Social Sustainability of Egg Production Project

Supported by the American Egg Board

Project Leaders:
Janice Swanson, MSU
Joy Mench, UC-Davis
Paul Thompson, MSU
Critical Study Areas

- **Hen Health and Welfare**
  - Don Lay, USDA-ARS, Scotti Hester Purdue

- **Supply Chain Dynamics, Economics and Labor**
  - Dan Sumner, UC Davis

- **Food Safety, Security, Quality and Human Health**
  - Pete Holt, USDA-ARS, Deana Jones USDA-ARS

- **Environmental Impacts, Ecological Integrity and Sustainability**
  - Hongwei Xin, Iowa State

- **Public Attitudes, Discourse and Assurance**
  - Paul Thompson, Michigan State
Institutions/Organizations

- Michigan State
- UC Davis
- Purdue
- Iowa State
- Tuskegee Institute
- Washington State
- University of Georgia
- Oklahoma State
- University of Minnesota
- US Department of Agriculture - ARS
- Cardiff University
- University of Bristol
- Wageningen University
- World Society for the Protection of Animals
- Safehouse Project
- Animal Welfare Quality Project
- Farm Animal Welfare Council (UK)
- HyLine
Social Sustainability of Egg Production Project

- Study team workshops (2008 - 2011)
- Symposium 2010 – PSA/ADSA/ASAS

- 7 papers published in Poultry Science
- Developed framework for a large scale system-based research project
Coalition for Sustainable Egg Supply

http://www.sustainableeggcoalition.org
Coalition for Sustainable Egg Supply

• Comprised of leading scientists, research institutions, non-governmental organizations, egg suppliers, food manufacturers, restaurant/foodservice and food retail companies. Leadership team:

• Conducting commercial-scale research to generate data that will allow food system stakeholders to make informed, independent decisions.
Our Structure

• The CSES leadership team includes:
  – Research – Michigan State University and University of California, Davis
  – Egg Supplier – Cargill Kitchen Solutions, Inc.
  – Food Retailer – McDonald’s USA
  – Animal Well-Being – American Humane Association
  – Facilitator – Center for Food Integrity

• Member advisors include:
  – American Veterinary Medical Association
  – USDA Agricultural Research Service
  – Environmental Defense Fund (non-member advisor)
Additional Members

• Au Bon Pain
• Bob Evans Farms
• British Columbia Egg Marketing Board
• Burnbrae Farms
• Cracker Barrel Old Country Store
• Daybreak Foods
• Egg Farmers of Canada
• Egg Farmers of Ontario
• Flowers Foods, Inc.
• Forsman Farms
• Fremont Farms of Iowa
• Herbruck’s Poultry Ranch
• Iowa State University
• Michael Foods
• Midwest Poultry Services
• Ohio Egg Marketing Program
• Poultry Science Association
• Purdue University
• Sparboe Foods
• Sodexo
• Sysco Corporation
• Tyson Foods
• United Egg Producers
• University of Guelph
CSES Research Overview

- Three types of hen housing systems are being evaluated
  - Conventional cage system
  - Enriched colony system
  - Cage-free aviary

