

The image features three white feathers of varying sizes and orientations scattered across a black and white checkered pattern. The pattern is a classic houndstooth or checkerboard design. The feathers are positioned in the upper left, lower left, and right-center areas of the frame. The text is centered in the lower half of the image.

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**14<sup>th</sup>**  
**EDITION**

# **The effect of stocking density on turkey tom production and welfare**

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# Canadian situation

## Codes of Practice updated in 2016

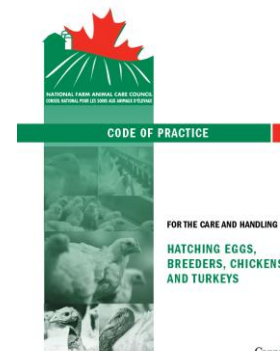
- <https://www.nfacc.ca/codes-of-practice/chickens-turkeys-and-breeders>

## Science informed

- Required practices
- Recommended practices

## Stocking density for turkeys

- Limited information





# Previous studies – Performance

- **Body weight**
  - **Negatively impacted in older birds** (Coleman and Leighton, 1969; Proudfoot et al., 1979; Denbow et al., 1984; Noll et al., 1991; Martrenchar et al., 1999)
- **Feed consumption**
  - **Decreased feed intake with increasing SD** (Denbow et al., 1984; Noll et al., 1991)
- **Feed efficiency**
  - **No effect – densities ranging from 32 to 62 kg/m<sup>2</sup>** (Coleman and Leighton, 1969; Proudfoot et al., 1979)
  - **Negative effects – densities ranging from 19 to 92 kg/m<sup>2</sup>** (Denbow et al., 1984; Noll et al., 1991)



# Previous studies – Performance

- **Uniformity**
  - Not evaluated in turkeys
  - In broilers – greater variability at low SD (Feddes et al., 2002)
- **Mortality**
  - No effect (Coleman and Leighton, 1969)
  - Tendency for higher mortality as SD increases (Noll et al., 1991)
- **Economics**
  - Monetary return increases as SD increases (Proudfoot et al., 1979)



# Previous studies – Health

## Footpad lesions

- Increased incidence with increasing litter moisture (Martland, 1984; Martrenchar et al., 1999)
- Litter moisture increases with increasing SD (Martrenchar et al., 1999)
- May relate to pain and poorer gait scores (Martrenchar et al., 1999; Weber Wyneken et al., 2015)

## Gait score

- High SD may reduce the bird's ability to exercise
- Poorer gait scores associated with increasing SD (Martrenchar et al., 1999)



# Previous studies – Health

## Feather condition

- Poorer feather cover as SD increases (Coleman and Leighton, 1969)
- **May relate to poor feed efficiency as seen in laying hens**  
(Leeson and Morrison, 1978)

## Heterophil/lymphocyte ratio (H/L ratio)

- Indication of chronic stress
- **No effect at SD of 25, 48, and 58 kg/m<sup>2</sup>** (Hafez et al., 2015)
- Increases seen with transportation stress (Huff et al., 2015; Vermette et al., 2017)

# Previous studies – Behaviour

## Few studies have evaluated turkey SD and behaviour

- No effect on aggressive behaviour (Denbow et al., 1984)
- No effect on walking activity, resting, feeding, or drinking (Martrenchar et al., 1999)
- **Increased feather pecking at low SD** (Gunthner and Bessei, 2006)





# Current Recommendations

## SD recommendations for heavy toms

- Certified Humane (2014) – 36.6 kg/m<sup>2</sup>
- Global Animal Partnership (2015) – 48.8 kg/m<sup>2</sup>
- Canadian Codes of Practice\* (2016) – 65 kg/m<sup>2</sup>
- National Turkey Federation (2012) – 73.2 kg/m<sup>2</sup>



# Overall Objectives

- Provide comprehensive data to help determine optimal stocking density for heavy toms
- Determine the effects on:
  - Performance
  - Health
  - Behaviour



# Experimental Design

## SD treatments

- 30 kg/m<sup>2</sup> (122 birds)
- 40 kg/m<sup>2</sup> (161 birds)
- 50 kg/m<sup>2</sup> (189 birds)
- 60 kg/m<sup>2</sup> (236 birds)

Two 16 wk trials – two room replicates per treatment





# Birds and Housing

**1,434 Nicholas Select toms per trial**

- Number/room based on predicted body weight at 16 wk (Aviagen, 2015) + 5% to account for mortality

**Housed in large independently controlled rooms**

- 6.71 m x 10.06 m = 67.50 m<sup>2</sup>
- Feeder and drinker space – per bird basis
- Environmental enrichment – per bird basis
- **Standard temperature curve** (Aviagen, 2015)
- **Lighting program 18L:6D**
  - Started at 10 lux and reduced to 3 lux at 13 wk

# Air Quality

- Used as an indicator of environment – goal is to remove variability due to environment
- Carbon dioxide – 3x weekly
  - Ventilation rates were adjusted when differences greater than 20%
- Ammonia – 2x weekly
  - Ventilation rates were adjusted when differences greater than 5ppm



# Data Collection – Productivity

## Body weight & feed consumption

- 0, 4, 8, 12, and 16 wk
- Feed efficiency calculated

## Body weight uniformity

- Individual body weights  
12 and 16 wk (20 birds/rep)

