

Curriculum Vitae for Hong Li

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PROFESSIONAL PREPARATION

Institution	Major	Degree	Year
China Ag.University, Beijing, China	Ag. Engineering	B.S.	1998
China Ag.University, Beijing, China	Ag. Engineering	M.S.	2001
Iowa State University, Ames, IA	Ag. Engineering	Ph.D.	2006

PROFESSIONAL EXPERIENCE

2011-Present	Assistant Professor, Dept. of Animal & Food Sciences, University of Delaware, Newark, DE
2010-2011	Assistant Professor, Dept. of Bioresources Engineering, University of Delaware, Newark, DE
2009-2010	Associate Scientist and Adjunct Assistant Professor, Dept. of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA
2007-2009	Assistant Scientist, Dept. of Agricultural and Biosystems Engineering, Iowa State University, Iowa State University, Ames, IA
2006 – 2007	Post-doctoral Research Associate, Dept. of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA
2005 – 2006	Pre-doctoral Research Associate, Dept. of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA
2002 – 2005	Graduate Research Assistant, Dept. of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA
1998 – 2001	Graduate Research Assistant, Dept. of Horticulture, China Agricultural University, Beijing, China

AWARDS AND HONORS

- AOCABFE Early Career Award (2015)
- Technical Paper Award by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) (2014)
- Rev P.T. Taiganides Award for Outstanding Ph.D. Students in Agricultural Engr. (2006)
- First Place in 2004 AOCABFE paper competition

PROFESSIONAL SOCIETY ACTIVITY

- American Society of Agricultural and Biological Engineers (ASABE)
 - Associate editor of ASABE, SE Division (2011.1–present)
 - Organizing Committee of the 10th International Livestock Environment Symposium (2016–2018)
 - Meeting Council – NABEC Representative (2015-2017)
 - SE 302 (Chair, 2013; Vice Chair, 2012; Secretary, 2011)
 - SE 305 (Technical session moderator, 2014 and 2015)
 - SE 405 (Chair, 2013; Vice Chair, 2012; Secretary, 2011)

- Association of Overseas Chinese Agricultural, Biological and Food Engineers (AOCABFE) (2004 –present)
 - Member of Board of Directors (2013-2015); Vice President (2014-2015), President-elect (2017-2018)
- Air and Waste Management Association (AWMA) (2006–present)
- Poultry Science Association (2016 – present)
- USDA multi-state research project NE1442: Poultry Production Systems and Well-being: Sustainability for Tomorrow (2014 – present)

PUBLICATIONS

Refereed Journal Articles (from work conducted at UD)

1. Qi, Y., Z. Yang, **H. Li**, M. D. Buser, J. D. Wanjura, P. M. Downey, C. Zhang, C. Craige, A. Torrents, L. L. McConnell, G. A. Holt, C. J. Hapeman. 2018. Assessment of Particulate Matter and Ammonia Emission Concentrations and Respective Plume Profiles from a Commercial Poultry House. *Environmental Pollution*. (Accepted)
2. Yang, X. C. Zhang, and **H. Li**. 2018. Field Comparison of TSI DustTrak versus TEOM in Two Poultry Houses. *Transactions of the ASABE* (Accepted)
3. Martin, J., P. A. Moore, Jr., **H. Li**, A. Ashworth, and D. Miles. 2018. Effects of Land-Applied Ammonia Scrubber Solutions on Yield, Nitrogen Uptake, Soil Test Phosphorus, and Phosphorus Runoff. *Journal of Environmental Quality* (in press)
4. Hristov, A. N., A. T. Degaetano, C. A. Rotz, E. Hoberg, R. H. Skinner, T. Felix, **H. Li**, P. H. Patterson, G. Roth, M. Hall, T. L. Ott, L. Baumgard, W. Staniar, R. M. Hulet, C. J. Dell, A. F. Brito, D. Y. Hollinger. 2017. Climate change effects on livestock in the Northeast U.S. and strategies for adaptation. *Climatic Change. Vulnerability Assessment of US Agriculture and Forests developed by the USDA Climate Hubs*. July 2017. DOI 10.1007/s10584-017-2023-z
5. Weir, J., **H. Li**, L. K. Warren, E. Macon, and C. Wickens. 2017. Characterizing ammonia emissions from horses fed different crude protein concentrations *J. Anim. Sci.* 2017.95:1–11
6. **Li, H.**, X. Wen, R. Alphin, Z. Zhu, and Z. Zhou. 2017. Effects of two different broiler flooring systems on production performances, welfare, and environment under commercial production conditions. *Poultry Science* 96(5): 1108-1119
7. Shepherd, T., Xin, H., Hayes, M., Zhao, Y., and **Li, H.** 2017. Ammonia and carbon dioxide emissions of three laying-hen housing systems as affected by manure accumulation time. *Transactions of the ASABE* 60(1): 229-236
8. Willis, W. B., Eichinger, W. E., Prueger, J. H., Hapeman, C. J., **Li, H.**, Buser, M. D., & Hatfield, J. L. 2017. Particulate capture efficiency of a vegetative environmental buffer surrounding an animal feeding operation. *Agriculture, Ecosystems & Environment* 240:101–108.
9. Willis, W.B., W.E. Eichinger, J.H. Prueger, C.J. Hapeman, **H. Li**, M.D. Buser, J.L. Hatfield, J.D. Wanjura, G.A. Holt, A. Torrents, S.J. Plenner, W. Clarida, S.D. Browne, P.M. Downey, and Q. Yao. 2017. Lidar method to estimate emission rates from extended sources. *J. Atmos. Oceanic Technol.* 34, 335–345
10. Zhang, C., A. Weiss, C. Lin, **H. Li**, R. Joerger, P. Chiu. 2016. Effects of multiple litter amendment applications in commercial broiler on ammonia emissions and litter microflora. *Transactions of the ASABE* 59(5): 1393-1401
11. Eugene, B., P. A. Moore, Jr., H. Li, D. Miles, S. Trabue, R. Burns, M. Buser. 2015. Effect of Alum Additions to Poultry Litter on In-House Ammonia and Greenhouse Gas (GHG) Concentrations and Emissions. *Journal of Environmental Quality* 44:1530-1540