- Across five sustainability factors:
  - Environmental Impact
  - Food Safety
  - Worker Safety
  - Animal Health and Well-Being
  - Food Affordability
Conventional Housing
Aviary Housing
<table>
<thead>
<tr>
<th></th>
<th>Conv. Cage</th>
<th>Aviary System</th>
<th>Enriched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension (L x W x H)</td>
<td>464 x 84 x 20 ft</td>
<td>506 x 70 x 10 ft</td>
<td>506 x 45 x 13 ft</td>
</tr>
<tr>
<td>Hen breed</td>
<td></td>
<td>Lohmann White</td>
<td></td>
</tr>
<tr>
<td>No. hens at 19 weeks</td>
<td>193,424</td>
<td>49,842</td>
<td>46,795</td>
</tr>
<tr>
<td>Hens per cage</td>
<td>6</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>Designed space per bird, in²</td>
<td>80</td>
<td>144</td>
<td>116</td>
</tr>
<tr>
<td>Welfare enrichment elements</td>
<td>N/A</td>
<td>Perch, nest area, litter access</td>
<td>Perch, nest area, scratch pad</td>
</tr>
<tr>
<td>Ventilation type</td>
<td>Tunnel</td>
<td>Ceiling/perimeter slot inlets, Cross vent</td>
<td></td>
</tr>
<tr>
<td>Manure handling</td>
<td>Manure belt</td>
<td>Manure belt + litter</td>
<td>Manure belt</td>
</tr>
<tr>
<td>Manure removal</td>
<td>every 3-4 days</td>
<td>Belt: every 3-4 days</td>
<td>every 3-4 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Litter: end of flock</td>
<td></td>
</tr>
<tr>
<td>Photoperiod (Light:Dark)</td>
<td></td>
<td>16:8</td>
<td></td>
</tr>
</tbody>
</table>
• Construction and Early Research
  – Some research began in November 2010 with baby chicks and hatchery
  – Construction of commercial scale aviary and enriched cage facilities completed April 2011

• Flock Placements and Research
  – First research flocks were placed in April 2011
  – Second research flocks were placed in June 2012

• Completion and Results
  – Study complete in 2014
  – Preliminary report early 2015
Food Safety
Egg Safety & Quality
Food Safety

• Research sub-area: Exterior Egg Quality
  – Measuring and analyzing shell characteristics
    • Presence of micro cracks
    • Shell thickness
    • Shell dynamic stiffness (eggshell strength evaluation)
    • Shell strength
    • USDA grade (determined by both interior and exterior quality)

Researcher Deana Jones examines eggs for shell quality defects

Measuring Egg Dynamic Stiffness

Measuring Shell Strength
Food Safety

• Research sub-area: Interior Egg Quality
  – Measuring and analyzing:
    • Yolk index
    • Vitelline membrane strength and elasticity (the covering of the yolk)
    • Haugh unit (measures quality of albumen or egg white)
    • USDA Grade

Measuring yolk index

Candling allows one to look inside the egg without breaking it to judge its quality.

Measuring membrane strength
Food Safety

- Research sub-area: Microbial Evaluations
  - Evaluating microbiological populations on eggs, layer housing and processing facilities

Salmonella enteritidis

Eggs on egg belt in layer house
Food Safety

- Research sub-area: Hen Immunological Response
  - Monitoring immunological response of hens to vaccines
  - Analyzing gastrointestinal mucosal response

Hens in enriched colony housing.
Worker Health and Safety
Worker Health and Safety

• Research sub-area: Respiratory Health
  – Assessing personal exposure to gaseous and particulate matter
    • Ammonia
    • Particulates (dust, etc.)
    • Endotoxins
  – Characterize associations between different hen housing environments and respiratory health for workers

Researchers use this device to measure the pulmonary function of workers before and after their shift.

Researchers collect data by outfitting workers with a lightweight backpack containing a personal sampling pump.
Worker Health and Safety

- **Research sub-area: Musculoskeletal Impact**
  - Defined required tasks for each type of housing
  - Evaluating and comparing ergonomic stressors related to worker tasks
  - Characterizing extent of musculoskeletal disorders (i.e. injuries and disorders of soft tissues like muscles, tendons, ligament, joints, etc.)

Worker performs daily care check using moving cart.

Worker collects floor eggs in aviary.
Hen Health and Well-Being
Hen Health and Well-Being

• Research sub-area: Resource and Space Use
  – Characterizing resource and space use in the enriched colony and aviary systems
    • More than 300 cameras are installed in these two systems. Video tape allows researchers to collect behavioral observations such as:
      – How do hens use the space and resources?
      – Are there changes over the laying cycle?
      – What is the frequency of aggression and comfort behaviors?
Hen Health and Well-Being