## Mortality

- Daily
- Necropsy for cause



# Results - Productivity



## RESULTS

Significant differences  $P \leq 0.05$

Trends  $P \leq 0.10$

# Average Body Weight (kg)

| Age (wk) | Est. stocking density (kg/m <sup>2</sup> ) |       |       |       | SEM    | P-value (linear) | P-value (quadratic) |
|----------|--|-------|-------|-------|--------|------------------|---------------------|
|          | 30   | 40    | 50    | 60    |        |                  |                     |
| 0        | 0.06                                       | 0.06  | 0.06  | 0.06  | 0.0004 | 0.2524           | 0.2610              |
| 4        | 1.49                                       | 1.51  | 1.48  | 1.49  | 0.020  | 0.8965           | 0.8823              |
| 8        | 6.12                                       | 6.23  | 6.21  | 6.20  | 0.031  | 0.4379           | 0.3975              |
| 12       | 12.59                                      | 12.65 | 12.61 | 12.40 | 0.036  | 0.0595           | 0.0354              |
| 16       | 18.78                                      | 18.71 | 18.55 | 18.13 | 0.098  | 0.0097           | 0.2940              |



# Average Body Weight Gain (kg)

| Age (wk) | Est. stocking density (kg/m <sup>2</sup> ) |       |       |       | SEM   | P-value (linear) | P-value (quadratic) |
|----------|--|-------|-------|-------|-------|------------------|---------------------|
|          | 30   | 40    | 50    | 60    |       |                  |                     |
| 0-4      | 1.43                                       | 1.45  | 1.42  | 1.43  | 0.020 | 0.8778           | 0.8651              |
| 4-8      | 4.63                                       | 4.72  | 4.72  | 4.71  | 0.016 | 0.0788           | 0.0978              |
| 8-12     | 6.47                                       | 6.42  | 6.40  | 6.20  | 0.056 | 0.0999           | 0.4674              |
| 12-16    | 6.19                                       | 6.06  | 5.94  | 5.73  | 0.070 | 0.0106           | 0.7620              |
| 0-12     | 12.53                                      | 12.59 | 12.55 | 12.34 | 0.036 | 0.0577           | 0.0337              |
| 0-16     | 18.72                                      | 18.65 | 18.49 | 18.07 | 0.098 | 0.0095           | 0.2904              |



# Discussion

## Body weight

- Decreased body weight and body weight gain – 12-16 wk
- Similar to previous studies
  - No effect up to 8 wk and decreased body weight at high SD at 12 and 20 wk (19 to 92 kg/m<sup>2</sup>) (Denbow et al., 1984)
  - No effect at 10 wk and decreased body weight at high SD at 14 wk (36 to 62 kg/m<sup>2</sup>) (Coleman and Leighton, 1969)
  - No effect up to 12 wk and decreased body weight at high SD up to 20 wk (29 vs 61 kg/m<sup>2</sup>) (Noll et al., 1991)

**Factors impacting growth may include stress or reduction in mobility and mobility associated behaviour**

# Average Feed Consumption (kg)

| Age (wk) | Est. stocking density (kg/m <sup>2</sup> ) |       |       |       | SEM   | P-value (linear) | P-value (quadratic) |
|----------|--|-------|-------|-------|-------|------------------|---------------------|
|          | 30   | 40    | 50    | 60    |       |                  |                     |
| 0-4      | 1.86                                       | 1.86  | 1.86  | 1.87  | 0.032 | 0.8999           | 0.9316              |
| 4-8      | 7.25                                       | 7.43  | 7.46  | 7.52  | 0.037 | 0.0062           | 0.3513              |
| 8-12     | 14.79                                      | 14.74 | 14.73 | 14.70 | 0.081 | 0.7148           | 0.9548              |
| 12-16    | 20.34                                      | 19.54 | 19.47 | 19.25 | 0.186 | 0.0420           | 0.4010              |
| 0-12     | 23.91                                      | 24.03 | 24.05 | 24.09 | 0.069 | 0.3594           | 0.7853              |
| 0-16     | 44.24                                      | 43.57 | 43.51 | 43.35 | 0.210 | 0.1478           | 0.1478              |

# Feed-to-Gain Ratio Mortality Corrected

| Age (wk) | Est. stocking density (kg/m <sup>2</sup> ) |      |      |      | SEM   | P-value (linear) | P-value (quadratic) |
|----------|--|------|------|------|-------|------------------|---------------------|
|          | 30   | 40   | 50   | 60   |       |                  |                     |
| 0-4      | 1.29                                       | 1.28 | 1.30 | 1.30 | 0.004 | 0.2131           | 0.3167              |
| 4-8      | 1.55                                       | 1.57 | 1.57 | 1.58 | 0.003 | <b>0.0041</b>    | 0.6312              |
| 8-12     | 2.25                                       | 2.27 | 2.28 | 2.35 | 0.015 | <b>0.0228</b>    | 0.3054              |
| 12-16    | 3.20                                       | 3.21 | 3.27 | 3.35 | 0.027 | <b>0.0308</b>    | 0.5128              |
| 0-12     | 1.88                                       | 1.88 | 1.89 | 1.92 | 0.006 | <b>0.0068</b>    | 0.3190              |
| 0-16     | 2.29                                       | 2.29 | 2.31 | 2.35 | 0.010 | <b>0.0162</b>    | 0.3106              |



# Discussion

## Feed efficiency

- Increased linearly starting as early as wk 4
- Supported by previous studies
  - Poorer feed efficiency at high SD at 8-12 and 12-20 wk (25 to 92 kg/m<sup>2</sup>) (Denbow et al., 1984)
  - Poorer feed efficiency at high SD 16-20 wk (29 vs 61 kg/m<sup>2</sup>) (Noll et al., 1991)
- Other studies showed no effect (Coleman and Leighton, 1969; Proudfoot et al., 1979)

**Poor feed efficiency may be a result of increased stress or poor feather cover**

# Uniformity

**No effect observed in relation to increasing SD**

**Broiler studies found poorer uniformity at low SD** (Feddes et al., 2002)

- Differences may be due to space restrictions and social feeding behaviour increasing the uniformity at high SD