12. **Li, H.**, C. Zhang, H. Xin. 2015. Performance of an infrared photoacoustic single gas analyzer in measuring ammonia from poultry houses. *Applied Engineering in Agriculture* 31(3):471-477
13. Zhao, Y., T. A. Shepherd, **H. Li**, H. Xin. 2015. Environmental assessment of three egg production systems—Part I: Monitoring system and indoor air quality. *Poult. Sci.* 94 (3): 518-533
14. Shepherd, T. A., Y. Zhao, **H. Li**, J. P. Stinn, M. D. Hayes, H. Xin. 2015. Environmental assessment of three egg production systems — Part II. Ammonia, greenhouse gas, and particulate matter emissions. *Poult. Sci.* 94 (3): 534-543. doi: 10.3382/ps/peu075
15. Brown-Brandl, T.M, M.D. Hayes, H. Xin, J.A. Nienaber, **H. Li**, R.A. Eigenberg, J.P. Stinn, and T.A. Shepherd. 2014. Heat and moisture production of modern swine. *Transactions of the ASHRAE* 120(1): 469-489
16. Hayes, M.D. H. Xin, **H. Li**, T. A. Shepherd, and J. P. Stinn. 2014. Electricity and fuel usage of aviary layer houses in the Midwestern USA. *Applied Engineering in Agriculture* 30(2): 259-266
17. Mendes, L., **H. Li**, H. Xin, J.W. do Nascimento. 2014. Evaluation of ec-5 soil moisture sensors for real-time determination of poultry manure or litter moisture content. *Applied Engineering in Agriculture* 30(2): 277-284
18. Stinn, J.P., H. Xin, T.A. Shepherd, **H. Li**, and R.T. Burns. 2014. Ammonia and greenhouse gas emissions of a modern U.S. swine breeding-gestation-farrowing system. *Atmospheric Environment* 98(2014): 620-628
19. Hayes, M.D. H. Xin, **H. Li**, T.A. Shepherd, Y. Zhao, and J. P. Stinn. 2013a. Ammonia, greenhouse gas, and particulate matter concentrations and emissions of aviary layer houses in the Midwestern USA. *Transactions of the ASABE* 56(5): 1921-1932
20. Zhao, Y., H. Xin, T. Shepherd, M. Hayes, J. Stinn, H. Li. 2013. Thermal Environment, Ammonia Concentrations, and Ammonia Emissions of Aviary Houses with White Laying Hens. *Transactions of the ASABE.* 56(3): 1145-1156
21. Hayes, M. D., H. Xin, **H. Li**, T. A. Shepherd, Y. Zhao, J. P. Stinn. 2013b. Heat and moisture production of Hy-line brown hens in aviary houses in the Midwestern United States. *Transactions of the ASABE* 56(2): 753-761.
22. **Li, H.**, C. Lin, S. Collier, W. Brown. 2013. Assessment of frequent litter amendment application on ammonia emission from broilers operations. *Journal of the Air & Waste Management Association.* 63(4): 442-452.

Refereed Journal Articles Prior To UD

23. Trabue, S., K. Scoggin, L. L. McConnell, **H. Li**, A. Turner, R. Burns, H. Xin, R. Gates, A. Hasson, S. Ogunjemiyo, R. Maghirang, and J. Hatfield. 2013. Performance of commercial non-methane hydrocarbon analyzers in monitoring oxygenated volatile organic compounds emitted from animal feeding operations. *Journal of the Air & Waste Management Association* 63(10): 1163-72.
24. **Li, H.**, H. Xin, R.T. Burns, S.A. Roberts, S. Li, J. Kliebenstein, K. Bregendahl. 2012. Reducing ammonia emissions from laying-hen houses through dietary manipulation. *Journal of the Air & Waste Management Association*, 62(2): 160-169
25. Chepete, J.H., H. Xin, and **H. Li**. 2012. Effect of partially covering turkey litter surface on ammonia emission. *J. App. Poult. Res.* 21:521–529
26. Chepete, J.H., H. Xin, **H. Li**, L. Mendes, and T. Bailey. 2012. Ammonia emission and performance of laying hens as affected by different dosages of yucca schidigera. *J. App. Poult. Res.* 21:530–538.