• **Research sub-area: Hen Welfare**
  – Evaluating hen welfare using a standardized, performance-based assessment on hens in each housing system
    • Heat stress
    • Keel bone deformation
    • Foot pad
    • Toe condition
    • Enlarged crops
    • Eye condition
    • Lice/mite infestation
    • Comb abnormalities
    • Beak condition
    • Skin lesions
    • Plumage damage and plumage dirtiness
Hen Health and Well-Being

- **Research sub-area: Hen Health**
  - Evaluating and comparing the health of a single strain of laying hens in three different housing systems
    - Recording daily mortality
    - Determining causes for mortality by performing necropsies (hen autopsy)
    - Breeder company veterinarian visits
    - Blood samples
Hen Health and Well-Being

• Research sub-area: Skeletal Evaluation
  – Determining the effects of housing on the bone quality of laying hens
  – Biological markers in the blood
  – Biomechanical properties of tibia and humerus
  – Bone mineral density and morphology
Hen Health and Well-Being

- **Research sub-area: Hen Stress**
  - Understand the impact of various housing systems on physiological stress in laying hens
    - Measured invasively (blood, adrenal weight)
    - Measured non-invasively (egg corticosterone)

100X of a heterophil and red blood cells.

Blood films showing heterophils, red blood cells, thrombocytes and variant heterophils.
Environmental Impact
Environmental Impact

• Research sub-area: Indoor Air Quality and Thermal Conditions
  – Measuring gaseous and particulate matter concentrations and thermal conditions inside the houses
  – Using state-of-the-art mobile air emissions monitoring unit equipped with gas analyzers, air sampling control system, data acquisition system and instrument calibration accessories
Environmental Impact

- **Research sub-area: Emissions from Layer Housing and Manure Storage**
  - Monitoring gaseous and particulate matter emission rates by housing system using mobile air emissions unit previously mentioned
  - Characterizing manure/litter removed from each facility and accounting for total nitrogen in the system
    - Measuring the amount of manure produced by each system
    - Analyzing its characteristics, such as moisture content, solids content, pH, ammonia content and total nitrogen content

![Manure load out](image1)

![Manure storage](image2)
Environmental Impact

• **Research sub-area: Data Analysis and Modeling**
  
  – Determining and comparing feed, water and energy use (fuel and electricity) and egg production efficiency
    
    • Egg production data is being used in assessing emissions on the basis of per kg of egg production
    
    • Shows feed and energy utilization efficiency
  
  – Conducting modeling on indoor air quality, thermal conditions and gaseous emissions as affected by the housing systems, manure management and climatic conditions.
Food Affordability
Food Affordability

- **Research sub-area: Production Costs and Revenue**
  - Assessing differences in input use and farm costs
    - Feed
    - Land and buildings
    - Labor
    - Disease and health
    - Pullet costs
  - Assessing marketable output flows and revenue
Preliminary Findings
Flock 1
## Flock 1 Production Summary (Week 19 – 78)