**Lack of differences seen in turkeys may be due to:**

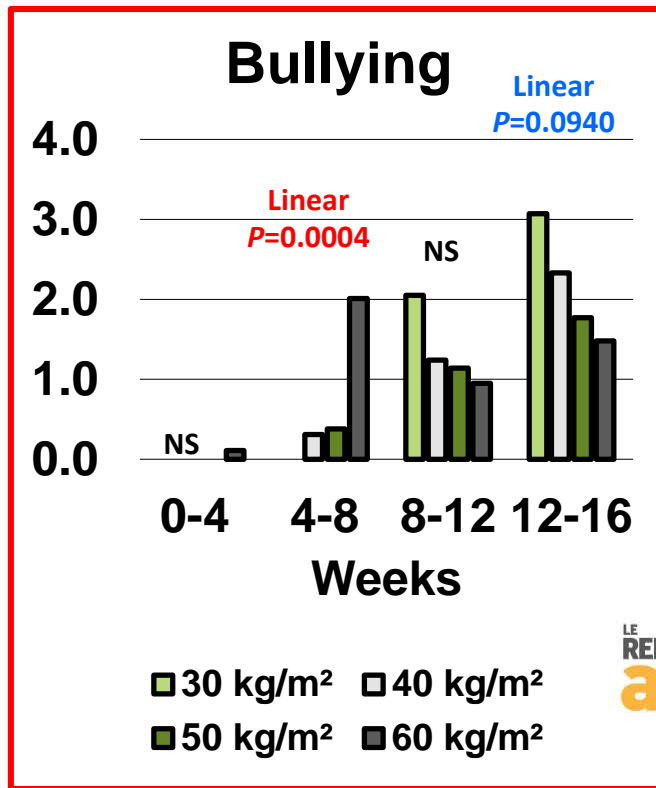
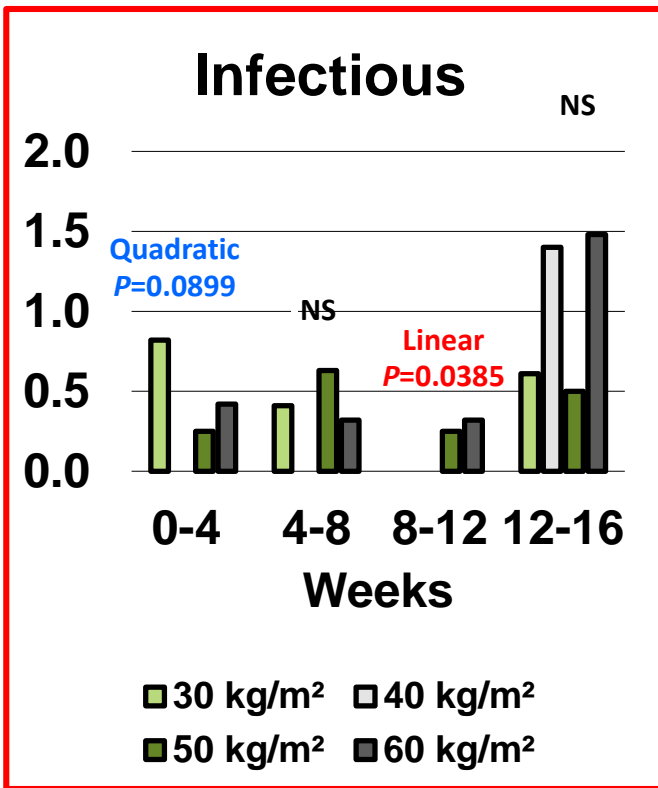
- Species differences
- Sample numbers (20 birds/room)



# Mortality (%)

| Age (wk) | Est. stocking density (kg/m <sup>2</sup> ) |       |       |       | SEM   | P-value (linear) | P-value (quadratic) |
|----------|--|-------|-------|-------|-------|------------------|---------------------|
|          | 30   | 40    | 50    | 60    |       |                  |                     |
| 0-4      | 1.84                                       | 1.40  | 1.26  | 1.59  | 0.316 | 0.7527           | 0.6971              |
| 4-8      | 1.64                                       | 1.40  | 1.64  | 2.97  | 0.301 | 0.0811           | 0.3635              |
| 8-12     | 3.89                                       | 3.73  | 3.16  | 3.28  | 0.400 | 0.6985           | 0.9735              |
| 12-16    | 6.76                                       | 6.21  | 4.17  | 5.51  | 0.515 | 0.2157           | 0.3182              |
| 0-12     | 7.38                                       | 6.52  | 6.06  | 7.84  | 0.648 | 0.6600           | 0.4354              |
| 0-16     | 14.14                                      | 12.73 | 10.23 | 13.35 | 0.852 | 0.5928           | 0.1856              |

# Mortality by Cause (%)







# Discussion

## Mortality

- No effect on overall mortality
- Slight differences in bullying and infectious related mortality
- Previous studies
  - No effect on mortality with a numerical increase noted (36 to 62 kg/m<sup>2</sup>) (Coleman and Leighton, 1969)
  - Tendency for increased mortality at high SD (29 vs 61 kg/m<sup>2</sup>) (Noll et al., 1991)
- Difficult to demonstrate the impact of SD as mortality rates are often low



# HEALTH AND PHYSICAL CONDITION



# Data Collection

## Footpad lesion score

- 10 (trial 2 only), 12, and 16 weeks (20 birds/rep)
- Scale of 0-4 (Hocking et al., 2008)

