Proposal #6

Texas A&M AgriLife Research Air Quality Research Program (FY 2014-2015)

Title: Development of a Hemisphere-Belt Floor System for Commercial Broiler Production

Principal Investigator: Jason T. Lee, Assistant Professor, POSC

Co-principal Investigators: Brock Faulkner, Assistant Professor, BAEN; Craig D. Coufal and Gregory S. Archer, Assistant Professors and Extension Specialists, POSC

Amount requested per year: $99,115 FY 2014; $78,777 FY 2015

Executive Summary

In the United States, broiler production has increased substantially over the past 10 years. The value of broilers produced during 2010 was $23.7 billion, up 41 percent from 2000. Approximately 640 million broilers are reared in 4,000 poultry houses on 750 farms in Texas annually, and production in Texas will continue to increase due to a recent announcement by Sanderson Farms, Inc. of their intentions to expand production in the Palestine, Texas area. This expansion is projected to require the construction of 496 additional poultry houses on 82 new farms. With the number of disputes and lawsuits against intensive animal feeding operations increasing, gas and particulate matter (PM) emissions from poultry production houses have become a major environmental issue for the Texas livestock and poultry industry.

In commercial broiler houses in Texas, chickens are raised exclusively on litter-covered floors. Wood shavings or other bedding materials are spread on the floor prior to bird placement, and the mixture of bedding and manure is referred to as litter. The common practice in the poultry industry is to reuse litter for many flocks. As the litter builds up, the nitrogen content of the litter increases. Microbial degradation of the organic nitrogen within the litter results in the formation of ammonium, which is converted to ammonia (NH_3) gas and easily volatilizes from the litter. This NH_3 must be exhausted from the buildings to prevent bird and worker health problems.

Animal agriculture is the largest source of NH_3 in the US (USEPA, 2004). According to EPA, broilers constitute 54% of poultry contributions to the US NH_3 inventory and 14.8% of total emissions from animal agriculture. Research has demonstrated that broiler houses using built-up litter have higher NH_3 emissions than houses with new litter. Since broiler litter is often reused for many flocks over several years, the potential for NH_3 loss is high. Furthermore, reuse of litter over many flocks can result in high concentrations of pathogens in the litter that may lead to decreased bird performance and increased bird mortality.

In this research project, a previously patented hemisphere-belt floor (HBF) concept (US patent number 5,596,949) will be employed. It is hypothesized that the HBF production system will: (1) decrease NH_3 emissions while preserving more nitrogen in the manure by continuously removing manure off floor surfaces; (2) decrease PM emissions by eliminating the use of litter; and (3) reduce bird mortalities and improve production efficiency by lowering exposure of birds to harmful pathogens residing on contaminated floor surfaces. This novel HBF concept has not been taken to full implementation since it was put forward in 1997, but there has been interest from a major manufacturer in the US in commercializing the system in recent months. It is expected that the new, fully-engineered HBF production systems will be an invaluable tool to improve the economic and environmental sustainability of broiler chicken production.

Proposal Narrative

Goal: The goal of this research is to engineer a HBF system for commercial broiler production as an alternative to traditional litter-based broiler production practices to minimize adverse environmental impacts while simultaneously improving bird health, performance and welfare. The new system will be designed, and several pilot-scale systems will be built in order to quantify reductions in air pollutant emissions and assess bird growth, health and welfare parameters relative to conventional production systems.

Specific objectives:

1) Engineer and construct pilot-scale HBF broiler rearing units.
2) Evaluate air emissions from buildings in which broilers are reared on the HBF system compared to traditional litter floor (TLF) production.
3) Evaluate broiler health, performance, welfare, and carcass quality, and monitor manure production and composition from the HBF system compared to the TLF production.
4) Conduct statistical and economic analyses of broiler production data collected over one year on both the HBF and TLF systems to forecast the desirability of implementing the hemisphere-belt system in the commercial broiler industry.

Strategy: A novel broiler production system will be engineered and built as an alternative to traditional litter systems for commercial broiler production using a patented HBF system. The complete HBF concept, which was developed at Texas A&M University and patented in 1997, has not previously been fully engineered for implementation. The proposed project will address engineering of the systems required to implement and manage the system on a pilot scale, and then assess its effectiveness for scale-up to commercial application.

Methodology: Four HBF broiler rearing units will be engineered and constructed in the Biological and Agricultural Engineering Research Laboratory at Texas A&M University. Figure 1 depicts a schematic representation of the HBF system, which includes a conveyor system with contiguous rows of hemispheres. The basic concept of the HBF system is that the flooring on which birds are raised is driven by an electric motor connected to rollers and moves continuously at very low speed (approximately 1 inch/minute). When the manure-covered HBF rolls underneath the conveyor, deposited poultry manure will fall off the belt into a chute on the floor due to gravity. If additional cleaning is required, high pressure nozzles in a washer module will spray intermittently to thoroughly clean the floor and decrease exposure of birds to harmful pathogens, thereby reducing mortalities and vaccination costs, while improving feed efficiency, indoor air quality, and reducing air pollutant emissions from broiler production facilities. Commensurately, an increase in the fertilizer-nutrient content of removed manure is expected as more nitrogen will be retained in the manure.