<table>
<thead>
<tr>
<th>Production Parameter</th>
<th>Conv.</th>
<th>Enriched</th>
<th>Aviary</th>
<th>Ref.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEN NUMBER/HOUSE (19 wk)</td>
<td>193,424</td>
<td>46,795</td>
<td>49,842</td>
<td>-</td>
</tr>
<tr>
<td>HEN NUMBER/HOUSE (78 wk)</td>
<td>184,322</td>
<td>44,404</td>
<td>44,082</td>
<td>-</td>
</tr>
<tr>
<td>CUMULATIVE MORTALITY (%)</td>
<td>4.7</td>
<td>5.1</td>
<td>11.6</td>
<td>6.8</td>
</tr>
<tr>
<td>AVG. HD EGG PROD (%)</td>
<td>85.9</td>
<td>89.0</td>
<td>88.1</td>
<td>88.2</td>
</tr>
<tr>
<td>EGGS PER HEN HOUSED</td>
<td>352</td>
<td>363</td>
<td>340</td>
<td>360</td>
</tr>
<tr>
<td>CASE WEIGHT (LB/CASE)</td>
<td>46.4 ± 4.4</td>
<td>46.9 ± 3.1</td>
<td>46.3 ± 2.9</td>
<td>48.6</td>
</tr>
<tr>
<td>FEED PER CWT (LB/100bd-day)</td>
<td>22.8 ± 3.9</td>
<td>23.6 ± 3.0</td>
<td>23.3 ± 3.6</td>
<td>22.4</td>
</tr>
<tr>
<td>WATER PER CWT (GAL/100bd-day)</td>
<td>5.85 ± 0.48</td>
<td>5.15 ± 0.30</td>
<td>4.83 ± 0.46</td>
<td>-</td>
</tr>
<tr>
<td>WATER/FEED (LB/LB)</td>
<td>2.07</td>
<td>1.73</td>
<td>1.64</td>
<td>-</td>
</tr>
<tr>
<td>FEED CONVERSION (LB/Doz. eggs)</td>
<td>3.18</td>
<td>3.13</td>
<td>3.28</td>
<td>3.14</td>
</tr>
<tr>
<td>FC (LB feed/LB egg)</td>
<td>2.02</td>
<td>1.99</td>
<td>2.12</td>
<td>1.94</td>
</tr>
<tr>
<td>BODY WEIGHT @ 78 wk (LBS)</td>
<td>3.44</td>
<td>3.42</td>
<td>3.37</td>
<td>3.71</td>
</tr>
</tbody>
</table>

*Lohmann white reference value (in conventional cage)  
*Preliminary data*
Hen Health and Well-being
Flock 1
Preliminary Findings
Preliminary Findings: Flock 1

• Hen mortality over the life of the flock was approximately double in the aviary system:
  – Due to conditions associated with egg production, and
  – Behavioral issues with hens either being excessively pecked, or picked out (vent).

• Hens in the enriched system experienced more fractured wings and legs during placement into the house.
Preliminary Findings: Flock 1

• When compared to birds in the conventional system, those in aviary and enriched systems both had a higher incidence of keel (breast bone) deviations.

• The hens in conventional cages had the highest incidence of foot problems, mainly hyperkeratosis.

• When hens in the aviary had foot problems they were more severe than those in conventional or enriched cages.
Preliminary Findings: Flock 1

• Conventional and enriched hens had cleaner feathers but worse feather cover than aviary hens.

• Hens with large areas of feather loss lost more body heat than better-feathered hens.

• Patterns of feather loss suggested that hens in conventional and enriched systems lost feathers due mainly to abrasion against the cage, while those in the aviary system lost feathers due to aggressive pecking from other birds.
Environmental Impact

Flock 1

Preliminary Findings
Preliminary Findings: Flock 1

• The conventional and enriched houses
  – very good indoor air quality, with ammonia and particulate matter (dust) levels being very low.

• Aviary ammonia levels tended to be 1.5 to 2 times as high
  – likely due to manure on the floor not being removed until the end of the flock
  • Can be corrected with higher ventilation rates but that will use more energy use -- illustrates the tradeoffs between systems
Preliminary Findings: Flock 1

- Dust-bathing & foraging in the aviary system generated eight to 10 times more dust than in the enriched or conventional houses.
- Ammonia & particulate matter emissions from the houses were highest for the aviary house, followed by the conventional house and the lowest for the enriched house.
- Methane emissions for all housing systems were similar and quite small.
- Electricity use was similar across all three systems. The aviary house also used small amount of supplemental heat (from propane) (about 1,400 gallons for the year), although the winter during the monitoring period was milder than normal.
Food Affordability

Flock 1

Preliminary Findings
Preliminary Findings: Flock 1

• On the basis of per dozen eggs, overall costs are highest for eggs produced in the aviary system, followed by those from enriched housing and then by conventional housing.

• Annual operating costs—feed, pullet and labor costs—were highest in the aviary system, while the other two houses were lower, and similar to each other.
Preliminary Findings: Flock 1

• Capital costs per dozen eggs were higher for aviary and enriched systems than conventional due to the cost of the barns and equipment and the smaller scale of those houses.
Coalition for Sustainable Egg Supply

http://www.sustainableeggcoalition.org