## Subjective gait score

- 12 and 16 weeks (20 birds/rep)
- Scale of 0-5 (Garner et al., 2002; Vermette et al., 2016)

## Feather condition & cleanliness score

- 10 (trial 2 only), 12, and 16 weeks (20 birds/rep)
- Condition – Scale of 1-4 (Davami et al., 1987; Sarica et al., 2008)
- Cleanliness – Scale of 1-4 (Forkman and Keeling, 2009)

# Data Collection

## Heterophil/lymphocyte ratio

- 4, 12, and 16 weeks (15 birds/rep)

## Incidence of injuries due to aggression

- Recorded daily (trial 2 only)



# Data Collection - Welfare



## RESULTS

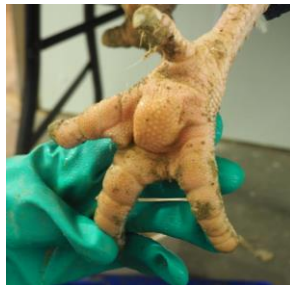
Significant differences  $P \leq 0.05$

Trends  $P \leq 0.10$

# Footpad Lesion Severity

| Age<br>(wk)                                     | Est. stocking density (kg/m <sup>2</sup> ) |      |      |      | SEM   | P-value<br>(REG) | P-value<br>(RSREG) |
|---|--|------|------|------|-------|------------------|--------------------|
|   | 30   | 40   | 50   | 60   |       |                  |                    |
| <i>Average footpad lesion score (scale 0-4)</i> |  |      |      |      |       |                  |                    |
| 10*   | 0.25                                       | 0.55 | 0.75 | 1.03 | 0.124 | <b>0.0062</b>    | 0.9367             |
| 12  | 1.13                                       | 1.26 | 1.59 | 1.66 | 0.176 | 0.2291           | 0.9317             |
| 16  | 1.24                                       | 1.20 | 1.60 | 2.35 | 0.189 | <b>0.0206</b>    | 0.2318             |

\* Week 10 data for Trial 2 only

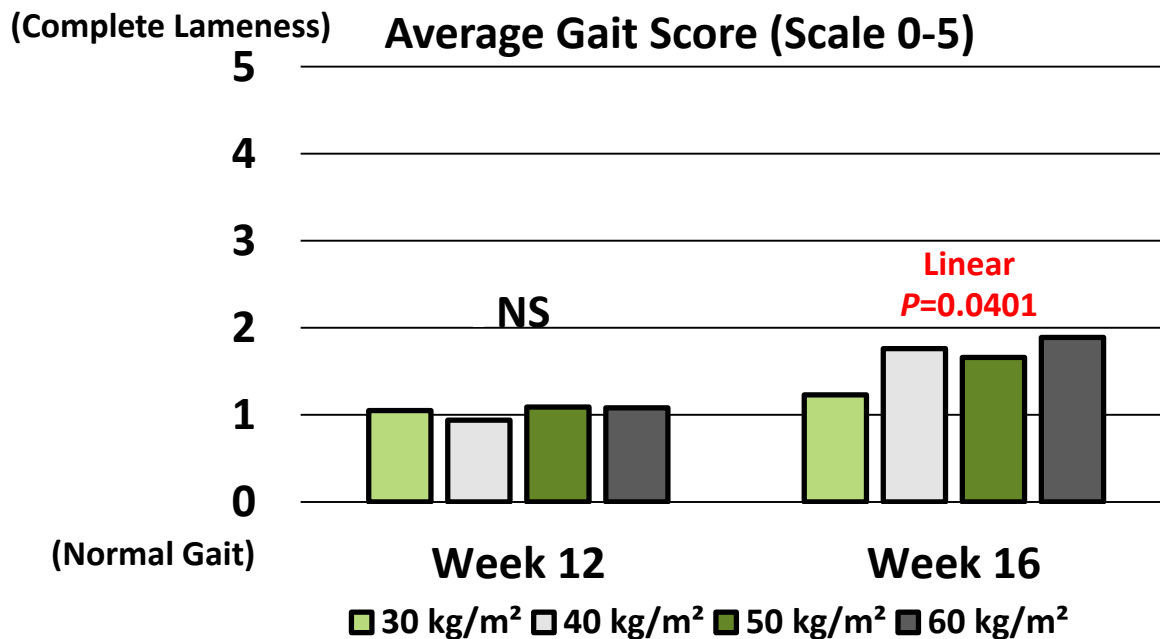


Score 0



Score 4

# Mobility





# Discussion

## Footpad lesion score

- Increase in severity with increasing SD (10 and 16 wk)

## Gait score

- Poorer gait score (16 wk)