The conveyor system is comprised of rows of hemispheres on which chickens are reared, belt rollers, drive and control systems, and fences to ensure bird safety. The size of the conveyor and its power capacity may be customized based on the dimensions of poultry houses in which it is implemented, but for the present research, the conveyor will be 13 feet long (center-to-center of rollers) and 10 feet wide and will facilitate 130 broilers per flock. The power requirements of the drive system will be determined as part of the proposed project.

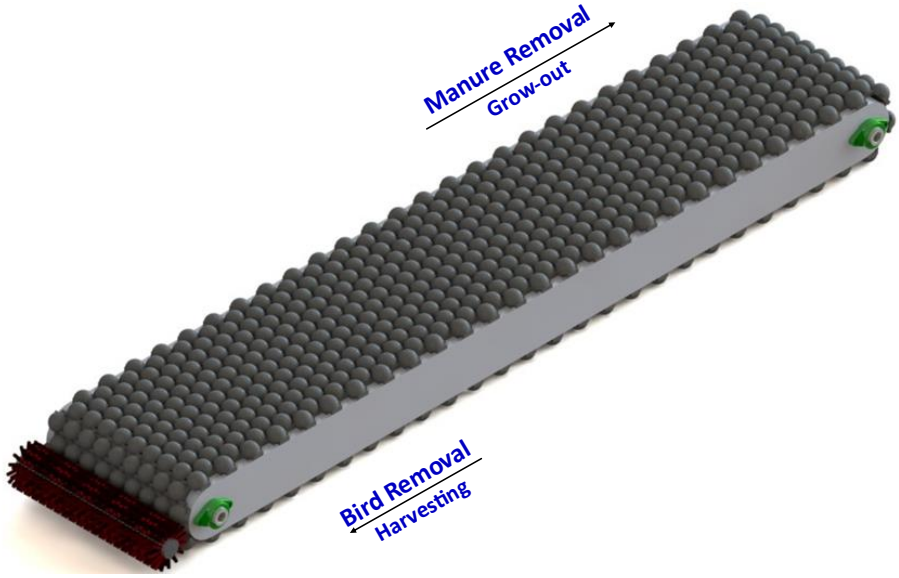

Figure 1. The assembled hemisphere-belt floor systems with contiguous rows of raised hemispheres and the brush module.

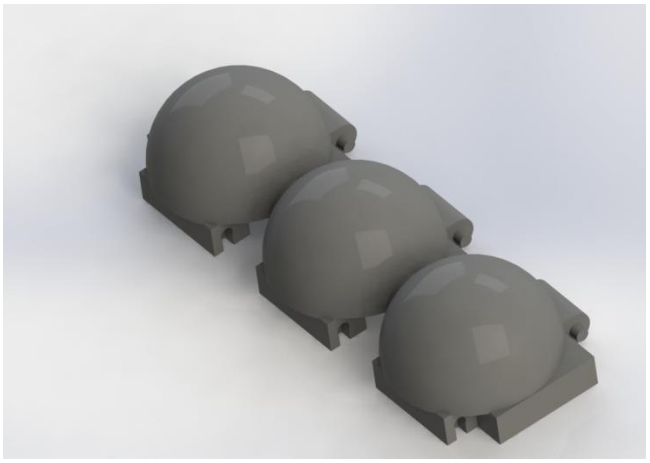

Figure 2. One component of the hemisphere-belt floor. Each hemisphere is approximately 2 inches in diameter. Multiple similar pieces are snapped together to form the conveyor belt.

As shown in Figure 2, the hemisphere contour has been designed to distribute the pressure applied to the breasts and legs of resting birds more uniformly than litter so that breast blisters and foot/leg problems can be reduced. Each hemisphere is about two inches in diameter and will be made using injection-molded polypropylene, which can resist degradation by birds' manure. Multiple components will be assembled together to form the hemisphere floor surface that will function like a conveyor belt. Gearing and motor control systems will be engineered so that the

conveyor may be run at relatively higher speeds in the reverse direction to enable easy removal of the birds for harvesting. In addition, safety mechanisms (e.g., limit switches used for motor interlocks and barriers) will be engineered to prevent unintended or dangerous operation of the conveyor systems and to stop birds from falling off the HBF systems.

Waste collection systems will be designed to effectively collect manure and store wastewater for land application. Waste streams will be analyzed for fertilizer value using standard wet-chemistry methods at the Texas A&M AgriLife Extension Service Soil, Water and Forage Testing Laboratory, and these values will be compared against the fertilizer value of litter removed from the TLF systems.

Comparison of the proposed HBF system to the TLF system will be carried out in four identical, solid-walled rooms (each 20 feet wide x 30 feet long) at the Texas A&M Poultry Science Research Farm. Each room is equipped with a single exhaust fan controlled by a thermostat and cycle timer. Ambient air enters through an evaporative cooling pad system in the wall opposite the exhaust fan. Each room also has a floor drain system, gas-fired heater and dimmable incandescent lighting. Thus, all of the four test rooms can be environmentally controlled in the same manner as a commercial broiler barn.