27. Mendes, L.B., H. Xin and **H. Li**. 2012. Ammonia emissions of pullets and laying hens as affected by stocking density and manure accumulation time. *Transactions of the ASABE* 55(3):1067-1075.
28. Rahman, S., H. Xin, S.A. Roberts, J.A. Arthur, R.T. Burns, **H. Li**, Z. Zhu, L.B. Moody, and K. Bregendahl. 2012. Effects of laying-hen variety on manure properties and ammonia emission. *Transactions of the ASABE* 55(3):105-1065.
29. Li, S., **H. Li**, H. Xin, R.T. Burns. 2011. Particulate matter concentrations and emissions of a high-rise layer house in Iowa. *Transactions of the ASABE* 54(3): 1079-1084
30. **Li, H.**, H. Xin, R.T. Burns, L.D. Jacobson, S. Noll, S.J. Hoff, J.D. Harmon, J.A. Koziel, B.P. Hetchler. 2011. Air emissions from tom and hen turkey houses in the U.S. Midwest. *Transactions of the ASABE* 54(1): 305-314
31. Chepete, J.H., H. Xin, and **H. Li**. 2011. Technical Note: Heat and moisture production of W-36 laying hens at 24 to 27 °C temperature conditions. *Transactions of the ASABE* 54(4): 1491-1493.
32. Chepete, J.H., H. Xin, **H. Li**. 2011. Ammonia emissions of laying-hen manure as affected by accumulation time. *Journal of Poultry Science* 48: 133-138
33. Muhlbauer, R.V., T.A. Shepherd, **H. Li**, R.T. Burns, H. Xin. 2011. Development and testing of an induction-operated current switch for monitoring fan operation. *Applied Engineering in Agriculture* 27(2): 287-292
34. **Li, H.**, H. Xin. 2010. Lab-scale assessment of gaseous emissions from laying-hen manure storage as affected by physical and environmental factors. *Transactions of the ASABE* 53(2): 593-604
35. Trabue, S., K. Scoggin, **H. Li**, R.T. Burns, H. Xin, J. Hatfield. 2010. Speciation of volatile organic compounds from poultry production. *Atmospheric Environment* 44(29): 3538-3546
36. **Li, H.**, H. Xin, S. Li, R.T. Burns. 2009. Upstream vs. downstream placement of FANS to determine fan performance *in situ*. *Transactions of the ASABE* 52(6): 2087-2090
37. Xin, H., **H. Li**, R.T. Burns, R.S. Gates, D.G. Overhults, J.W. Earnest. 2009. Use of CO₂ concentration difference or CO₂ balance to assess ventilation rate of broiler houses. *Transactions of the ASABE* 52(4): 1353-1361
38. **Li, H.**, H. Xin, R.T. Burns, Y. Liang. 2008. Reduction of ammonia emission from stored poultry manure using additives: Zeolite, Al+Clear, Ferix-3 and PLT. *Appl. Poult. Res.* 2008 17:421-431
39. Trabuea, S., K. Scoggina, **H. Li**, R.T. Burns, and H. Xin. 2008. Field sampling method for quantifying odorants in humid environments. *Environ. Sci. Technol* 42 (10): 3745–3750
40. Trabuea, S., K. Scoggina, F. Mitloehnerb, **H. Li**, R.T. Burns and H. Xin. 2008. Field sampling method for quantifying volatile sulfur compounds from animal feeding operations. *Atmospheric Environment* 42:3332–3341
41. Zhu, Z., H. Xin, **H. Li**, R. T. Burns, H. Dong. 2007. Assessment of in-line dust filter type and condition on ammonia adsorption. *Transactions of the ASABE* 50(5): 1823-1830
42. Liang, Y., H. Xin, **H. Li**, R. S. Gates, E. F. Wheeler and K. D. Casey. 2006. Effects of measurement intervals on estimation of ammonia emissions from layer houses. *Transactions of the ASABE* 49(1): 183-186
43. Liang, Y., H. Xin, E. F. Wheeler, R. S. Gates, **H. Li**, J. S. Zajackowski, P. A. Topper, K. D. Casey, B. R. Behrends, D. J. Burnham, F. J. Zajackowski. 2005. Ammonia emissions from u.s. Laying hen houses in iowa and pennsylvania. *Transactions of the ASAE* 48(5): 1927-1941

44. **Li, H.**, H. Xin, Y. Liang, R. S. Gates, E. F. Wheeler, and A.J. Heber. 2005. Comparison of direct vs. indirect ventilation rate determinations in layer barns using manure belts. *Transactions of the ASAE* 48(1): 367-372
45. Chen, Q.Y., **H. Li**. 2001. Study on the expert system of cucumber culture management in greenhouse. *Transactions of the CSAE* 17(6): 142-146
46. Wang, Y. X., D.S. Chen, T.Z. Zhang, **H. Li**. 1999. Double skin inflated greenhouse inner local climate control characteristics in higher cold area. *Transactions of the CSAE* 15(4): 167

Work in Progress

- 1) Zhang, C., C. Hapeman, and **H. Li**. Volatile Organic Compound Emissions from Broiler Operations with Different Litter Treatments.
- 2) Joerger, R., C. Schmidt, and **H. Li**. Investigate and Characterize the Microbial Environment of AAS-Treated Poultry Litter
- 3) Nacchia, V. and **H. Li**. Using Motion Detection to Determine Broiler Activities.
- 4) Buddle, A. and **H. Li**. Effect of Klasp on *clostridium spp* in poultry litter.
- 5) Zhang, C. and **H. Li**. Determination of Activation of Aluminum Sulfate And Develop a New Litter Amendment on Ammonia Control for Broiler Litter under Winter Conditions.

Presentations And Abstracts (* indicates Dr. Li was the mentor of the first author)

1. Weir, J. M. *, **H. Li**, L. K. Warren, E. Macon, and C. Wickens. 2017. Manure nitrogen characteristics from horses fed warm season grass hays. 25th Symposium of the Equine Science Society, Minneapolis, Minnesota.
2. Weir, J. M. *, **H. Li**, E. Rankins, and C. Wickens, 2017. Ammonia emissions from equine facilities in the Mid-Atlantic region. 25th Symposium of the Equine Science Society, Minneapolis, Minnesota.
3. Weir, J. M. *, **H. Li**, C. Zhang, D. Ferguson, S. Dougherty, and C. Wickens. 2017. Determining the aversion of horses to different ammonia concentrations. 25th Symposium of the Equine Science Society, Minneapolis, Minnesota.
4. Weir, J. M. *, **H. Li**, L. K. Warren, E. Macon, and C. Wickens. 2017. Evaluating the Impact of Ammonia Emissions from Equine Operations on the Environment. *Waste to Worth*, Cary, North Carolina.
5. Zhang, C. *, **H. Li**, J. Martin, P. Moore, M. Buser, C. Hapeman, G. Martin, P. Patterson. 2017. Using wet scrubber to reduce ammonia emission from broiler house. *Waste to Worth*, Cary, North Carolina.
6. **Li, H.**, C. Zhang, S. Collier, and J. Moyle. 2016. Assessment of Fan Performances Affected by Vegetative Environmental Buffers. *ASABE 2016 annual international meeting*, Orlando, Florida, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
7. Weiss, A., D. Bautista, and **H. Li**. 2016. Assessment of different litter amendments with multiple applications on ammonia emission, growth, and health of broilers. *PSA 2016 annual meeting*, New Orleans, LA.
8. Nacchia, V. * and **H. Li**. 2016. Using a choice test to account for preference in perching behavior of broilers. *PSA 2016 annual meeting*, New Orleans, LA
9. **Li, H.**, R. Alphin, Z. Zhu, Z. Zhou, and X. Wen. 2016. Comparison of two different flooring systems for broilers. *International Poultry Scientific Forum 2016*, Atlanta, Georgia.
10. Yang, X. *, **H. Li**, and C. Zhang. Development of a Spinner-Disc Spreader System to Apply Litter Amendments in Broiler Houses. *ASABE 2015 annual international meeting*, New