## Few studies conducted in turkeys

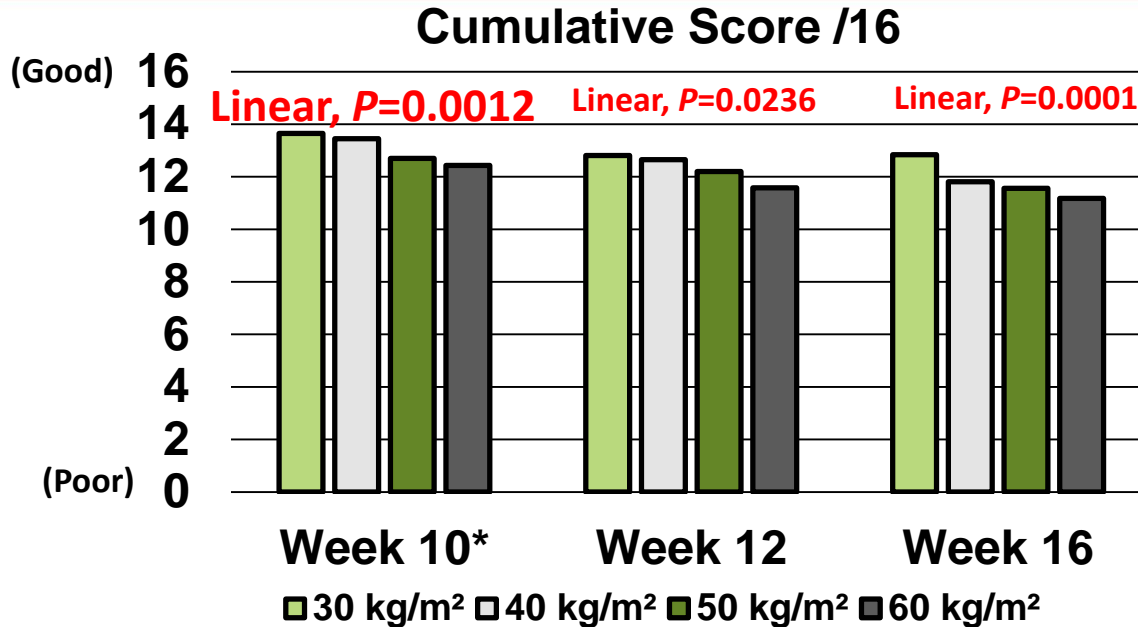
- Increased incidence of footpad lesions and poorer gait score (33 to 52 kg/m<sup>2</sup>) (Martrenchar et al., 1999)

## Higher litter moisture as SD increases (Martrenchar et al., 1999)

## Footpad lesions may be painful (Weber Wyneken et al., 2015)



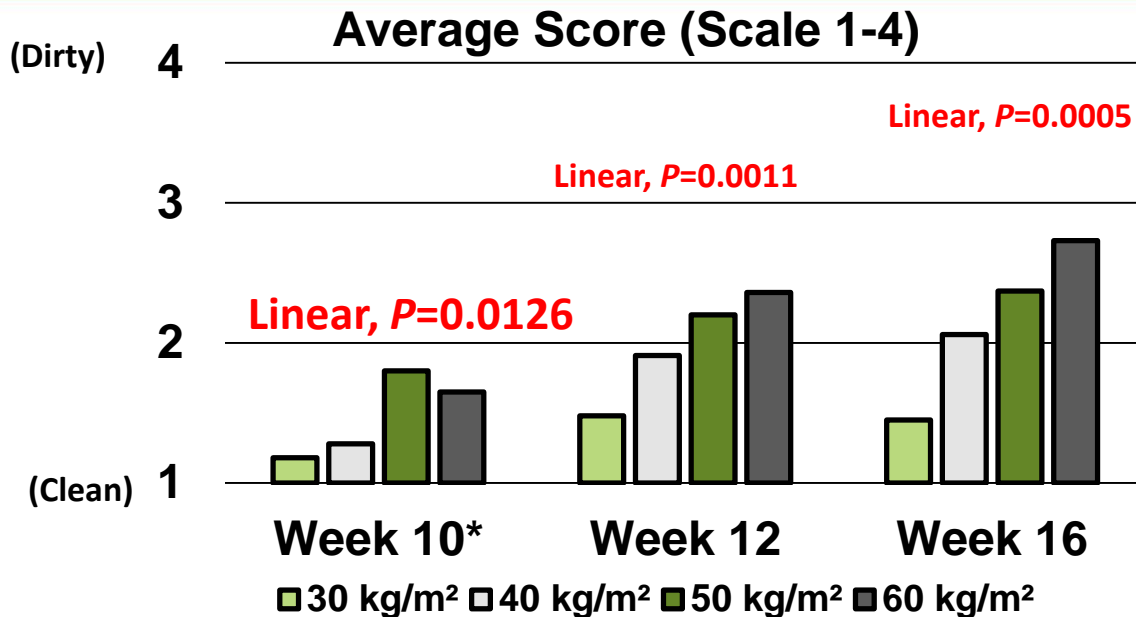
# Feather Condition



4 individual areas scored – back, wings, tail, and breast  
Score 1= no feather cover, Score 4=full intact plumage

\* Week 10 data from Trial 2 only

# Feather Cleanliness



Score 1 = greater than 75% of the feathers free from soiling

Score 4 = less than 25% of the feathers free from soiling

\* Week 10 data from Trial 2 only



# Discussion

## Feather condition

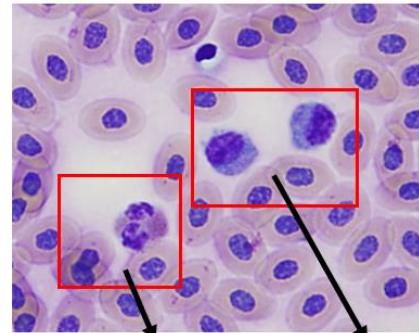
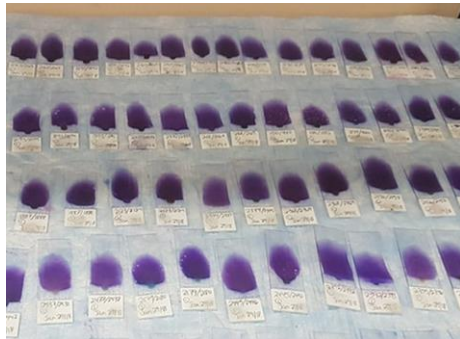
- Decreases linearly with increasing SD (10, 12 and 16 wk)
- Coleman and Leighton (1969) – poorer feather condition with increasing SD (36 to 62 kg/m<sup>2</sup>)
- May relate to poorer feed efficiency as seen in laying hens (Leeson and Morrison, 1978)