Two of the four rooms will each house two pilot-scale HBF units for a total of four HBF units. The other two rooms will each house two floor pens constructed in the same dimensions as the HBF units but using wood shavings (first flock) and recycled litter (all subsequent flocks). In the litter floor pens, four inches of fresh pine shavings will be spread prior to placement of the first flock. After each flock of broilers is removed at the end of the grow-out period, caked litter will be removed with a pitchfork, and the friable, small litter particles will remain in the pen to be used for the next flock. This procedure will mimic the use of de-caking machines used in commercial TLF production houses.

Six flocks of broilers, each raised to ~49 days of age, will be reared on each of four HBF systems or four TLF systems, i.e., a total of 48 replicate groups of broilers will be raised in the eight units (4 HBF units and 4 TLF units) over a 1-year period. During the rearing period for each flock, metrics of animal health and welfare, production efficiency, carcass quality, air contaminant concentrations and emissions, environmental parameters, and waste production will be measured to compare the HBF and TLF production systems. Temperature, ventilation, and lighting in each room will be managed as identically as possible, and will mimic programs used in the commercial broiler industry. A standard industry feeding program will also be utilized for all replicates. Each replicate pen will be equipped with a nipple drinker system and commercial-style pan feeders in a quantity appropriate for the number of broilers in each experimental unit.

An air emission measurement (AEM) system will be developed to characterize NH_3 concentrations and emissions from each of the four test rooms. The AEM system will contain a gas sampling system, a data acquisition system, NH_3 gas analyzer (available in Co-PI Coufal's laboratory), gas calibration cylinders, and other supplies. The gas sampling system mainly comprises sampling pumps and solenoid switches. The sampling pumps will be used to provide constant flows for each sampling line while the solenoid switches will enable gas samples from each emission source to be delivered to the gas analyzer in 10 min switching increments (the first

9 minutes for stabilization, and the last 1 minute for measurement of the pollutant concentrations). The data acquisition system will be programmed to control all the sampling pumps and solenoid switches as well as collect/store concentration data and other parameters.

For NH_3 monitoring, Teflon® tubing will be routed to each of the four rooms. An infrared NH_3 analyzer (SAM-IV, O.I. Analytical, College Station, TX) will be used to quantify NH_3 concentrations. For PM measurement, two Tapered Element Oscillating Microbalance (TEOM) ambient PM_{10} monitors (Model 1400a, Rupprecht & Patashnick, Albany, NY) will be employed, with one located in a HBF treatment room and the other located in a TLF treatment room. These analyzers are available in Co-PI Faulkner's laboratory. Routine calibration and leak checks will be conducted per manufacturer recommendations. Also, the environment parameters (e.g., temperature, relative humidity, and barometric pressure) and room ventilation status will be simultaneously monitored. Ammonia and PM emission rates will be determined by multiplying the airflow rate of the ventilation fans by the increase in NH_3 and PM concentrations between the room ventilation inlet and outlet.

It should be noted that, based on budget constraints, NH_3 and PM measurements will only be collected "per room" and not "per treatment unit" as each treatment room will house two HBF systems, so, as proposed, only two measurements per treatment for the air pollutant emissions will be available. Although a statistical comparison of air emissions between the HBF and TLF systems will not be possible, time-series analyses can be conducted on each treatment. Furthermore, Habasit North America (a conveyor belt manufacturer) has entered into a non-disclosure agreement with the PIs and has expressed interest in constructing the pilot-scale HBF units. Upon commitment from Habasit to provide the units, funds from the proposed project will be redirected to enable a third room for testing each treatment, enabling pair-wise comparisons of collected data.

While the goal of this research is to develop a rearing system for broilers that will reduce air pollutant emissions, it is impractical to attempt to commercially implement a rearing system that is detrimental to the well-being of the birds. Therefore, assessments of broiler behavior and welfare will be undertaken to assure the newly designed HBF system is practical for commercial use. The general behavior of each pen of birds will be digitally video recorded for 24 hours the same day per week. The videos will be used to determine a behavioral time budget. Focal birds will be used for some measures and will be marked individually for identification. Video systems (two 16-channel digital video recorders and 32 CCTV cameras) are already available in Co-PI Archer's laboratory. Several other measures of bird welfare will be used to ascertain the effects of the HBF system on the stress, fear, physical asymmetry, and lameness response of broiler chickens. In addition, birds will be scored at the end of each grow-out period for hock burns, plumage quality, foot pad dermatitis, and breast blisters using established scoring systems.

Deliverables and timeline: The design, construction and initial testing of the HBF units, TLF pen set-up, and installation and calibration of air emissions monitoring equipment will require approximately one year. Year 2 will consist of rearing six flocks of broilers and gathering all air emissions, broiler performance and welfare, and litter/manure composition data. A full year of continuous broiler rearing will be required to accurately assess performance of the HBF system over all seasonal conditions. Based on the statistical results of bird performance, a simple

economic analysis will be conducted to compare projected costs and benefits of commercial-scale HBF systems relative to control systems (TLF). The costs for scale-up to commercial-scale systems will be projected based on project results.