Orleans, Louisiana, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

11. Zhang, C. * and **H. Li**. 2015. Using Wet Scrubber to Capture Ammonia from Broiler Houses. *ASABE 2015 annual international meeting*, New Orleans, Louisiana, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

12. Zhang, C. * and **H. Li**. 2015. Impacts of C/N ratio and Inoculum to Substrate Ratio on Anaerobic Digestion of Poultry Litter. ASABE 2015 annual international meeting, New Orleans, Louisiana, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

13. **Li, H.**, K. Ro, C. Lin, L. Harper, T. Flesch, M. Johnson, S. Collier, C. Hapeman, L. McConnell, S. Trabue, P. Patterson, G. Martin. 2014. Effectiveness of Vegetative Environmental Buffers on Trace-Gas Plume Concentration. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

14. **Li, H.**, C. Zhang, A. Weiss, R. Joerger, S. Collier. 2014. Air Quality and Microbial Environment in Two Commercial Broilers Houses in Delaware with Frequent Litter Amendment Application during Grow-out. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

15. Zhang, C.*, J. Weir, **H. Li**, C. Wickens. 2014. Development of an Ammonia Preference Head Box System for Horses. Paper number: 1902180. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

16. Patterson, P. H., G. P. Martin, H. K. Burley, **H. Li**, and C. Lin. 2014. Miscanthus gigantus as a renewable bedding material for commercial broilers versus pine shavings. *PSA 2014 annual meeting*, Corpus Christi, TX.

17. Yao, Q, C. Hapeman, L. McConnell, **H. Li**, A. Nguyen, P. Downey, M. Buser, G. Holt, J. Preuger, W. Eichinger, K. Ro, A. Torrents. 2014. Utilizing vegetative environmental buffers to mitigate ammonia and particulate matter emissions from poultry houses. *248th ACS National Meeting and Exposition*. August 10-14, 2014, San Francisco, CA

18. Yao, Q., C. Hapeman, L. McConnell, **H. Li**, A. Nguyen, P. Downey, M. Buser, G. Holt, J. Preuger, W. Eichinger, K. Ro, A. Torrents. 2014. Assessing the Release of Ammonia and Particulate Matter Emissions from Poultry Houses. Chesapeake-Potomac Regional Chapter (CPRC) SETAC 2014 Annual Spring Meeting.

19. **Li, H.**, C. Lin, and S. Collier. 2014. Reducing Ammonia Concentration and Emissions with Frequent Litter Amendment Application During Grow-out. *International Poultry Scientific Forum 2014*, Atlanta, Georgia.

20. **Li, H.**, C. Lin, S. Collier. 2013. Gaseous emissions affected by depth and moisture content of poultry built-up litter. Paper number: 1574922. *ASABE 2013 annual international meeting*, Kansas City, MO, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

21. **Li, H.** 2012. Ammonia emissions from poultry operation affected by dietary modification and litter amendment. Paper number: 252. The 244th ACS National Meeting, Philadelphia, Pennsylvania, August 19-23, 2012.

Conference Proceedings (* indicates Dr. Li was the mentor of the first author)

1. **Li, H.**, D. Bautista and A. Weiss*. 2017. Mitigating ammonia with different amendments for broiler production system. 2017 International Symposium on Animal Environment and Welfare, Chongqing, China.

2. Nacchia, V*. and **H. Li**. 2017. Perching behavior and preference of broilers with perching enrichment. 2017 International Symposium on Animal Environment and Welfare, Chongqing, China.
3. Zhang, C. *, W. D. Alexis, **H. Li**, M. Guo, and J. Moyle. 2016. Using Poultry Litter-Derived Biochar as Litter Amendment to Control Ammonia Emissions. *ASABE 2016 annual international meeting*, Orlando, Florida, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
4. Zhang, C. *, **H. Li**, X. Yang, C. Lin, S. Collier, J. Martin, B. Eugene, P. Moore, M. Buser, C. Hapeman, and E. Benson. 2016. Using wet scrubber to reduce ammonia emission from broiler house. *ASABE 2016 annual international meeting*, Orlando, Florida, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
5. Yang, X. *, C. Zhang, and **H. Li**. 2015. Field Comparison of TSI DustTrak PM Monitor with Tapered Element Oscillating Microbalance (TEOM). *ASABE 2015 annual international meeting*, New Orleans, Louisiana, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
6. Zhang, C. * and **H. Li**. 2015. Greenhouse Gas Emissions of Corn Fielded with Broilers Litter Treated by Litter Amendment. *NABEC 2015 annual meeting*, Newark, Delaware, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
7. Zhang, C. * and **H. Li**. 2015. Impact of Frequent Litter Amendment Application on Nutrient Composition Changes of Stored Broiler. *NABEC 2015 annual meeting*, Newark, Delaware, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
8. **Li, H.**, R. Alphin. 2015. Comparison of Two Different Floor Systems for Broilers. *NABEC 2015 annual meeting*, Newark, Delaware, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
9. Sutterfield, D., D. Buser, P. A. Moore, **H. Li**, C. Hapeman. 2014. Design and development of an isokinetic multi-point particulate matter air sampling system. Paper number: 1914266. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
10. Sutterfield, D., D. Buser, P. A. Moore, **H. Li**, C. Hapeman. 2014. Velocity profile development for a poultry facility acid scrubber. Paper number: 1914254. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
11. Zhao, Y., H. Xin, T. A. Shepherd, **H. Li**. 2014. Concentrations of Ammonia, Greenhouse Gases and Particulate Matters in Conventional Cage, Aviary, and Enriched Colony Laying-Hen Houses. Paper number: 1904027. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
12. Shepherd, T. A., H. Xin, Y. Zhao, **H. Li**, J. Stinn, M. Hayes. 2014. Gaseous and Particulate Matter Emissions from Three Laying-hen Housing Systems: Conventional Cage, Aviary, and Enriched Colony. Paper number: 1913718. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
13. Moore, P. A., B. Eugene, **H. Li**, M. D. Buser, S. L. Trabue, R. Burns, D. Miles, M. Reiter. 2014. Development and Testing of the ARS Air Scrubber: A Simple Acid Scrubber for Reducing Ammonia, Dust and Odors from Poultry and Swine Facilities. Paper number: 1896678. *ASABE 2014 annual international meeting*, Montreal, QC, Canada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

