Risk factors for laying hen keel bone damage

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Background

Keel bone damage:
• Recognized as an important concern affecting hens in alternative housing systems[1,2]
• Linked to increased mortality[3], reduced egg production efficiency and egg quality[4,5]
• Likely association with pain[5,7,8]

Previous work:
• Focused on aviary and barn systems
• Evaluated causes of damage indirectly
Research Objectives:

**Objective 1:** Determine which behaviors produce high energy outputs and long point pressure exposure outputs at the keel within enriched colony cage systems.

**Objective 2:** Evaluate the relative occurrence of keel damage types at different flock ages.

**Objective 3:** Determine the roles of collision and perching frequencies, the energy thresholds experienced at the keel, and evidence of previous damage on the development of keel curvature and fracture.
Housing

Rm.1: Cage Type R
Rm.2: Cage Type R
Rm.3: Cage Type S
Rm.4: Cage Type S
Housing

Laying Hen Research Facility, MSU

Rm.1: Cage Type R
Rm.2: Cage Type R
Rm.3: Cage Type S
Rm.4: Cage Type S
Data Collection

Focal hens:
- 10 hens
- 10 hens
- 10 hens

Time rep. 1 (3 week):
- 52-55 wk
- 55-58 wk
- 58-61 wk

Time rep. 2 (3 week):
- 74-77 wk
- 77-80 wk
- 81-84 wk

Rm.4: Cage Type S
Data Collection

*The image shows 1/3 of the cage*
Research Objectives

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Impacts and Behaviors: Accelerometer Data

Peak summed acceleration forces:
- 12-20 G (<20 G)
- 20-39.99 G
- 40-50.99 G
- 60-79.99 G
- 80-99.99 G
- >100 G
Impacts and Behaviors: Behavioral Data

Behavioral categories:

- collision
- grooming
- aggressive interaction
- wing flapping
- mass scattering
- cannot ID (removed from analysis)

*The image shows 1/3 of the cage*
Impacts and Behaviors: Results

14,516 impacts categorized

7,877 impacts matched to video

Legend:
- ≥100 G
- 80-99 G
- 60-79 G
- 40-59 G
- 20-39 G
- >20 G

Legend:
- ≥100 G
- 80-99 G
- 60-79 G
- 40-59 G
- 20-39 G
- >20 G
Impacts and Behaviors: Results

7,877 impacts matched to video

Legend:
- Scattering
- Wing flapping
- Aggressive interaction
- Grooming
- Collision
Impacts and Behaviors: Results

Objects of collision:
(based on 2,920 collisions observed):

Collisions occurred when hens:
• ascended onto perches (30.1%)
• were pushed into an object (26.5%)
• fell into an object (17%)
• moved between perches (11.5)
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### Keel Bone Integrity

<table>
<thead>
<tr>
<th>Score</th>
<th>Fracture</th>
<th>Deviation</th>
<th>Tip Fracture</th>
<th>Tip Bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>none</td>
<td>none</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>one</td>
<td>slight</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>multiple</td>
<td>severe</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Keel Bone Integrity
## Keel Bone Integrity

### Time Replicate 1

**Pre-scan**

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Nr. (%) bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>Fracture</td>
<td>32</td>
</tr>
<tr>
<td>Deviation</td>
<td>8</td>
</tr>
<tr>
<td>Fracture &amp; Deviation</td>
<td>55</td>
</tr>
</tbody>
</table>
## Keel Bone Integrity

### Time Replicate 1
Pre-scan (101 bones)

<table>
<thead>
<tr>
<th>Damage Type</th>
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<tbody>
<tr>
<td>None</td>
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<tr>
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<td>32</td>
</tr>
<tr>
<td>Deviation</td>
<td>8</td>
</tr>
<tr>
<td>Fracture &amp; Deviation</td>
<td>55</td>
</tr>
</tbody>
</table>

### Post-scan (81 bones)
- No change
- Additional fractures
- Additional deviations
- Additional fractures and deviations
# Keel Bone Integrity

## Time Replicate 1

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Nr. bones</th>
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<tbody>
<tr>
<td>None</td>
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<tr>
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<td>32</td>
</tr>
<tr>
<td>Deviation</td>
<td>8</td>
</tr>
<tr>
<td>Fracture &amp; Deviation</td>
<td>55</td>
</tr>
</tbody>
</table>