Individual responsibilities: Dr. Jason Lee will be the project director and responsible for all aspects of broiler rearing and health management and broiler performance evaluation. Dr. Brock Faulkner will oversee the design and construction of the HBF systems and air emissions monitoring and quantification. Dr. Craig Coufal will be responsible for litter and manure management, sample collection and analyses. Dr. Gregory Archer will oversee and conduct all measures of broiler welfare throughout the project. Drs. Coufal and Archer will also assist Dr. Lee with supervision of daily broiler management during the grow-out periods.

Potential for Leveraging Resources

Preliminary data is highly favorable when submitting research proposals containing novel solutions to a problem. Data gathered during this project will provide the investigators with such preliminary data that would allow future proposals to be more competitive when applying for additional funding under many federal and commodity organization programs. Federal agencies such as the USDA and EPA have put forth RFPs in recent years that are targeted to research that can reduce the environmental impact of animal production systems. The investigators of this proposal submitted a proposal to USDA under such a program in the spring of 2013, although a decision has not yet been received. Commodity organizations such as the US Poultry and Egg Association also have competitive research programs targeted to finding solutions for poultry production problems.

In addition, Habasit North American has expressed interest in working with the PIs to develop the HBF system, and have entered into a non-disclosure agreement with the PIs. Therefore, it is highly likely that funding for this proposed research will be successfully leveraged by the PIs to gain future funding for developing operational, pilot-scale HBF units that can serve as proofs of concept for commercial-scale units.

Budget

FY 2014		Allocated to:			
		Lee	Faulkner	Coufal	Archer
POSC Ph.D. Student	$15,960			7,980	7,980
BAEN personnel - Gang Sun (post-doc)	$14,000		14,000		
Matt Shimek (technician)	$11,355		11,355		
HBF plastic components	$35,800	35,800			
Hardware to construct HMF units	$15,000	15,000			
Hardware to construct TLF broiler pens	$1,000	1,000			
Air sampling equipment	$4,000		4,000		
Air sampling expendables	$2,000		2,000		
FY 2014 total	**$99,115**				
FY 2015					
POSC Ph.D. Student	$15,960			7,980	7,980
POSC student worker	$8,000	8,000			
BAEN personnel - Gang Sun (post-doc)	$14,420		14,420		
Matt Shimek (technician)	$7,797		7,797		
Air sampling expendables	$1,500		1,500		
Broiler chicks	$2,800	2,800			
POSC farm charges for rearing broilers ($3,300 per flock x 6 flocks)	$19,800	19,800			
HBF maintenance (parts and supplies)	$2,000			2,000	
POSC sample analyses/lab supplies	$6,500	1,500		2,000	3,000
FY 2015 total	**$78,777**				
Project totals	**$177,892**	**$83,900**	**$55,072**	**$19,960**	**$18,960**

Jason T. Lee, Ph.D.
Assistant Professor, Department of Poultry Science
Texas A&M University/Texas A&M AgriLife Research

Education and Training

Institution	Degree	Completed	Field of Study
Texas A&M University	B.S.	May 2001	Poultry Science
Texas A&M University	M.S.	Dec 2002	Poultry Science
Texas A&M University	Ph.D.	Dec 2006	Poultry Science

Positions and Employment

06/2001 – 08/2003 ***Graduate Research Assistant, Department of Poultry Science***
Texas A&M University, College Station, TX
09/2003 – 12/2006 ***Assistant Lecturer, Department of Poultry Science***
Texas A&M University, College Station, TX
01/2007 – Present ***Assistant Professor, Department of Poultry Science***
Texas A&M University, College Station, TX

Awards and Honors

2009 Poultry Science Association Early Achievement Award
2005 Outstanding Student Research Presentation at Southern Poultry Science Society
1998 National Collegiate Poultry Judging High Point Individual and Champion Team
1997 US Poultry and Egg Collegiate Poultry Judging Contest

Selected Publications

1. **Lee, J. T**., C. A. Bailey, and A.L. Cartwright. 2003. β-mannanase ameliorates viscosity-associated depression of growth in broiler chickens fed guar germ and hull fractions. Poult. Sci. 82:1925-1931.
2. **Lee, J. T**., C. A. Bailey, and A. L. Cartwright. 2003. Guar meal germ and hull fractions differently affect growth performance and intestinal viscosity of broiler chickens. Poult. Sci. 82:1589-1595.
3. **Lee, J. T**., S. Conner-Appleton, A. U. Haq, A. Cartwright, and C. Bailey. 2004 Quantitative measurement of negligible trypsin inhibitor activity and nutrient analysis of guar meal fractions. J. Agric. Food Chem. 52:6492-6495.
4. **Lee, J. T**., S. Connor, A. Cartwright, C. Bailey. 2005. Effects of Guar Meal By-Product with and without β-mannanase Hemicell on Broiler Performance. Poult. Sci. 84:1261-1267.
5. **Lee, J. T.,** C. Broussard, S. Fitz-Coy, P. Burke, N. H. Eckert, S. M. Stevens, P. N. Anderson, S. M. Anderson, and D. J. Caldwell. 2009. Evaluation of Coccivac®-B or Salinomycin for Control of Field Strain *Eimeria* Challenge in Broilers on Two Different Feeding Programs. J. Applied Poult Res. 18:458-464.
6. Stringfellow, K., J. McReynolds, **J. Lee**, J. Byrd, D. Nisbet, and M. Farnell. 2009. Effect of Bismuth Citrate, Lactose, and Organic Acid on Necrotic Enteritis in Broilers. Poult. Sci. 88:2280-2284.

