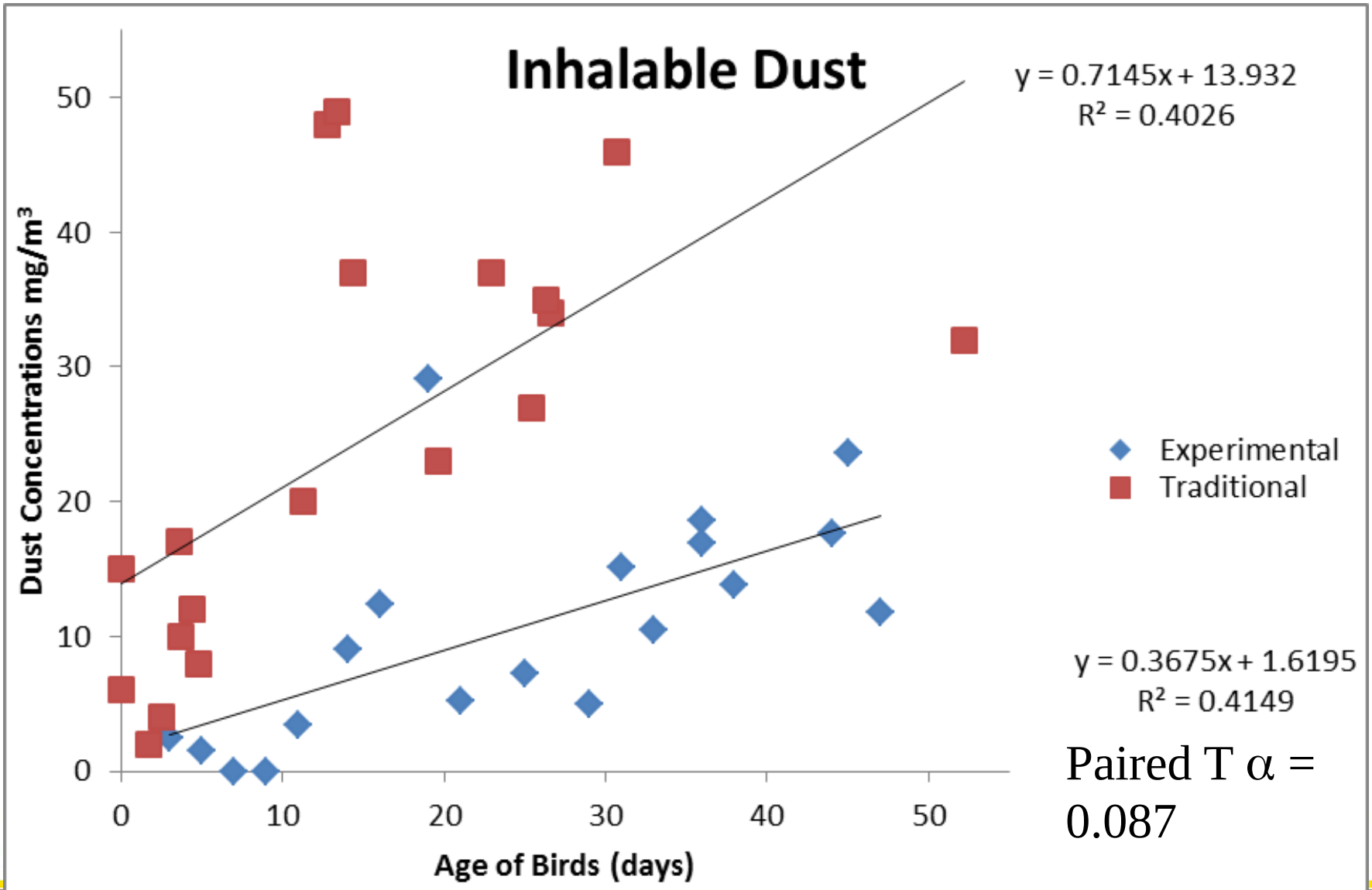


Study 1: Results - Inhalable Aerosol Exposure

- Litter sampling
  - Inhalable dust — 3.9 mg/m^3 (GSD = 2.8)
- Dead Bird Pickup
  - "Traditional" Inhalable dust — 16.2 mg/m^3 (GSD = 1.4)
  - "Experimental" Inhalable dust — 12.0 mg/m^3 (GSD = 2.7)