14. Lin, C.* and **H. Li**. 2013. Effects of moisture content and litter amendment application rate on ammonia emission from poultry litter. Paper number: 1593044. **ASABE 2013 annual international meeting**, Kansas City, MO, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
15. **Li, H.**, C. Lin, S. Collier, S. White-Hansen, W. Brown. 2012. Assessment of Repeated Litter Amendment Application on Ammonia Reduction. Paper number: 121337336. **ASABE 2012 annual international meeting**, Dallas, TX, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
16. **Li, H.**, H. Xin. 2012. Performance of an infrared photoacoustic single gas analyzer in measuring ammonia in poultry buildings. Paper number: 121337337. **ASABE 2012 annual international meeting**, Dallas, TX, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
17. Lin, C. *, **Li, H.**, C. Xin, H. Xin. 2012. Ammonia adsorption characteristics of clinoptilolite (zeolite) in livestock and poultry houses. Paper number: 121337338. **ASABE 2012 annual international meeting**, Dallas, TX, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
18. **Li, H.**, J. Harter-Dennis, W. Brown, S. Collier. 2012. Evaluation of Enzyme Feed Additive on Ammonia Emission from Broilers. In *Proc of the 9th International Livestock Environment Symposium*, July 8-12, 2012, Valencia, Spain. St Joseph, MI: ASABE
19. Chen, Y. H. Xin, **H. Li**, T.A. Shepherd, M.D. Hayes, J.P. Stinn, R.T. Burns, R.S. Gates, and H. Dong. 2012. Comparison of using diurnal integration vs. daily mean concentration and ventilation rate to determine ammonia emissions from poultry houses. In *Proc of the 9th International Livestock Environment Symposium*, July 8-12, 2012, Valencia, Spain. St Joseph, MI: ASABE
20. Hayes, M.D., H. Xin, **H. Li**, T.A. Shepherd, Y. Chen, Y. Zhao, and J. P. Stinn. 2012. Bioenergetics of Hy-Line brown hens in aviary houses. In *Proc of the 9th International Livestock Environment Symposium*, July 8-12, 2012, Valencia, Spain. St Joseph, MI: ASABE
21. Hayes, M.D., H. Xin, **H. Li**, T.A. Shepherd, Y. Chen, Y. Zhao, and J. P. Stinn. 2012. Ammonia, greenhouse gas, and particulate matter concentrations and emissions of aviary layer houses in the Midwestern USA. In *Proc of the 9th International Livestock Environment Symposium*, July 8-12, 2012, Valencia, Spain. St Joseph, MI: ASABE
22. Hayes, M.D., H. Xin, **H. Li**, T.A. Shepherd, and J. P. Stinn. Electricity and fuel usage of aviary laying-hen houses in the Midwestern United States. In *Proc of the 9th International Livestock Environment Symposium*, July 8-12, 2012, Valencia, Spain. St Joseph, MI: ASABE
23. Stinn, J., H. Xin, **H. Li**, T. Shepherd, R. Burns. 2011. Quantification of greenhouse gas emissions from a Midwestern swine breeding/farrowing/gestation facility. Paper#1111151. **2011 ASABE Annual International Meeting**, Louisville, KY, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
24. Pepple, L., R. Burns, H. Xin, **H. Li**, J. Patience. 2011. Ammonia, hydrogen sulfide and greenhouse gas emissions from wean-to-finish swine barns fed traditional vs. a DDGS-based diet. Paper#1111201. **2011 ASABE Annual International Meeting**, Louisville, KY, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
25. Hayes, M., H. Xin, **H. Li**. 2011. Quantification of gaseous and particulate matter emissions from aviary laying-hen barns in Iowa. Paper#1111101. **2011 ASABE Annual International Meeting**, Louisville, KY, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE

26. Pepple L.M., R.T. Burns, H. Xin, **H. Li**, J.F. Patience. 2010. A comparison of gaseous emissions from swine finisher facilities fed traditional vs. a DDGS-based diet. *Proceedings of 2010 International Symposium on Air Quality and Manure Management for Agriculture*, Sep 13-16, Dallas, TX.
27. Mendes, L.B., H. Xin, **H. Li**. 2010. Ammonia emissions of laying hens as affected by stocking density and manure accumulation time. Paper # 1009252. *2010 ASABE Annual International Meeting*, Pittsburgh, PA, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
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35. Acevedo, R. R., **H. Li**, H. Xin, S.A. Roberts. 2009. Evaluation of a flux chamber for assessing gaseous emissions and treatment effects of poultry manure. Paper # 096362. *2009 ASABE Annual International Meeting*, Reno, Nevada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
36. Swestka, R., R. Burns, L. Tong, S. Hoff, **H. Li**, N. Keren, H. Xin, R. Spajic, R. Muhlbauer. 2009. Development of a Wireless Sensor Network to Quantify Hydrogen Sulfide Concentrations in Swine Housing. Paper # 096640. *2009 ASABE Annual International Meeting*, Reno, Nevada, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE.
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43. **Li, H.**, H. Xin, R. T. Burns, Steven Hoff, Jay Harmon, Larry Jacobson, Sally Noll and Jacek Koziel. 2008. Ammonia and pm emissions from a tom turkey barn in Iowa. Paper # 084425. 2008 ASABE Annual Meeting, Providence, RI, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
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45. Burns, R. T., **H. Li**, H.Xin, R.S. Gates, D. G. Overhults, J. Earnest and L.Moody. 2008. Greenhouse gas (GHG) emissions from broiler houses in the southeastern United States. Paper # 084649. 2008 ASABE Annual Meeting, Providence, RI, American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASAE
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66. **Li, H.**, H. Xin, and Y. Liang. 2005. Moisture Production of a Commercial Laying Hen House with Manure Belt. Proc of the 7th International Livestock Environment Symposium, May 18-20, 2005, Beijing, China. (eds) T. Brown-Brandl and R. Maghirang. St Joseph, MI: ASAE, Pp 162-170. LCCN 2005924086. ASAE Pub #701P0205
67. **Li, H.**, H. Xin, Y. Liang. 2004. Comparison of Direct vs. Indirect Ventilation Rate Determination for Manure Belt Laying Hen House, Paper number 044177, 2004 ASAE/CSAE Annual International Meeting ,Ottawa, Ontario, Canada, American Society of Agricultural Engineers, St. Joseph, MI: ASAE
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69. Liang, Y., H. Xin, **H. Li**, J. Koziel, L. Cai. 2005b. Evaluation of Treatment Agents and Diet Manipulation for Mitigating Ammonia and Odor Emissions from Laying Hen Manure. Paper # 054160. American Society of Agricultural and Biological Engineers, St. Joseph, MI: ASABE
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Invited Talks