7. Eckert, N.H., **J.T. Lee**, D. Hyatt, S.M. Stevens, S. Anderson, P.N. Anderson, R. Beltran, G. Schatzmayr, M. Mohnl, and D. J. Caldwell. 2010. Influence of Probiotic Administration by Feed or Water on Growth Parameters of Broilers Reared on Medicated and Non-medicated Diets. J. of Applied Poult. Res. 19: 59-67.
8. Stringfellow, K., D. Caldwell, **J. Lee**, A. Byrd, J. Carey, K. Kessler, J. McReynolds, A. Bell, R. Stipanovic, and M. Farnell. 2010. Pasteurization of chicken litter with steam and quicklime to reduce *Salmonella* Typhimurium. Journal of Applied Poultry Research. 19:380-386.
9. Stringfellow, K., D. Caldwell, **J. Lee**, M. Mohnl, R. Beltran, G. Schatzmayr, S. Fitz-Coy, C. Broussard and M. Farnell. Evaluation of Probiotic Administration on the Immune Response of Coccidiosis Vaccinated Broilers. Poult. Sci. (Accepted)
10. Dunn-Horrocks, S., M. Pichardo-Fuchs, **J. Lee,** C. Ruiz-Feria, C. Creger, D. Hyatt, K. Stringfellow, M. Sanchez, and M. Farnell. 2011. Effect of Omega-3 Enriched Layer Rations on Egg Quality. International Journal of Poultry Science. 10:8-11.
11. Jordan, A., D. J. Caldwell, J. Klein, J. Coppedge, S. Pohl, S. Fitz-Coy, and **J. T. Lee**. *Eimeria tenella* oocyst shedding and output in cecal or fecal contents following experimental challenge in broilers. Poult. Sci. (Accepted).
12. **Lee, J. T**., N. H. Eckert, K. A. Ameiss, S. M. Stevens, P. N. Anderson, S. M. Anderson, A. Barri, A. P. McElroy, H. D. Danforth, and D. J. Caldwell. 2011. The effect of dietary protein level on performance characteristics of coccidiosis vaccinated and non-vaccinated broilers following mixed species *Eimeria* challenge. Poult. Sci. 90:1916-1925.
13. Coppedge, J. R., J. Klein, B. Brown, B. Ratliff, F. Ruch, **J.T. Lee**. 2011. Effects of co-administration of phytase and NSPase on broiler performance and bone ash. International Journal of Poultry Science. 10:12:933-939.
14. Oden, L., D. J. Caldwell, S. Pohl, A. Klein, S. Anderson, S. Young, C. Broussard, S. Fitz-Coy, L. Newman, and **J. T. Lee**. 2011. Influence of Diet on Performance Parameters in Replacement Broiler Breeders following Live Oocyst Coccidiosis Vaccination. Journal of Applied Poultry Research. 20:401-408.
15. Oden, L.A., **J.T. Lee**, S.K. Pohl, A.E. Klein, S.A. Anderson, S.D. Young, C.T. Broussard, S.H. Fitz-Coy, L.J. Newman, and D.J. Caldwell. 2012. Influence of Diet on Oocyst Output and Intestinal Lesion Development in Replacement Broiler Breeders following Live Oocyst Coccidiosis Vaccination. Journal of Applied Poultry Research 21:445-459.
16. Coppedge, J., L. Oden, B. Ratliff, B. Brown, F. Ruch, and **J.T. Lee**. 2012. Evaluation of Non-Starch Polysaccharide Degrading Enzymes in Broiler Diets Varying in Nutrient and Energy Levels as Measured by Broiler Performance and Processing Parameters. J. Applied Poult. Res. 21:226-234.
17. **Lee, J. T**, K.A. Jessen, R. Beltran, V. Starkl, G. Schatzmayr, R. Borutova, D.J. Caldwell. 2012. Mycotoxin contaminated diets and deactivating compound in laying hens: 1. Effects on performance characteristics and relative organ weight. Poult. Sci. 91:2089-2095.
18. **Lee, J. T**, K.A. Jessen, R. Beltran, V. Starkl, G. Schatzmayr, R. Borutova, D.J. Caldwell. 2012. Effects of mycotoxin contaminated diets and deactivating compound in laying hens: 2. Effects on white shell egg quality and characteristics. Poult. Sci. 91:2096-2104.

William Brock Faulkner, Ph.D., P.E.