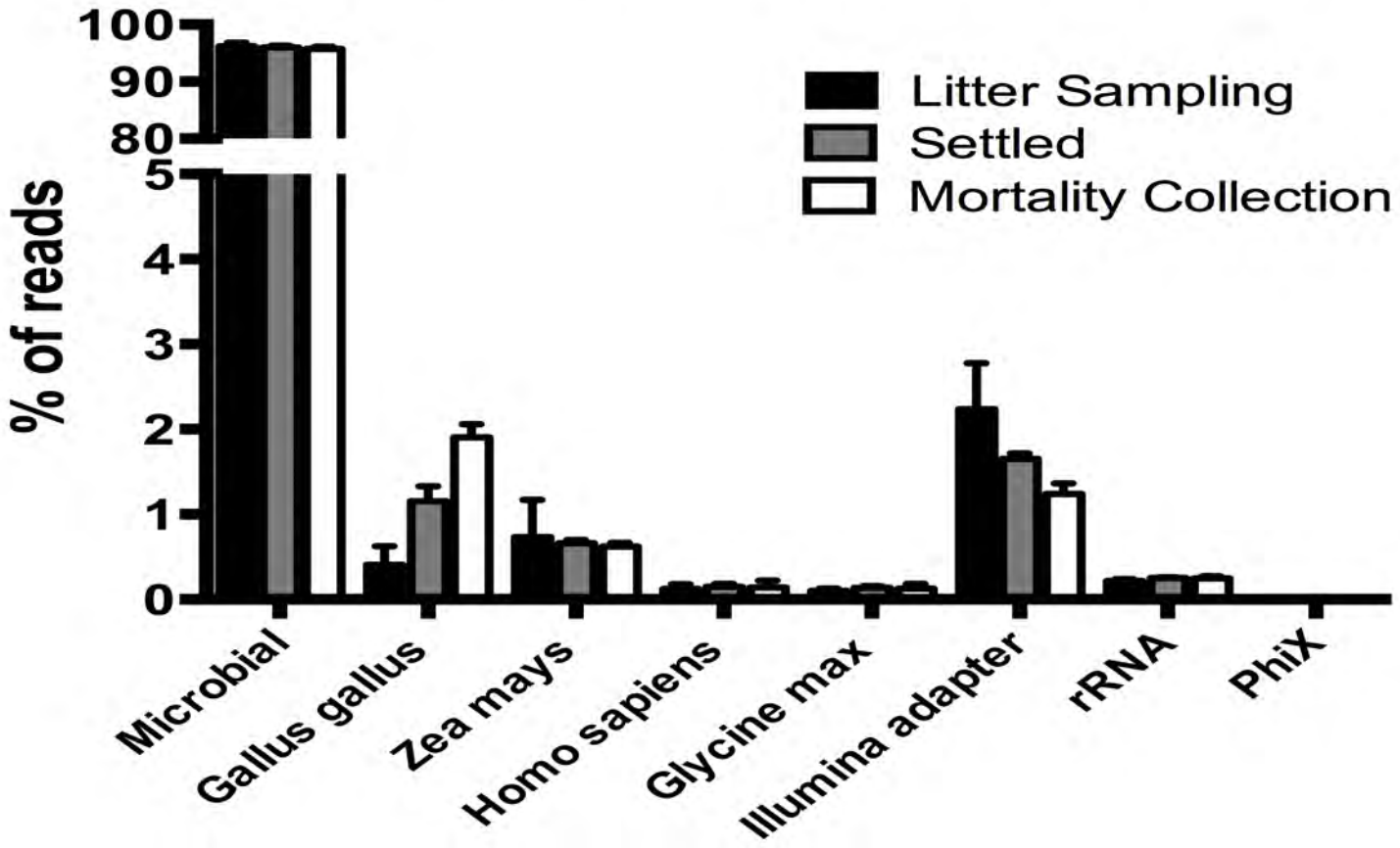
Multivariable analyses suggests that dust exposure was reduced in broiler houses using:

- mechanical fan ventilation ($p = 0.0005$)
- liquid litter amendment ($p = 0.009$)