1. Li., H. US Poultry Industry Overview. Emergency Management of Poultry Disease Outbreaks Certificate Course, July 6, 2017, University of Delaware, Newark, DE
2. Li., H. Poultry Air Emissions and Mitigation Technologies. Delaware Ag Week. January 9, 2017, Delaware State Fairgrounds, Harrington, DE
3. Li, H. Managing Vegetative Environmental Buffer and Scrubbers Conservation Innovation Grant. Poultry Grower Field Day. October 31, 2014, Hurlock, MD
4. Li, H. Vegetative Environmental Buffer and Scrubbers Conservation Innovation Grant. Poultry Buffer Air and Water Quality Training and Field Day. October 29, 2014, Princess Ann, MD
5. Li, H. Seasonable Technology for Managing Poultry House Emission. Penn State University Poultry Management and Health Seminar. May 13, 2014, Lancaster, PA
6. Li, H. Mitigating Air Emissions from Poultry Operations. Chinese Academy of Agricultural Science. August 23, 2013, Beijing, China
7. Li, H. Assessment of Frequent Litter Amendment (PLT) Application on Ammonia Emission from Broilers. DPI Environmental Committee. May 28, 2013, Salisbury, MD
8. Li, H. Updates on Development of Emissions Estimating Methodologies for Broiler Operations. DPI Environmental Committee. June 14, 2012, Georgetown, DE
9. Panel Discussion on Air Emissions, Chesapeake Bay Regional Technology Summit, Farm Pilot Project Coordination, Inc. March 23-25, 2011 – Westin, Annapolis, MD
10. Li., H. Poultry Air Emissions and Mitigation. Delaware Ag Week. January 17-22, 2011, Delaware State Fairgrounds, Harrington, DE

Funded Research Grants

Project Title	Grantor	PD	Co-PD	Period	Amount
Undergraduate Research and Education Exploring One Health	USDA NIFA	Parcells	Li and 13 others	6/1/17 – 5/31/20	\$300,402
Evaluate Ammonia Emission From An Innovative Flooring System For Broilers During Growout	Poultry EcoServices, LLC		Li	11/30/16– 9/30/17	\$22,221
Effect of litter amendments on <i>clostridium spp</i> in poultry litter		Li	Biddle	10/28/16 – 10/30/17	\$41,111
Using Choice To Evaluate Perch Environmental Enrichment For Broilers	Perdue PSA Fellowship	Li		9/1/16 – 8/30/18	\$60,400
Determination of Activation of Litter Amendment on Ammonia Control for Broiler Litter		Li		5/17/16 – 4/30/18	\$83,966

Using Poultry Litter-Derived Biochar as Delmarva Litter Amendment to Control Ammonia Seed		Li	Guo, Moyle		3/1/16-2/28/18	\$18,102
Development of an innovative massive vaccination administration method for poultry	UDRF	Li			6/01/15-5/31/17	\$35,000
Evaluation of probiotics on broiler production and emissions		Li			5/29/15-5/28/16	\$42,591
Field evaluation of feed additives on ammonia emission of high-rise layer houses	ISE America	Li			12/1/14-5/31/15	\$3,200
Enhance the animal environmental research at University of Delaware	Jones-Hamilton	Li			9/1/14-8/31/19	\$50,000
Assessment of different flooring systems for broilers in China	OSI	Zhu	Li, Alphin, Zhou		1/1/14-6/30/15	\$20,000
Developing and evaluating an innovative litter amendment application system for poultry operations	USDA-AFRI	Li	Benson, Chiu, Bautista, Joerger, Schmidt, Timmons		9/1/13-8/31/15	\$499,946
Increasing the ability of broilers to survive and grow under high environmental temperatures	Maryland Ag. Expt. Station (MAES)	Roselina	Porter, Timmons, Li		6/1/13-5/31/14	\$30,000
Frequent application of litter amendments in broiler houses	USPEA	Li	Benson, Chiu, Kniel, Jin, Joerger		10/1/12-03/31/14	\$55,444
Innovative approaches to capture nitrogen and air pollutant emissions from poultry operations	USDA-NRCS	Li	Benson and 9 others		9/1/12-8/31/15	\$967,461
Integrated nutrient management for high yielding corn in a poultry-grain production system	Farm Pilot Project Co.	McGrath	Coale, Li, Sims, Shober		6/1/12-12/1/14	\$89,856
Impact of incandescent, CFL, cold cathode, and LED lamps on bird health	USPEA	Benson	Alphin, Li, Schmidt		4/1/12-3/31/13	\$43,254
Evaluation of repeated PLT application on environmental impact reduction	Jones-Hamilton	Li			11/21/11-5/20/12	\$22,000
Reduction of environmental impact through dietary manipulation		Li			3/28/11-5/10/12	\$64,391