Assistant Professor
Biological and Agricultural Engineering Department, Texas A&M University

EDUCATION

Degree	*Institution*	*Major Field of Study*	*Dates*
Ph.D.	Texas A&M University	Biological and Agricultural Engineering	2008
M.S.	Texas A&M University	Biological and Agricultural Engineering	2006
B.S.	Texas A&M University	Agricultural Engineering	2004

PROFESSIONAL EXPERIENCE

Employer	*Position*	*Location*	*Dates*
Texas A&M University	Assistant Professor	College Station, Texas	2012
Texas A&M University	Research Assistant Professor	College Station, Texas	2008-2011
Texas A&M University	Research Associate	College Station, Texas	2006-2008

PROFESSIONAL AND SCIENTIFIC ORGANIZATIONS

USDA Agricultural Air Quality Task Force
EPA Science Advisory Board Panel for Review of Methodologies for Estimating Air Emissions from Animal Feeding Operations
American Society of Agricultural and Biological Engineers (ASABE)

HONORS AND AWARDS

2010	Member of team awarded Texas Environmental Excellence Award - Agriculture
2010	ASABE Texas Section Young Engineer of the Year
2004-2007	National Science Foundation Graduate Research Fellow
2004-2006	Regents Fellow – Texas A&M University

SELECT INVITED PRESENTATIONS

1. "Air Quality and Animal Agriculture" –Colorado Livestock Association Annual Convention (June 2008)
2. "Estimating $PM_{2.5}$ Emission Factors" –USDA Agricultural Air Quality Task Force (May 2009)
3. "An Evolving Case Study in Management of Reactive Nitrogen" - USDA Agricultural Air Quality Task Force (May 2009)
4. Rethinking Emissions from Cattle Operations" –EPA Office of Air Quality Planning and Standards (February 2010)
5. Improved Measurement of Particulate Matter (PM) from Animal Feeding Operations" – Continuing Professional Development course (September 2010)
6. Ammonia Regulation and the US Cattle Industry" - National Cattlemen's Beef Association (February 2011)
7. "Identifying BMPs for Reducing Ammonia Emissions from Livestock Production" – Colorado Livestock Association Annual Convention (June 2011)
8. "What's in the Air – And Why You Should Care" - Colorado Agriculture Air Quality Symposiums (February 2012)

SELECT CONSULTING

Client	*Subject*
Colorado Livestock Association	Air pollutant emissions, transport, modeling, monitoring, and deposition
Five Rivers Ranch Cattle Feeding	Evaluation of ammonia emissions monitoring plan for evaluation of best management practices
National Cattlemen's Beef Assoc.	Technical analysis of draft Policy Assessment Document for secondary NO_x/SO_x NAAQS

SELECT PEER-REVIEWED PUBLICATIONS

1. Borhan, M.S., S.C. Capareda, S. Mukhtar, **W.B. Faulkner**, R. McGee and C.B. Parnell. 2011. Greenhouse gas emissions from ground level area sources in dairy and cattle feedyard operations. *Atmosphere* 2(3): 303-329. doi: 10.3390/atmos2030303.
2. **Faulkner, W.B.**, D. Downey, D.K. Giles, and S.C. Capareda. 2011. Evaluation of particulate matter abatement strategies for almond harvest. *Journal of the Air and Waste Management Association* 61: 409-417.
3. **Faulkner, W.B.**, L.B. Goodrich, V.S.V. Botlaguduru, S.C. Capareda, and C.B. Parnell. 2009. Particulate matter emission factors for almond harvest as a function of harvester speed. *Journal of the Air and Waste Management Association* 59: 943-949.
4. **Faulkner, W.B.**, B.W. Shaw, and T. Grosch. 2008. Sensitivity of two dispersion models (AERMOD and ISCST3) to input parameters for a rural ground level area source. *Journal of the Air and Waste Management Association* 58: 1288-1296.
5. **Faulkner, W.B.** and B.W. Shaw. 2008. Review of ammonia emission factors for United States animal agriculture. *Atmospheric Environment* 42(27): 6567-6574.
6. **Faulkner, W.B.**, M.D. Buser, D.P. Whitelock, and B.W. Shaw. 2008. Effects of cyclone diameter on performance of 1D3D cyclones: cut point and slope. *Transactions of the ASABE* 51(1): 287-292.
7. **Faulkner, W.B.**, J.J. Powell, J.M. Lange, B.W. Shaw, R.E. Lacey, and C.B. Parnell. 2007. Comparison of dispersion models for ammonia emissions from a ground level area source. *Transactions of the ASABE* 50(6): 2189-2197.
8. **Faulkner, W.B.**, B.W. Shaw, and R.E. Lacey. 2007. Coarse fraction aerosol particles: theoretical analysis of rural versus urban environments. *Applied Engineering in Agriculture* 23(2): 239-244.

WHITE PAPERS

1. **Faulkner, W.B.** 2011. Potential impacts of changes in NAAQS for particulate matter. White Paper written on behalf of the Colorado Livestock Association to inform producers and policy makers about the impact of proposed changes to PM regulations.
2. **Faulkner, W.B.**, B.W. Shaw, and S. Krupa. 2009. Particulate matter (PM) and agricultural air quality: a summary of the current status and research needs. White Paper submitted to the USDA Agricultural Air Quality Task Force (AAQTF) at the request of the AAQTF Air Quality Standards Subcommittee.