## Feather cleanliness

- Not previously evaluated in relation to turkey SD
- Increases linearly (dirtier) with increasing SD (10, 12 and 16 wk)
- Likely as a result of increased excreta output

# Heterophil/Lymphocyte Ratio

| Age (wk) | Est. stocking density (kg/m <sup>2</sup> ) |      |      |      | SEM   | P-value (linear) | P-value (quadratic) |
|----------|--|------|------|------|-------|------------------|---------------------|
|          | 30   | 40   | 50   | 60   |       |                  |                     |
| 4        | 0.65                                       | 0.77 | 0.75 | 0.79 | 0.018 | <b>0.0105</b>    | 0.2361              |
| 12       | 0.93                                       | 0.89 | 1.10 | 1.01 | 0.028 | <b>0.0672</b>    | 0.6489              |
| 16       | 0.86                                       | 0.76 | 0.85 | 0.90 | 0.027 | 0.3974           | 0.1607              |



Heterophil

Lymphocyte

# Aggressive Damage (%)

| Age (wk) | Stocking density (kg/m <sup>2</sup> ) |       |       |       | SEM   | P-value (linear) | P-value (quadratic) |
|----------|---------------------------------------|-------|-------|-------|-------|------------------|---------------------|
|          | 30                                    | 40    | 50    | 60    |       |                  |                     |
| 0-4      | 0.41                                  | 0.31  | 0.25  | 1.48  | 0.223 | 0.1582           | 0.1321              |
| 4-8      | 3.28                                  | 2.48  | 2.27  | 8.90  | 1.085 | 0.1866           | <b>0.0406</b>       |
| 8-12     | 6.15                                  | 5.59  | 4.80  | 6.14  | 0.792 | 0.8537           | 0.6376              |
| 12-16    | 8.20                                  | 7.45  | 6.82  | 7.63  | 0.718 | 0.7218           | 0.5645              |
| 0-16     | 18.03                                 | 15.84 | 14.14 | 24.15 | 1.963 | 0.6033           | 0.1789              |





# Discussion

## Heterophil/lymphocyte ratio

- Increased linearly in young birds (4 wk)
- Tendency for increase seen in older birds (12 wk)
- Increased H/L ratio suggests SD is a stressor, even in young birds
- Previous experiment with SD showed no effect at 7, 12, 16, and 20 wk (Hafez et al., 2015)

## Aggressive damage

- Quadratic response from wk 4-8, highest at 60 kg/m<sup>2</sup>

**Increases in stress may result in higher aggressive behaviours**

# Data Collection - Behaviour

**Week 12, 14, and 16**

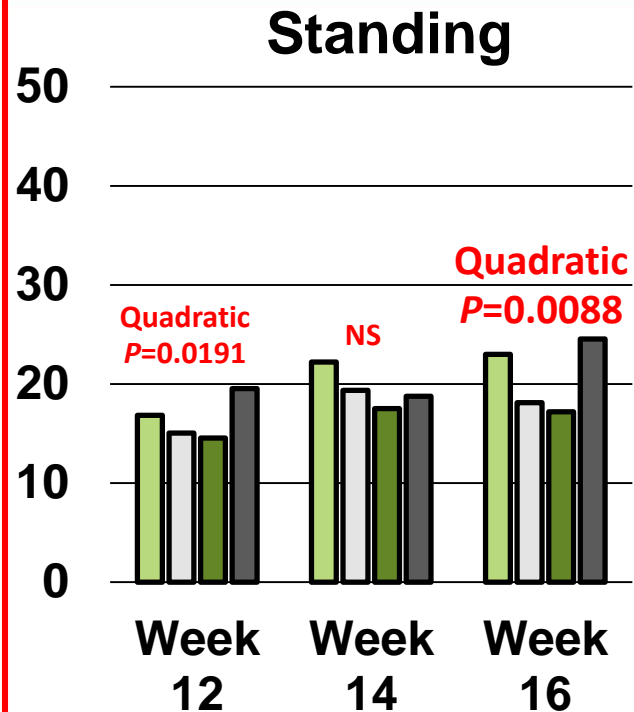
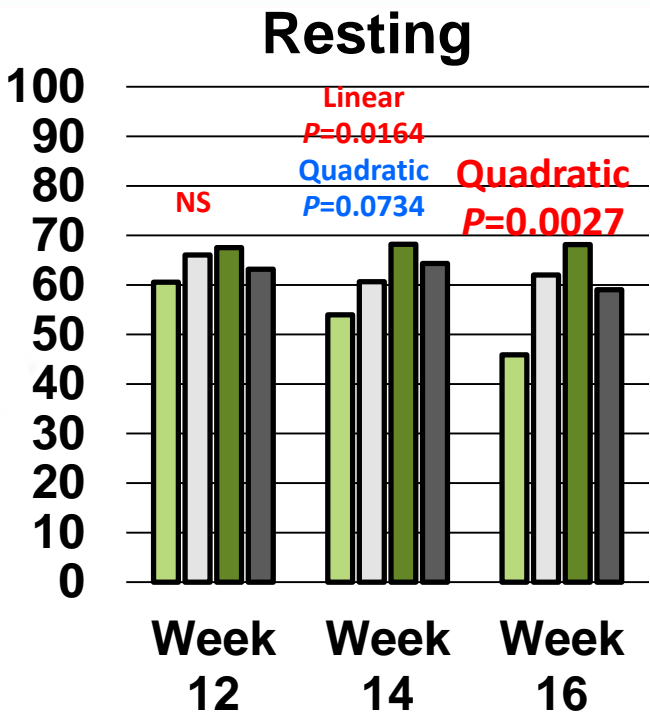
**24 hours recordings infrared video cameras**