TEACHING AND EDUCATION

Courses Developed and Taught

ANFS 111 Animal and Food Science Laboratory, 0.5 credits
Fall 2014 - 16

ANFS 340 Intro to Animal Environmental Management, 3 credits
Spring 2017, 5 students

ANFS 367 Animal Environmental Management, 3 credits
Spring 2016, 8 students

ANFS 421 Poultry Production, 3 credits
Fall 2014, 15 students
Fall 2015, 8 students
Fall 2016, 15 students

ANFS 466 Independent Study
Fall 2015, 1 student, 3 credits
Spring 2016, 1 student, 2 credits

BREG 466 Independent Study
Spring 2014, 1 student, 3 credits

ANFS 467/667 Animal Environmental Management, 3 credits
Spring 2012, 8 students

BREG 468 Undergraduate Research
Summer 2012, 1 student, 3 credits

ANFS 666 Graduate Independent Study
Fall 2014, 2 student, 3 credits
Fall 2015, 1 student, 4 credits

ANFS668 Research
Fall 2013, 1 student, 4 credits
Spring 2014, 1 student, 4 credits
Spring 2015, 1 student, 6 credits
Fall 2016, 2 students, 2-3 credits

ANFS 865 Graduate Student Seminar, 1 credit
Fall 2013 and Spring 2014

ANFS 868 Research
Fall 2013, 2 students, 2-3 credits
Spring 2014, 1 student, 3 credits
Fall 2014, 1 student, 6 credits
Spring 2015, 1 student, 6 credits
Fall 2016, 3 students, 7 credits

ANFS 869 Thesis
Spring 2015, 1 student, 3 credits
Spring 2017, 1 student, 3 credits

Guest Lectures

1. ANFS 418 Swine Production, Fall 2014 and 2016 Taught on Swine Environmental Management
2. Poultry science at Delaware State University, Fall 2016 Taught on Poultry Ventilation
3. Chemical Engineering Senior Design, Spring 2017 Participated in design of ammonia capture system for broiler operations and provided background information and design guidelines.

Undergraduate Advising

1. Currently advise 18 ANFS undergraduate students
2. New Student Orientation, July 6, 2015, June 20, June 21, and June 27, 2016

Undergraduate Recruitment Activities

1. Animal Science Exploration Day, October 14, 2016
2. Discovery Days, July 18, 2015
3. Poultry Science Exploration Day, October 24, 2014 and October 16, 2015

Undergraduate Career Development

US Poultry Foundation student recruiting program: advised 8 CANR undergraduate students to participate in US Poultry College Student Career Program. January 26-28, Atlanta, Georgia.

Undergraduate Researchers

Name	Duration	Project	Department	Credit
Melissa De Los Santos	2017	Microflora affected by litter amendments	ANFS	N/A
Tylor Reagle	2016	Design perches for broilers	ANFS	N/A
Joshua Aegerter	2016-2017	Design perches for broilers	ANFS	N/A
Jennifer Shuler	2016-2017	Design perches for broilers	ANFS	N/A
Laura Miller	2016-2017	Using litter amendments to control air emission	ANFS	N/A
Veronica Nacchia	2015-2016	Impact of litter amendment on animal welfare and care	ANFS	N/A
Wendell Alexis	2014-2016	Impact of PLT in feed on broiler health and performance	ANFS	N/A
Meghan Barns	2014-2017	Quantifying air emissions of broiler houses with litter amendments	ANFS	N/A
Zachary Spencer	2013-2014	Developing and construction of livestock gas emission sampling systems (major contribution to USDA CIG and AFRI project)	BREG (independent study)	3
Matthew Burkholder	2011	Mass Air Flow Sensor Testing for Use in Poultry Research Applications (major contribution to US Poultry proposal)	BREG (Independent research)	3
Thomas Santangelo	2011	Evaluation of continuous litter amendment application	ENSC	N/A
Josh Bounds	2011	Effects of enzyme additives on ammonia emission	BREG	N/A
Timothy Schofield	2011-2012	Effects of enzyme additives on ammonia emission	FREC	N/A
Carl Demander	2011	Effects of enzyme additives on ammonia emission	FREC	N/A
Anthony Serio	2012	Evaluation of continuous litter amendment application	BREG	N/A

Graduate Student Advised

- **Brittney Andersen M.S.** 2015–2017 Thesis: Development of a new foam vaccination

method for poultry in the hatcher. Brittney is currently working as an intern for Perdue Farms.

- **Jessie Weir** Ph.D. 2012–2016 Dissertation: Evaluating the impact of ammonia emissions from equine operations on the environment and equine welfare (co-advised with Dr. Carissa Wickens)
- **Alyson Weiss** M.S. 2013–2015 Thesis: Effects of acidic litter amendments with multiple applications on ammonia, microbial environment, production performances, and health of broilers. Alyson is a technician at Pennington Veterinary Clinic.
- **Chongyang Lin** M.S. 2011–2014 Thesis: Mitigating ammonia emission from broilers with frequent litter amendment application (co-advised with Dr. Pei Chiu)
- **Ricardo Acevedo** M.S. 2008–2010 at Iowa State University Thesis: Evaluation and application of a dynamic emissions chamber for quantifying gaseous emissions from laying hen manure (co-advised with Dr. Hongwei Xin)
- **Luciano Mendes** M.S. 2008–2010 at Iowa State University Thesis: Ammonia emissions, feeding and defecation dynamics of W36 pullets and laying hens as affected by stocking density and manure accumulation time (co-advised with Dr. Hongwei Xin)

Current Graduate Students

- **Chen Zhang** Ph.D. candidate 2013–Expected completion 2017
- **Veronica Nacchia** M.S. candidate 2016–Expected completion 2018