CRAIG D. COUFAL

Assistant Professor and Extension Specialist
Department of Poultry Science, Texas A&M University
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EDUCATION

Ph.D., Poultry Science, Texas A&M University, 2005
M.S., Poultry Science, Texas A&M University, 2000
B.S., Poultry Science, Texas A&M University, 1997

PROFESSIONAL EXPERIENCE

August, 2008 - present	**Assistant Professor and Extension Specialist**, Department of Poultry Science, Texas A&M University, College Station, Texas
2006 - 2008	**Assistant Extension Professor**, Department of Poultry Science, Mississippi State University, Mississippi State, Mississippi
2005 - 2006	**Post-doctoral Research Associate**, Department of Poultry Science, Texas A&M University, College Station, Texas
2004 - 2005	**Graduate Assistant**, Department of Poultry Science, Texas A&M University, College Station, Texas
2001 - 2003	**Extension Associate**, Department of Poultry Science, Texas A&M University, College Station, Texas
1998 - 2000	**Graduate Assistant**, Department of Poultry Science, Texas A&M University, College Station, Texas
1997 - 1998	**Production Supervisor**, Cal-Maine Foods, Inc., Waelder, Texas

ACADEMIC HONORS AND AWARDS

2006 Alltech Student Research Manuscript Award, Poultry Science Association
2011 Early Achievement Award for Extension, Poultry Science Association
2013 Faculty Award of Merit for Extension, Gamma Sigma Delta, Texas A&M University Chapter

CURRENT TEACHING RESPONSIBILITIES

POSC 427 Animal Waste Management, 2008 -present
POSC 326 Commercial Egg Industry, 2009 – present

GRADUATE STUDENT ADVISING

Committee chair for 6 M.S. students, committee member for 5 M.S. students, and committee member for 2 M.Ag. students.

GRANTS AND CONTRACTS AWARDED

Environmental effects of in-house windrow composting of poultry litter. Funded by Texas State Soil and Water Conservation Board CWA §319(h) NPS Grant Program: $447,080 (co-investigator). September, 2009 – August, 2012.

Study of BioWish as a litter amendment and feed ingredient to reduce fecal odor in market broilers. Funded by Biowish Technologies, Inc,: $48,238.06 (co-investigator). 2010 – 2012.

Development of best practices for shell egg disinfection based upon efficacy, egg quality, and economics. Funded by US Poultry and Egg Association Project #F041: $15,295 (co-investigator). October 1, 2011 – October 1, 2013.

PROFESSIONAL ORGANIZATION AND COMMITTEE SERVICE

Poultry Science Association
- – Associate Editor for *Poultry Science*, 2010 - present
- – Ad hoc reviewer for *Journal of Applied Poultry Research*
- – Chair, Extension Symposium, 2009 annual meeting
- – Extension/Outreach Committee and Phibro Extension Award, member, 2007 – 2009
- – Section chair for Environment and Management section, 2008 annual meeting

National Poultry Waste Management Symposium, 2008 and 2010 planning committee member, co-chair for 2012 symposium

SELECTED PEER-REVIEWED PUBLICATIONS

Purswell, J. L., J. D. Davis, A. S. Kiess, and **C. D. Coufal**, 2013. Effects of frequency of multiple applications of litter amendment on litter ammonia and live performance in a shared air space. Journal of Applied Poultry Research (accepted for publication).

Harmel, R. D., K. L. Wagner, E. Martin, T. J. Gentry, R. Karthikeyan, M. Dozier, and **C. Coufal**, 2013. Impact of poultry litter application and land use on E. coli runoff from small agricultural watersheds. Biological Engineering Transactions 6(1): 3-16.

Barker, K. J., **C. D. Coufal**, J. L. Purswell, J. D. Davis, H. M. Parker, M. T. Kidd, C. D. McDaniel, and A. S. Kiess, 2011. In-house windrowing of a commercial broiler farm during summer months and its effects on litter composition. Journal of Applied Poultry Research 20:168-180.

Coufal, C. D., C. Chavez, P. L. Niemeyer, and J. B. Carey, 2006. Nitrogen emissions from broilers measured by mass balance over eighteen consecutive flocks. Poultry Science 85:384-391.

Coufal, C. D., C. Chavez, P. L. Niemeyer, and J. B. Carey, 2006. Effects of top-dressing recycled broiler litter on litter production, litter characteristics and nitrogen mass balance. Poultry Science 85:392-397.

Coufal, C. D., C. Chavez, P. L. Niemeyer, and J. B. Carey, 2006. Measurement of broiler litter production rates and nutrient content using recycled litter. Poultry Science 85:398-403.

CURRICULUM VITAE

Gregory S. Archer
Assistant Professor and Extension Specialist
Texas Agrilife and Texas A&M University
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Education

Virginia Polytechnic Institute and State University, Blacksburg, VA
B.S. Degree in Animal and Poultry Sciences, Equine emphasis
Texas A&M University, College Station, TX
M.S. Degree in Animal Science (Applied Ethology/Stress Physiology)
Ph.D. in Animal Science (Applied Ethology/Stress Physiology).