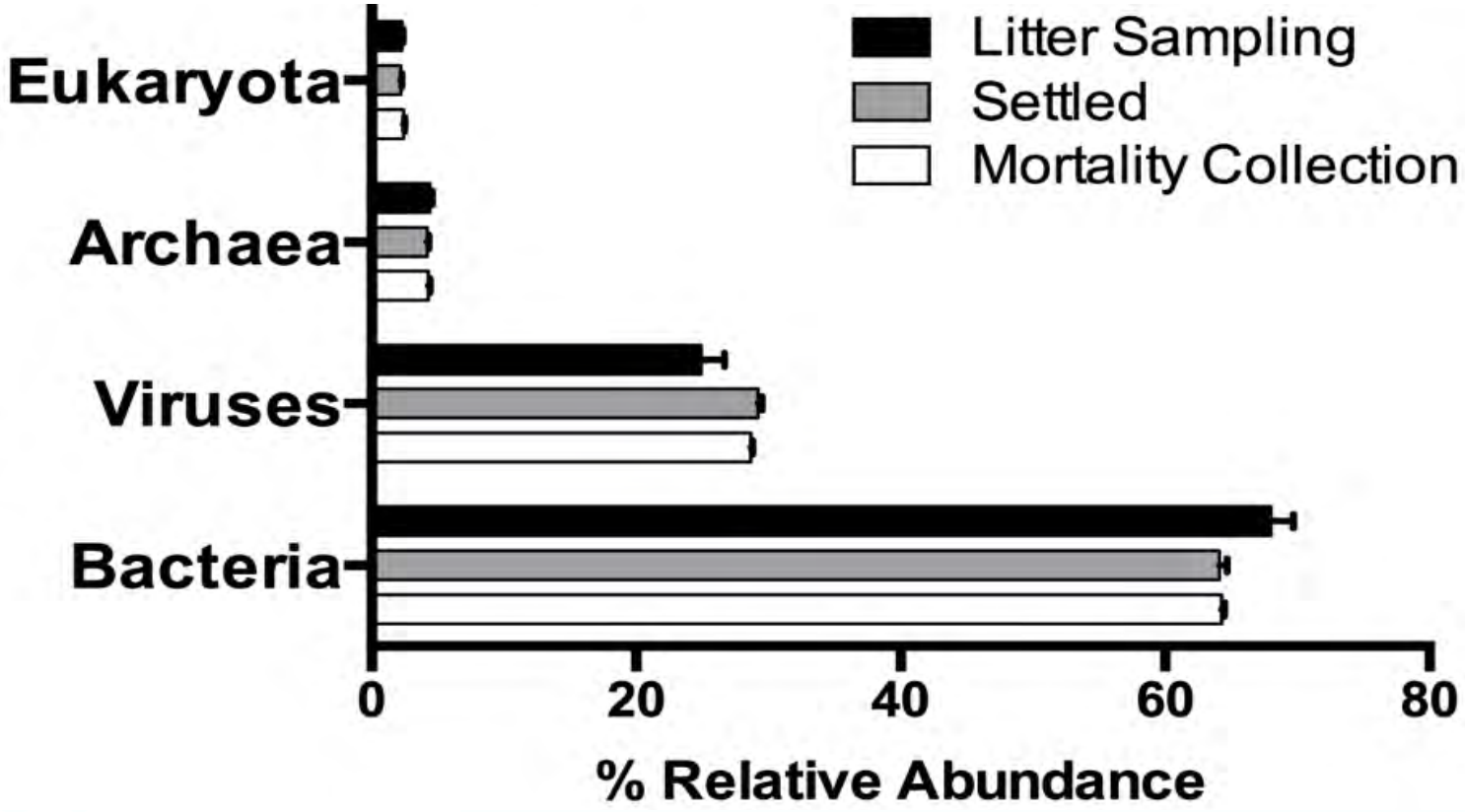


Paired T α = 0.087

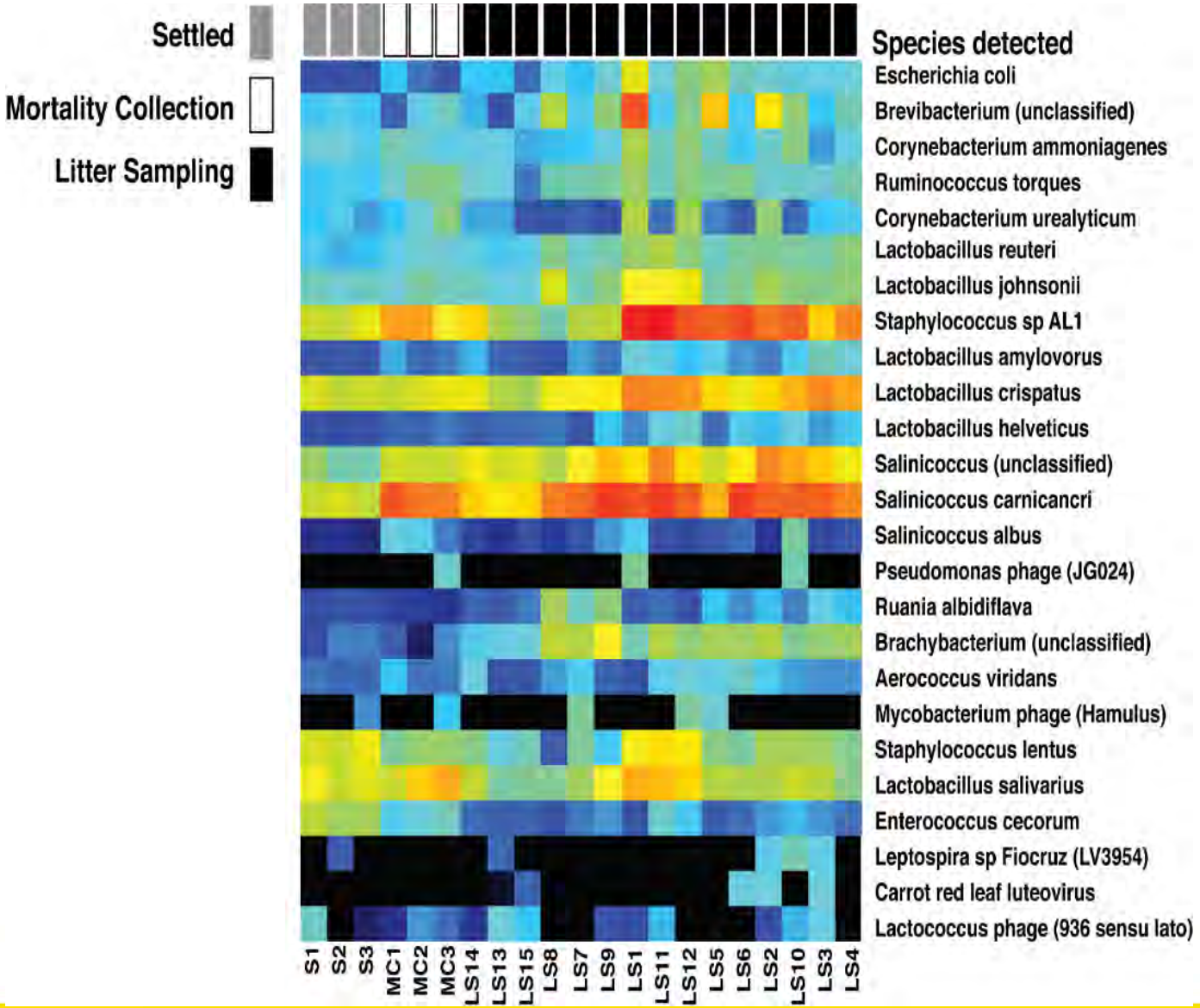
Study 1: Sequencing Composition of Poultry Dust