**Field of view observations (Torrey et al., 2013)**

**20 minutes interval scan sampling technique**

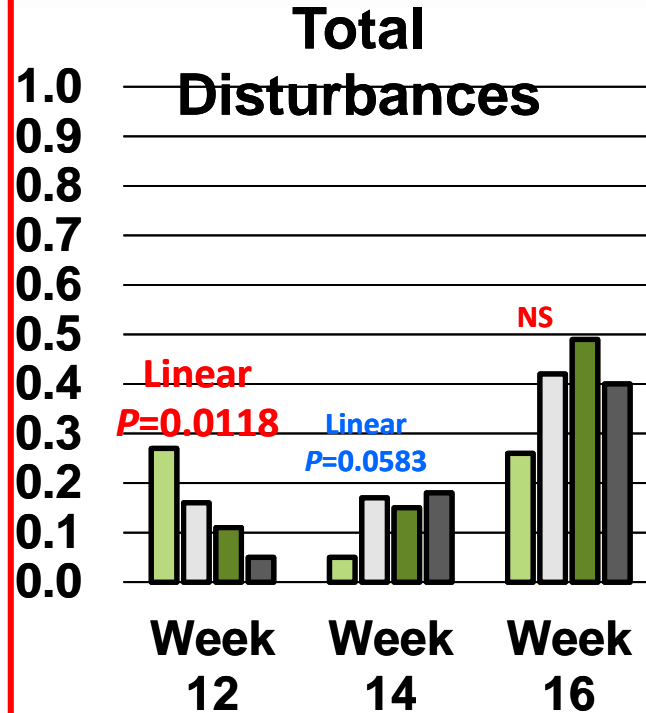
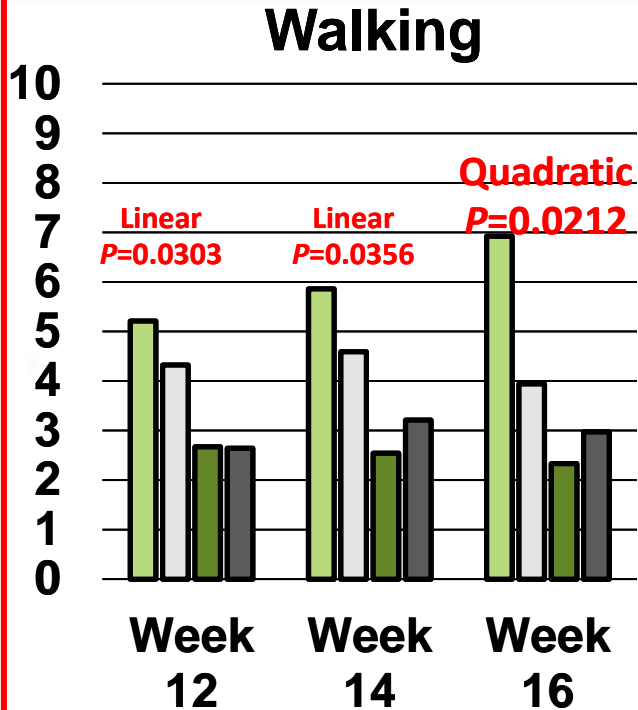


# Behaviour (% within field of view)

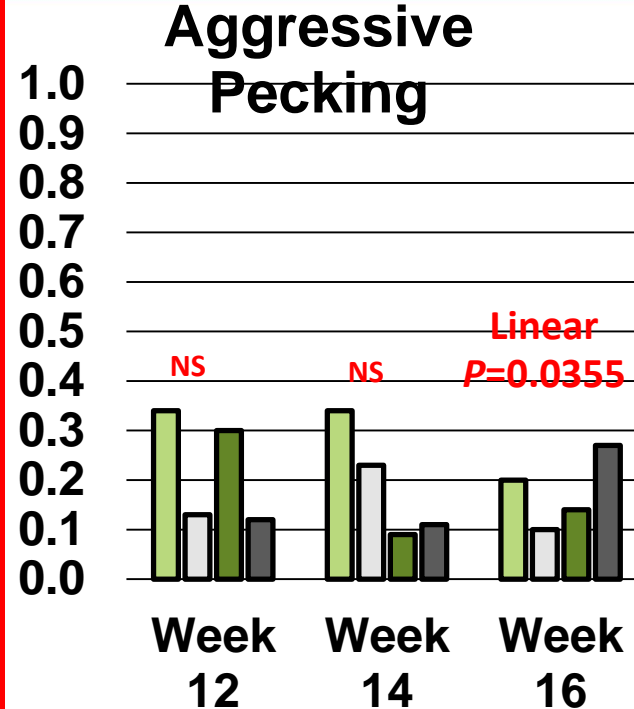
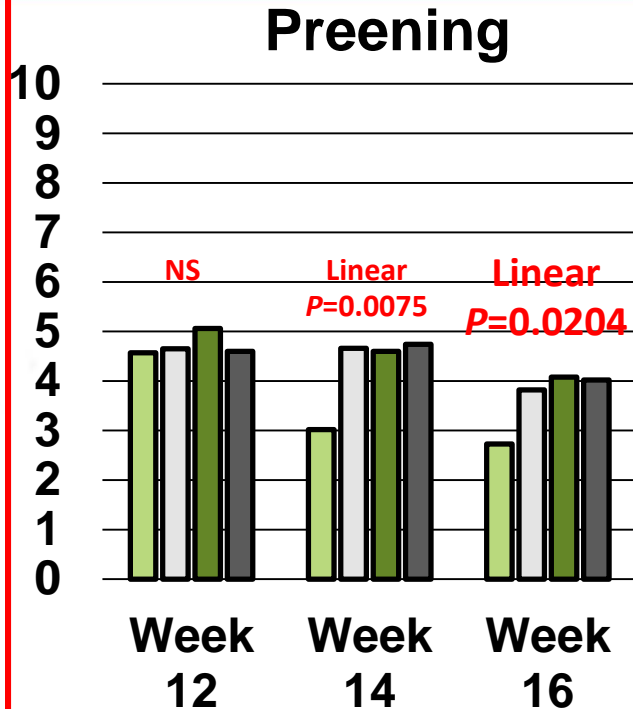