Work Experience

Texas A&M University, College Station, TX January 2001-May 2005
Graduate Teaching Assistant-Behavior & Management of Domestic Animals
Texas A&M University, College Station, TX May 2005-Sept 2005
Post Doctoral Research Assistant
Food Animal Concerns Trust, IL September 2005-March 2006
Consultant
University of California at Davis, CA October 2005-August 2011
Post Doctoral Researcher
University of California at Davis, CA September 2011-February 2012
Assistant Project Scientist
Texas A&M University, College Station, TX March 2012-current
Poultry Extension Specialist and Assistant Professor

Awards/Recognitions

- Research recognized as a major event in the first century of the Texas A&M Department of Animal Science (The Texas A&M University Agriculture Program (Lifescapes))
- Elsevier Featured Article at the 2003 Joint meeting of the American Dairy Science Association and the American Society of Animal Science, Phoenix, Az.

Funding Awards

- Competitive USDA-CREES NRI grant **$365,000** (2008-2012)

Professional Affiliations

- International Society of Applied Ethology (ISAE)
- American Society of Animal Science (ASAS)
- Poultry Science Association (PSA)
- Animal Behavior Society (ABS)

Peer Reviewed Publications

Archer, G.S., J. Piedrahita, C.H. Nevill, S. Walker, T.H. Friend. **2003**. Variation in Behavior Cloned Pigs. Applied Animal Behaviour Science**.** 81 (4): 321-331.

Archer, G.S., S. Dindot, T.H. Friend, S. Walker, G. Zaunbrecher, B. Lawhorn, and J.A. Piedrahita. **2003.** Hierarchical Phenotypic and Epigenetic Variation in Cloned Swine.Biology of Reproduction. 69: 430-436.

Williams, J.L., T.H. Friend, C.H. Nevill, and **G. Archer**. **2004.** The efficacy of a

secondary reinforcer (clicker) during acquisition and extinction of an operant task in horses**.** Applied Animal Behaviour Science. 88 (3-4): 331-341.

Archer, G.S. and T.H. Friend. **2005**. Ideal statistical analysis vs biological significance: a response to Shutler et al. (2005). Applied Animal Behaviour Science. 91 (3-4): 367-369.

Bashir, M., G. Zaunbrecher, **G.S. Archer**, T.H. Friend, and J. Piedrahita. **2005.** Progeny of somatic cell nuclear transfer (SCNT) pig clones is phenotypically similar to non-cloned pigs. Cloning and Stem Cells. 7 (2): 119-125.

Martin, T. I., T. H. Friend, J. L. Williams and **G. S. Archer**. **2006**. Predictors of success in an undergraduate animal behavior course. NACTA Journal. Sept:51-56.

Archer, G.S., TH. Friend, D. Caldwell, K. Ameiss, and P. Krawczel. **2007**. Effect of feeding *Ascophyllum nosodum* on growth, humoral immune response, and physiology in response to walking and transport. Journal of Animal Science. 85: 225-232.

Krawczel, P.D., T.H. Friend, D.J. Caldwell, **G. Archer**, K. Ameiss, and R. Johnson. **2007**. The effects of continuous versus rested transport on the blood chemistry, behavior, and antibody production of lambs. Journal of Animal Science. 85: 468-476.

Iacono, C.M., T.H. Friend, R.D. Johnson, P.D. Krawczel, and **G.S. Archer**. **2007.** A Preliminary study of the utilization of an onboard watering system by slaughter horses during transport. Applied Animal Behaviour Science. 105 (1-3): 227-231.

Archer, G.S., TH. Friend, D. Caldwell, K. Ameiss, P. Krawczel, H. Keen, C. Iacono, and T. Martin. **2008**. Effect of feeding *Ascophyllum nosodum* and its components on growth, immune response, and physiology in response to transport. Animal Feed Science and Technology. 140 (3-4): 258-271

Krawczel, P.D., T.H. Friend, and **G.S. Archer**. **2008.** Behavior of lambs in rest pens during long-distance transport. J. Applied Animal Welfare Science. 11 (4): 337-345.

Blatchford, R.A., K.C. Klasing, H.L. Shivaprasad, P.S. Wakenell, **G.S. Archer**, and J.A. Mench. **2009**. The effect of light intensity on the behavior and health of broiler chickens. Poultry Science. 88: 20-28.

Archer, G.S., H.L. Shivaprasad, and J.A. Mench**. 2009**. Effect of providing light during incubation on the health, productivity, and behavior of broiler chickens. Poultry . Science. 88 (1): 29-37.

Alvino, G.M., R.A. Blatchford**, G.S. Archer**, and J.A. Mench. **2009**. Light intensity during rearing affects the behavioural synchrony and resting patterns of broiler chickens. British Poultry Science. 50(3): 275-283.

Alvino, G.M., **G.S. Archer**, and J.A. Mench. **2009**. Time-budgets of broiler chickens reared in varying light intensities. Applied Animal Behavior Science. 118(1-2): 54-61.

Blatchford, R.A., **G.S. Archer**, and J.A. Mench. **2012**. Contrast in light intensity, rather than day length, influences the behavior and health of broiler chickens. Poultry Science, 91(8): 1768-1774.

Alvino, G.M., CB. Tucker, **G.S. Archer**, and J.A. Mench. **2013**. Astroturf as a dustbathing substrate for laying hens. Applied Animal Behavior Science. In Press.