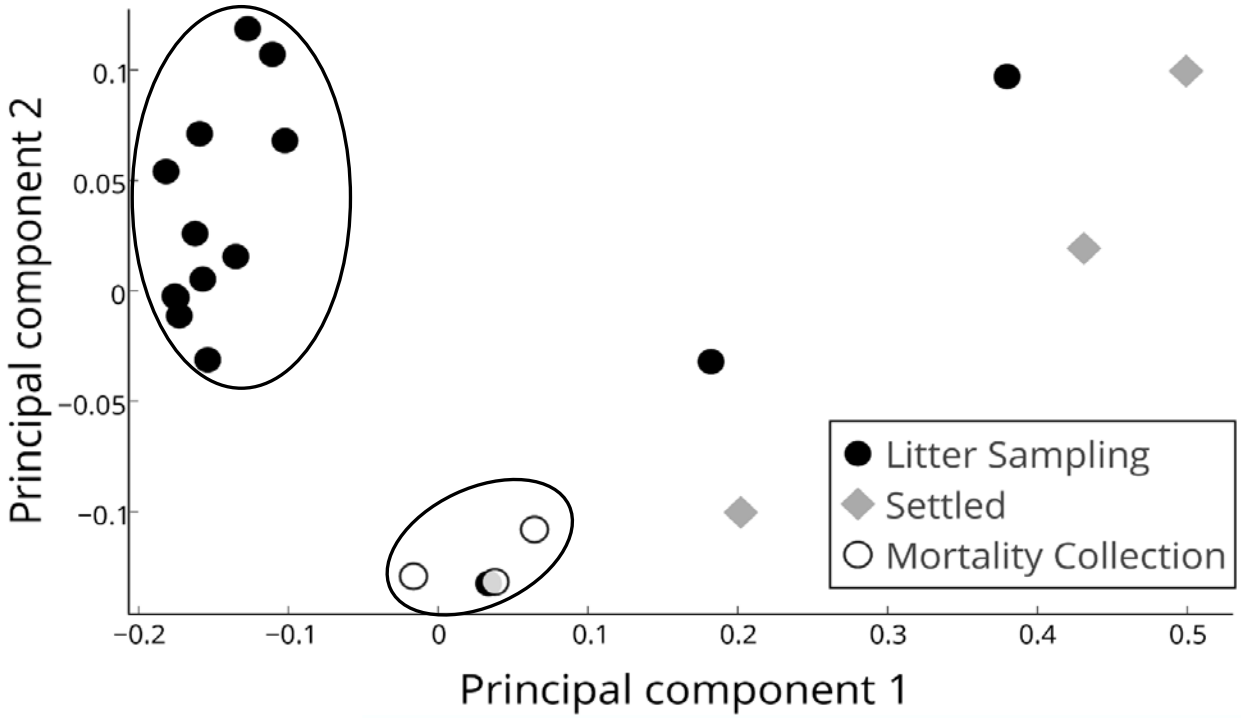
Domain-level Taxonomic Profiles of Poultry Dust



Heat map of 25 Most Abundant Microbe Species in Poultry Dust



Microbe Variance among Poultry Dust Samples



Study 3: Hazard Assessment

- June, 2015 – AI outbreak on two turkey farms in Iowa
- Airborne concentration measurements of gas during the composting process
  - Two farms
  - Several hours of work
  - Researcher wore the instrumentation
- ToxiRae Pro NH_3 Direct reading instrument
  - Data logging