# Behaviour (% within field of view)

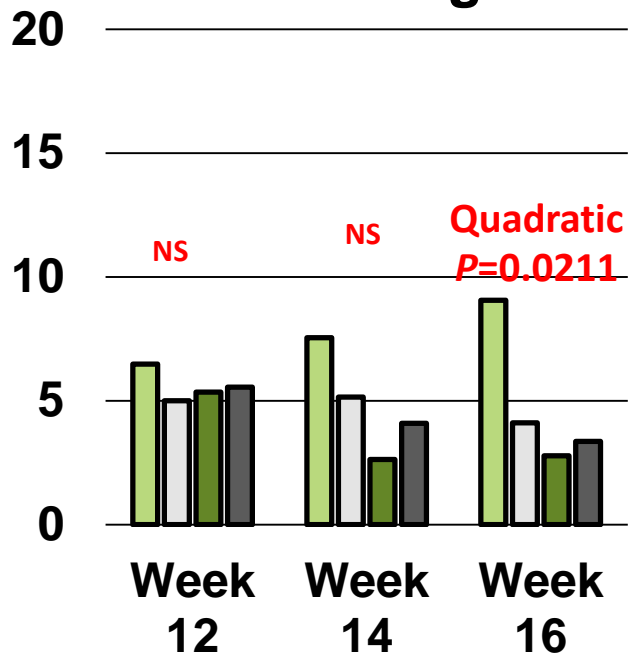


# Behaviour (% within field of view)



# Behaviour (% within field of view)

## Feeding





## Discussion

### **Birds at low SD are more active – more space to perform activity**

- Birds were standing more frequently at low and high SD (30 and 60 kg/m<sup>2</sup>)
- Walking activity decreased as SD increased
- Total disturbances was highest at 12 wk at low SD
- Feeding behaviour was highest at 16 wk at low SD

### **Birds at high SD may be lacking space to lie down comfortably and may have difficulty accessing the feeders**

- Resting behaviour was highest at 50 kg/m<sup>2</sup>

# Performance Summary

| Parameter                 | 0-4 (4 wk) | 4-8 (8 wk)                 | 8-12 (12 wk)                              | 12-16 (16 wk)   |
|---------------------------|------------|----------------------------|---|-----------------|
| Body weight               | NS         | NS                         | Quadratic (60 kg/m <sup>2</sup> lightest) | Linear decrease |
| Feed consumption          | NS         | Linear increase            | NS  | Linear decrease |
| Feed-to-gain <sup>m</sup> | NS         | Linear increase            | Linear increase                           | Linear increase |
| Uniformity                | -          | -                          | NS  | NS              |
| Mortality                 | NS         | Linear increase (bullying) | Linear increase (infectious)              | NS              |

- Increasing SD negatively impacts body weight and feed efficiency
- Uniformity and overall mortality are unaffected by high SD

# Health and Physical Condition Summary

| Parameter                   | 0-4 (4 wk)      | 4-8 (8 wk)                                   | 10 wk           | 8-12 (12 wk)    | 12-16 (16 wk)   |
|-----------------------------|-----------------|--|-----------------|-----------------|-----------------|
| Footpad lesions             | -               | -  | Linear increase | NS              | Linear increase |
| Gait Score                  | -               | -  | -               | NS              | Linear increase |
| Feather Condition           | -               | -  | Linear decrease | Linear decrease | Linear decrease |
| Feather Cleanliness         | -               | -  | Linear decrease | Linear decrease | Linear decrease |
| Heterophil/Lymphocyte Ratio | Linear increase | -  | -               | NS              | NS              |
| Aggressive Damage           | NS              | Quadratic (highest at 60 kg/m <sup>2</sup> ) | -               | NS              | NS              |

# Behaviour Summary and Conclusions

| Behaviour          | 12 wk                                       | 14 wk                   | 16 wk                                       |
|--------------------|---|-------------------------|---|
| Resting            | NS  | Linear increase         | Quadratic<br>(50 kg/m <sup>2</sup> highest) |
| Standing           | Quadratic<br>(60 kg/m <sup>2</sup> highest) | NS                      | Quadratic<br>(60 kg/m <sup>2</sup> highest) |
| Walking            | Linear decrease                             | Linear decrease         | Quadratic<br>(30 kg/m <sup>2</sup> highest) |
| Total Disturbance  | Linear decrease                             | NS<br>(Linear tendency) | NS  |
| Preening           | NS  | Linear increase         | Linear increase                             |
| Aggressive Pecking | NS  | NS                      | Linear<br>(60 kg/m <sup>2</sup> highest)    |
| Feeding            | NS  | NS                      | Quadratic<br>(30 kg/m <sup>2</sup> highest) |



# Overall Conclusions

## High SD negatively impacts:

- Body weight, feed efficiency
- Footpad lesions, mobility, feather condition, and feather cleanliness
- Behaviour – activity and resting

## Low SD may also have negative impacts on bird welfare

- Lower incidence of comfort behaviours, increased disturbances, and increased aggression at certain ages



# Acknowledgements

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# Questions



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