**Pre-scan (101 bones)**

**Post-scan (81 bones)**

- No change: 0
- Additional fractures: 0
- Additional deviations: 2
- Additional fractures and deviations: 3
# Keel Bone Integrity

## Time Replicate 1

**Pre-scan (101 bones)**

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Nr. bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>Fracture</td>
<td>32</td>
</tr>
<tr>
<td>Deviation</td>
<td>8</td>
</tr>
<tr>
<td>Fracture &amp; Deviation</td>
<td>55</td>
</tr>
</tbody>
</table>

## Post-scan (81 bones)

- 0: No change
- 3: Additional fractures
- 0: Additional deviations
- 2: Additional fractures and deviations
### Keel Bone Integrity

#### Time Replicate 1

**Pre-scan (101 bones)**

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Nr. bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>Fracture</td>
<td>32</td>
</tr>
<tr>
<td>Deviation</td>
<td>8</td>
</tr>
<tr>
<td>Fracture &amp; Deviation</td>
<td>55</td>
</tr>
</tbody>
</table>

**Post-scan (81 bones)**

- **No change**: 0
- **Additional fractures**: 3
- **Additional deviations**: 2
- **Additional fractures and deviations**: 2

Pre-scan (101 bones):

- Total bones: 101
- Fracture: 32 bones
- Deviation: 8 bones
- Fracture & Deviation: 55 bones

Post-scan (81 bones):

- Total bones: 81
- Additional fractures: 3
- Additional deviations: 2
- Additional fractures and deviations: 2
Keel Bone Integrity

<table>
<thead>
<tr>
<th>Time</th>
<th>Replicate 1</th>
<th>Replicate 2</th>
<th>Whole bone</th>
<th>Tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture</td>
<td>Pre-scan</td>
<td>Post-scan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Keel Bone Integrity

Time Replicate 2
Pre-scan (102 bones)

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Nr. bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>Fracture</td>
<td>30</td>
</tr>
<tr>
<td>Deviation</td>
<td>7</td>
</tr>
<tr>
<td>Fracture &amp; Deviation</td>
<td>62</td>
</tr>
</tbody>
</table>

Post-scan (100 bones)

- No change: 0
- Additional fractures: 32
- Additional deviations: 6
- Additional fractures and deviations: 8

Time: Replicate 2
Pre-scan (102 bones): 102 bones
Post-scan (100 bones): 100 bones
Keel Bone Integrity

<table>
<thead>
<tr>
<th>Time replicate 1</th>
<th>Fracture Deviation</th>
<th>Fracture Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-scan</td>
<td>[60, 40]</td>
<td>[80, 20]</td>
</tr>
<tr>
<td>Post-scan</td>
<td>[40, 60]</td>
<td>[20, 80]</td>
</tr>
</tbody>
</table>

Legend:
- **Whole bone**
- **Tip**
Research Objectives

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Impacts, Behavior and Keel Bone Integrity

What cause new damage (fractures and deviations)?

- Number of impacts? ×
- Strength of impacts? ×
- Presence of previous fractures? ×
- Number of collisions? ✓
  - $P=0.06$ (Collisions – new fractures)
  - $P=0.05$ (Collisions – new damage)
Summary and Discussion

• Summed peak accelerations ranged up to >100G
• Collisions accounted for over 80% of impacts >20 G
• Hens collided most often with perches (74% collisions), mainly while ascending onto them (30.5% collisions)
• Descriptive data and statistical trends highlight the perch as a likely risk factor for the development of keel bone damage by hens in enriched colony cage systems.

• Further research needed to understand what aspects of perch provision are associated with risk of keel bone damage (ex. height, design, location…), and role of variable outside the scope of this study (ex. hen strain, housing type…)
Acknowledgements

We wish to thank the 20 UC Davis and MSU undergraduate student who assisted during on-farm and in-lab data collection and analysis, and gratefully acknowledge the Egg Industry Center for funding this project.

Disclaimer: This presentation was prepared at UC Davis through funding provided by the Egg Industry Center. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and not necessarily reflect the views of the funding organizations or Iowa State University.