Study 3: Hazard Assessment

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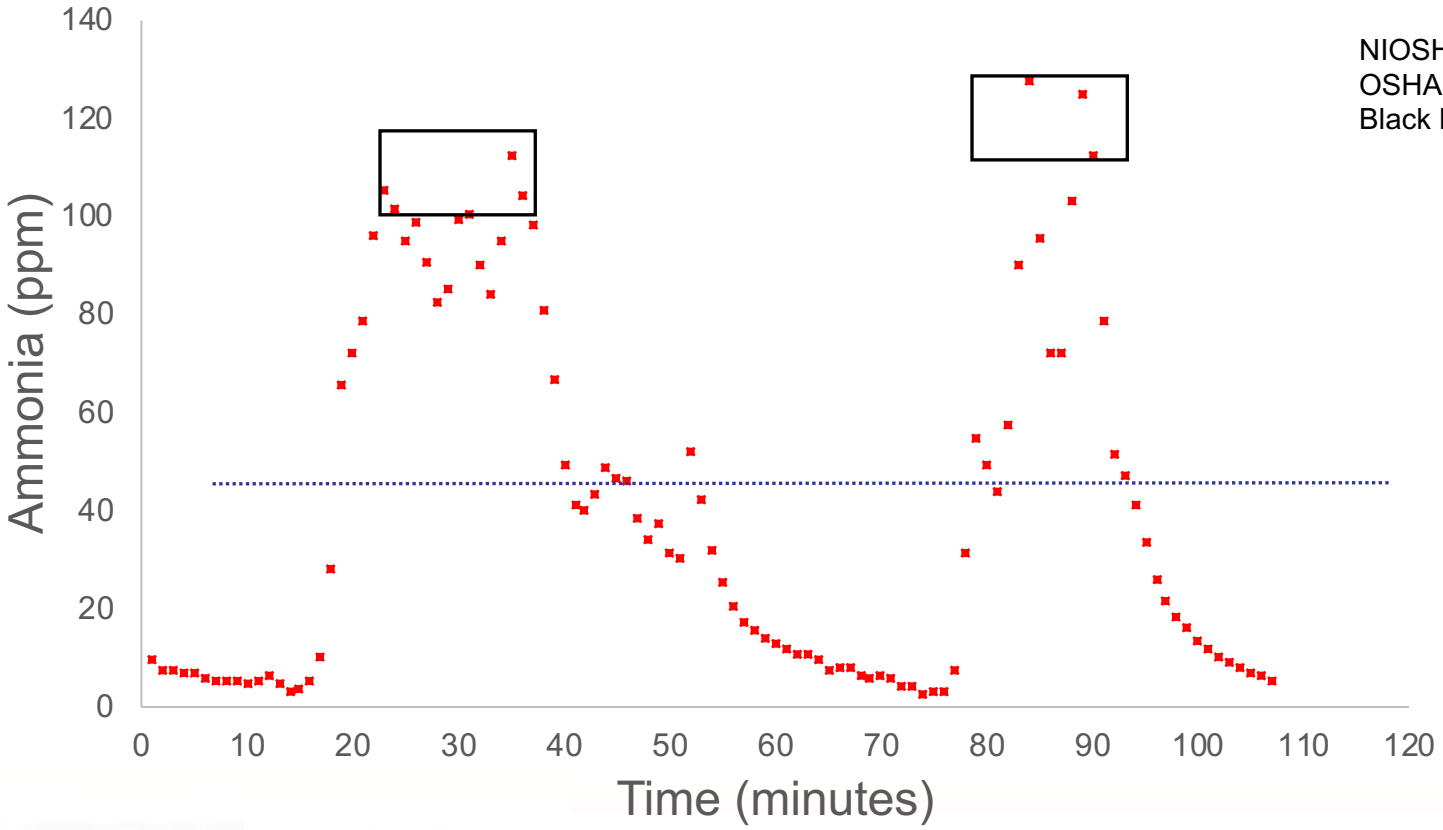
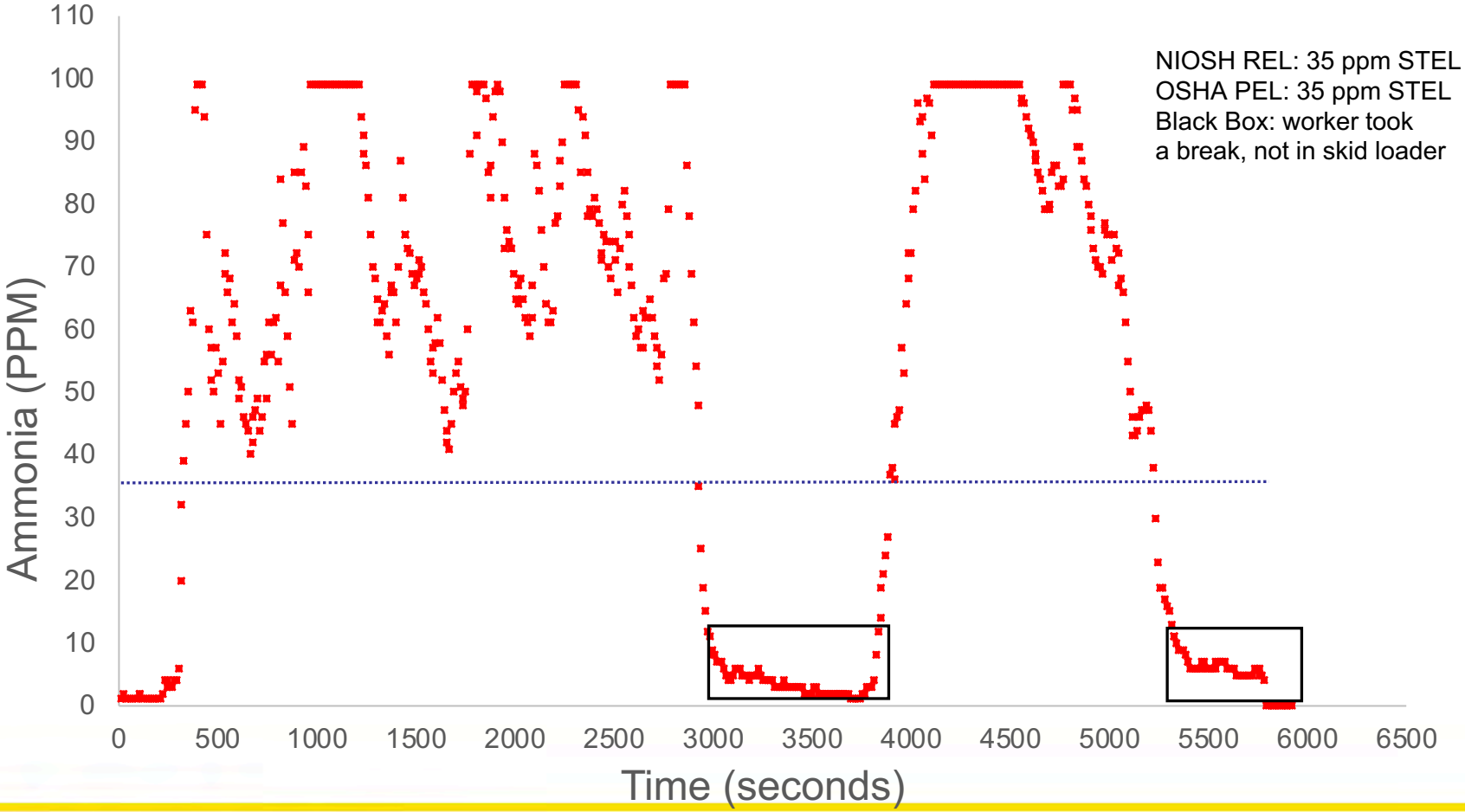
Study 3: Results – Farm 1