Graduate Committees

- **Qi Yao** Ph.D. 2013–2017 at University of Maryland Dissertation: Assessing the effectiveness of vegetative environmental buffers in mitigating poultry- emitted air pollutants
- **Xin Wen** M.S. 2013–2015 at Hunan Agricultural University Thesis: Effects of two different broiler flooring systems on production performances, welfare, and environment under commercial production conditions
- **Morgan Hayes** Ph.D. 2008–2012 at Iowa State University Dissertation: Environmental and energy assessment of an aviary laying-hen housing system in the Midwestern United States
- **Laura Pepple** M.S. 2009–2011 at Iowa State University Thesis: Impacts of feeding dried distillers grains with solubles on aerial emissions when fed to swine
- **Xiaopeng Ning** M.S. 2006–2008 at Iowa State University Thesis: Feeding, defecation and gaseous emission dynamics of W-36 laying hens

Post-Doc/Visiting Scholars

- **Dr. Xufei Yang** (Post-doc, 2014–2015), Assistant Professor, Environmental Engineering, Montana Tech of the University of Montana

Attended Workshops on Education

1. Improving Student Learning Through Writing, UD, June 14-18, 2014
2. Online Teaching and Active Learning: Flipping the Classroom, ASABE Continuing Professional Development, Orlando, Florida, July 17, 2016

Scholarship in Teaching

Parcells et al 2016 USDA NIFA: Undergraduate Research and Education Exploring One Health, *My role: co-PI.*

Community Education and Outreach Programs

1. Serving on Environmental Committee for Delmarva Poultry Industry (DPI)
2. Supporting field specialists (William Brown and Steven Collier at UD, Jonathon Moyle at UMD), as needed, in carrying out their extension programs
3. Conducting educational programs on poultry air quality, environmental control and production sustainability
 - Poultry emission and mitigation workshop. November 2, 2016, Dover, Delaware
 - Ammonia management tips, March 21, 2015
 - Poultry Field Day. October 31, 2014
 - Radiant tube heater heat distribution and maintenance recommendation, November 6, 2013
 - Effectiveness of grasses around fans. October 18 and November 16, 2012
 - Updates on EPA ammonia emission estimation methodology development, June 14, 2012
 - Attic ventilation system. February 29, 2012
 - Hot weather workshop. April 24, 2012
4. Integrating emerging animal industry issues into applied research and demonstration projects
 - Using Biochar as litter amendment, January 2017
 - Summer water management, August 2014
 - New litter management technology demonstration, June 2013
 - Improving nitrogen retention and utilization in poultry litter, May 2013
 - Develop new disinfection practices in broiler houses, March 2013
 - Alternative broiler housing system, October 2012
 - Effectiveness of continuous litter amendment application, July 2012
 - Using Klasp for poultry operations, March 2011.
 - New litter amendment for poultry operations, February 2011.
 - New low-cost ammonia sensor for poultry operations, December 2010.
5. Developing and maintaining strong partnerships/network with state and national commodity groups, interstate institutional and governmental agencies to enhance outreach programs
 - US Poultry Industry Overview, Emergency Management of Poultry Disease Outbreaks Certificate Course, July 6, 2017.
 - Allen-Harim, Jones-Hamilton, and University of Delaware Collaboration recognition meeting, January 24, 2017

SERVICE ACTIVES

University, College and Departmental Committees Served

- University of Delaware Committee on Student and Faculty Honors (2013–present)
- CANR Space Committee (2017–present)
- CANR R&D project for anaerobic digestion of manure and nutrient recovery (2013–2014)
- CANR Extension Poultry Specialist search committee (2016)
- CANR Nutrient Management Coordinator search committee (2016)
- Poultry Extension Agent advisory committee (2011–2016)
- ANFS Courses and Curriculum Committee (2011–present)
- ANFS faculty search committee (2017)
- ANFS Chair search committee (2014)
- ANFS Equine faculty search committee (2014)
- ANFS Newark poultry farm planning committee (2014)

- ANFS US Poultry College Career Program trip to Atlanta (2016)
- ANFS Animal and Poultry Science Exploration Day (2014–present)
- ANFS Graduate seminar (2013-2014)
- Supervising university poultry environmental house research (2011–present)
- Initiative of integrated poultry program with new broiler houses (2014–2016)

Recruitment Activities

- Animal Science Exploration Day, October 14, 2016
- Discovery Days, July 18, 2015
- New Student Orientation, July 6, 2016, June 20, June 21, and June 27, 2017
- Poultry Science Exploration Day, October 24, 2014 and October 16, 2015

Community and Industry Activities

- Delmarva Poultry Industry Environmental Committee (2011–present)
- OSI China UD CAAS collaboration (2012–2015)

Professional/Government/Commodity Organizations

ASABE (American Society of Agricultural and Biological Engineers)

- Associate editor of ASABE, SE Division (2011.1–present)
- Organizing Committee of the 10th International Livestock Environment Symposium (2016–2018)
- Meeting Council – NABEC Representative (2015-2017)
- SE 302 (Chair, 2013; Vice Chair, 2012; Secretary, 2011)
- SE 305 (Technical session moderator, 2014 and 2015)
- SE 405 (Chair, 2013; Vice Chair, 2012; Secretary, 2011)

AOCABFE (Association of Overseas Chinese Agricultural, Biological and Food Engineers)

- Member of Board of Directors (2013-2015); Vice President (2014-2015), President-elect (2017-2018)

Poultry Science Association

- Judge for student poster competition (2016).

Manuscript and Proposal Reviews

- Regular reviews of ASABE, Poultry Science, Applied Poultry Research, Biosystems Engineering, Atmospheric Environment, Journal of Environmental Quality, Bioresource Technology, Atmospheric Pollution Research, averaging 7 papers per years.
- Ad-hoc reviewer of research proposals for NSF Small Business Innovation Research (SBIR) (2010), USDA SBIR (2013), USDA ARS (2016), Universities (MAES, 2012), and Industries (Egg Industry Center, 2015).
- Reviewer for conference proceedings: 2017 International Symposium on Animal Environment and Welfare sponsored by the International Research Center for Animal Environment and Welfare