NIOSH REL: 35 ppm STEL
OSHA PEL: 35 ppm STEL
Black Box: agitating compost

Study 3: Results - Farm 2



Study 3: Results

- Work resulted in the creation of a fact sheet published by a collaboration across NIOSH Ag centers (IA, NE and MN, AgriSafe) – currently available as a resource from CDC/NIOSH

Avian Influenza

Personal Protective Equipment (PPE) Guidelines

Avian Influenza Outbreak

The USDA Animal and Plant Health Inspection Service (APHIS) reported that between December 2014 and June 2015 the avian influenza (HPAI) H5 outbreak affected over 47 million birds in the US. The virus is spread through contact with fecal droppings, saliva and nasal discharges of infected birds. More information on avian influenza can be found on the USDA website. The Centers for Disease Control and Prevention (CDC) has stated that "Although these viruses are not known to have caused disease in humans, their appearance might increase the likelihood of human infection in the United States." Anyone exposed to infected poultry should wear personal protective equipment (PPE). **Anyone anticipating contact with infected birds or affected operations should consult the USDA and CDC websites. Sick birds or unusual bird deaths should be reported to State/Federal officials either through the state veterinarian or through USDA's toll-free number at 1-866-536-7593.**

Information provided is intended as general guidelines for exposures.

Respiratory Exposures

Working in affected poultry facilities involves exposures to dust, toxic gases and disinfecting chemicals, in addition to avian influenza virus. It is important to select respiratory protection for all of these exposures.

Avian influenza and particulates (dusts) Appropriate protection for avian influenza and dusts is a NIOSH-approved particulate filtering respirator. Wear a particulate filtering respirator with an N95 or P100 filter or filter cartridge when working in poultry barns and when working with infected poultry and virus-contaminated materials or environments. Disposable 2-strap filtering face piece respirator masks (figure 1), half masks (figure 2) or full facepiece respirators with P100 filters.

Hazardous gases and vapors are commonly found in poultry buildings. **Ammonia** levels may be high during manure and

Study 4: Engineering Control

- Evaluate the effectiveness of a sprinkling system to reduce dust and gases in broiler chicken production

- Few engineering controls have been evaluated to reduce dust concentrations in broiler chicken production

- Water sprinkling systems used to reduce thermal stress in broiler production may also reduce dust concentrations.

Study 4: Methods

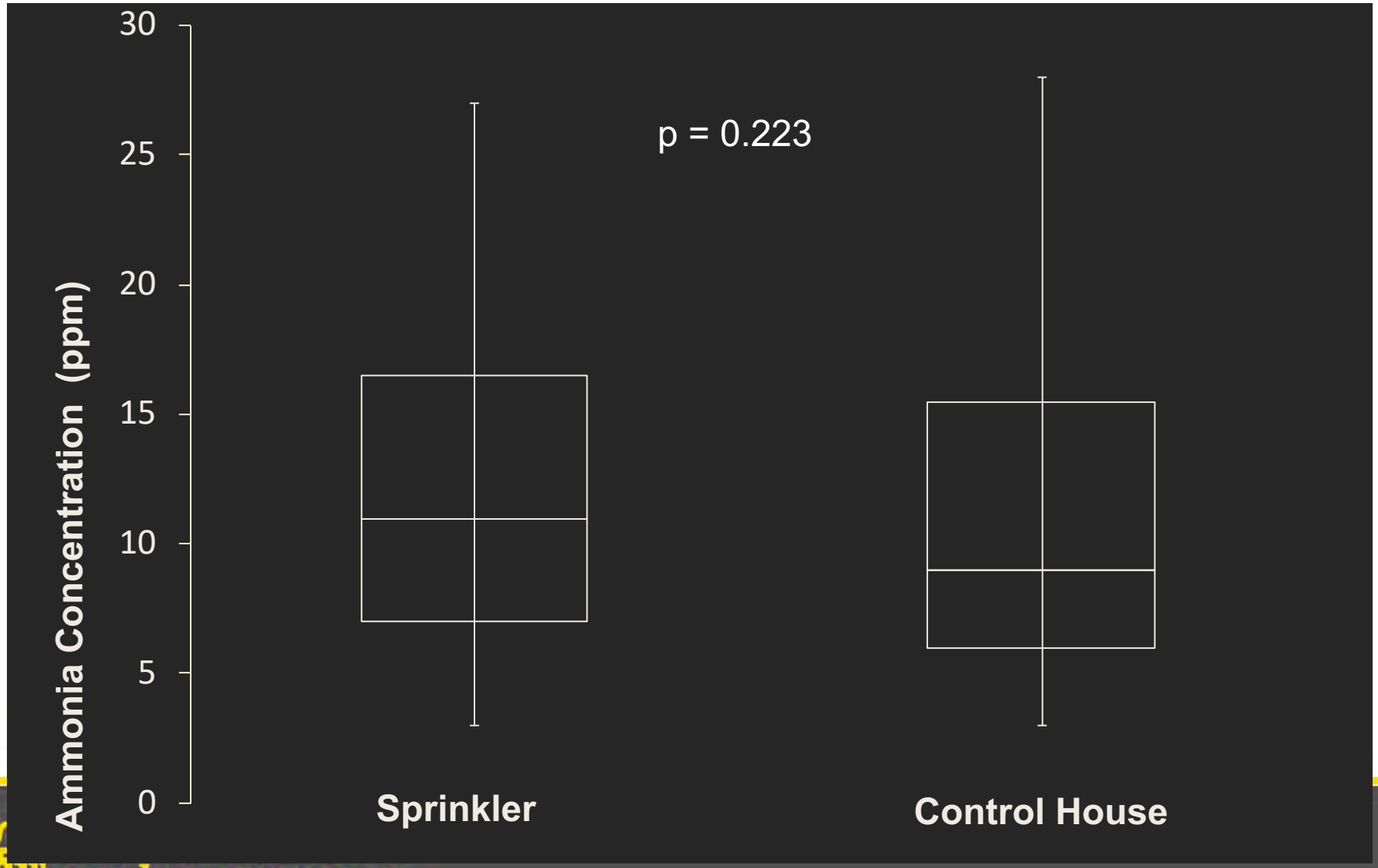
- Inhalable dust and ammonia were measured daily for the entire production cycle of a flock of broiler chickens (63 days)
  - Ammonia gas - ToxiRae Pro – datalogging
  - Inhalable Dust – SKC Button – Gravimetric analyses

- Sampling was performed on a mannequin inside two chicken houses. One house used a sprinkler cooling system to deliver a water mist throughout the house, the other was an untreated control

Study 4: Methods

Study 4: Results

Study 4: Results



Conclusions

- Inhalable dust exposure concentrations were below OSHA regulatory limits, but above recommended limits
  - Duration of work task varies by farm size
- Dust is predominantly composed of microbes
  - Additional bioaerosol control technology should be evaluated in poultry production
- There is a statistical difference in microbial populations between aerosolized dust and settled dust
- Lower variance in microbial populations among air samples
- Workers are exposed to hazardous concentrations of NH_3 during cleanup from AI events
- Use of mechanical fan ventilation and liquid litter amendment reduced exposure
  - Future studies should evaluate methods to reduce generation of dust

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