Economical Impact of Subclinical Coccidiosis in Broilers

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Coccidiosis is a Major Disease and Immunity Stressor

Commonly thought as the most expensive disease of poultry production with adverse effects on:

- Growth Rate
- FCR
- Malabsorption
- Mortality
Lesion Scores Monitor Coccidiosis Occurrence

But What Is The Performance Consequence & Calorific Cost?

E. acervulina

E. maxima

E. tenella
Best broiler performance: no gross lesions

+1 Scattered plaque-like lesions containing developing oocysts

+2 Lesions are closer, but not coalescent

+3 Lesions are coalescent, intestinal wall is thickened and contents watery

+4 Colonies completely coalescent
Congestion confined or spread
Mucosa may be bright red in color thickened, and filled with exudate bearing large numbers of oocysts

But what is the performance & Calorific cost??
Experimental Objectives

Objective 1: To extract broilers from varied cocci control backgrounds throughout the growth curve for cocci challenge, lesion scoring & performance + metabolic assessment

( Creates broad performance-lesion score inference space for microscopic and gross lesion response assessment)
Experimental Objectives

**Objective 2:** To quantify lesion score effects on calorific cost.

**Objective 3:** To contrast early vs late lesion scores on performance & diet caloric density cost.
Measuring Calorific Cost
CAPTURING ADDITIONAL ADVANTAGE

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWT (g)</td>
<td>2514</td>
</tr>
<tr>
<td>Days</td>
<td>38.7</td>
</tr>
<tr>
<td>MEn Cons (Kcal)</td>
<td>13676</td>
</tr>
</tbody>
</table>

Heat Loss (Kcal) 7308 (53% of MEn Cons.)
Variable to over 66% or + 1,700 Kcal
≥ 9,000 Kcal Of Wasted Heat Energy
Effective Caloric Value

Places Caloric value on nonnutritive factors

Factors include but not limited to:

Husbandry
(Lighting, Feed Form, Health)

Management
(Drinkers, Stocking Density, Ventilation)

McKinney and Teeter, PS 2004
Effective Caloric Value (ECV)

Relates Bird Performance & Nutrition

ECV System Affords Opportunity To Examine Diet Caloric Density Cost As Equivalents

McKinney and Teeter, PS 2004
Caloric Density Effects On Live Body Weight

Dietary caloric density ME\textsubscript{n} kcal/kg

- Blue triangle: 2700
- Red square: 2833
- Green diamond: 3066
- Orange circle: 3250

Body weight (g) vs. Days of age
Caloric Density Effects On Feed Conversion Ratio

Dietary caloric density $\text{ME}_n$ kcal/kg

Days of age

FCR

21 42 56

2700 2833 3066 3250
Dietary Energy, Body Weight and FCR Interrelationships

23:1 Lighting Program

12:12 Lighting Program

3250 kcal

3100 kcal

150 kcal

McKinney and Teeter, 2004
Behavior Observations
Bird Behavior Differences Resulted In Numerous Birds Gaining Similar Body Weights With A Broad FCR Range

FCR Ranged From 1.63 to 2.11!
EFFECTIVE CALORIC VALUE: EATING VS RESTING

Activity Moves a 3050 Kcal Ration To 3540 or 2560 Kcal / Kg
490 Kcal From Mean!

Activity Regulation Offers Avenue for Competitive Advantage
## Lighting Impact On Bird Heat Production

<table>
<thead>
<tr>
<th>Age (Days)</th>
<th>20</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>(HP Kcal/bird/h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>$8.0^c$</td>
<td>$12.8^a$</td>
</tr>
<tr>
<td>Dark</td>
<td>$2.9^d$</td>
<td>$9.3^b$</td>
</tr>
<tr>
<td>% Change</td>
<td>24</td>
<td>27</td>
</tr>
</tbody>
</table>
Lighting Effects on ECV Relative to 23L:1D

Growth phases:
- Starter
- Grower
- Finisher

Lighting Program Conserved 48% of Potential Activity Swing

Cum. ECV

- 12L:12D
- 1L:1D
- 23L:1D

Significance:
- NS

Effects:
- + 145 Kcal / Kg
- + 242 Kcal / Kg
- - 82 Kcal/kg
Pellet quality effects on diet caloric density and broiler activity

100% Pellets = + 187 Kcal ME\textsubscript{n} ECV / Kg Diet Over Mash
Materials and Methods:

- 936 Cobb males reared to 48 days

- Selected @ 14, 21, 28, 35 & 42 days for metabolic chambers by WB numbers

& Gavaged with (1ml) coccidiosis spore solution

\[ E.\ acervulina \]

\[ E.\ maxima \]

\[ E.\ tenella \]

\[ \text{or sterile water} \]

- Composition measured prior to and after chamber placement via DEXA

  - Protein, Fat, Water, Ash, Energy

- Chambers held 2 to 4 birds per depending upon age

  (300 chamber units)

Industry Based Lighting Program
Materials And Methods

- Post 6 day challenge and chamber housing birds were:
  - Weighed
  - Humanely sacrificed
  - Necropsied for lesion score
    (upper & middle SI, ceca)
    - Johnson and Reid, 1970
  - Metabolic HP quantified for 6 D
  - DEXA Scan
  - Interactive Modeling
Data Modeling

Created polynomial equations for variables using

Bird live or metabolic weights
Visual &/or microscopic lesion scores

Main and interactive combinations of linear, quadratic and cubic components

Forward stepwise regression added factors until

1) adding factors didn’t substantially increase $R^2$
2) factors in the model were significant ($P \leq 0.15$)
Growth Curve Partitioned Into 5 Segments:

- 14-20 days
- 21-27 days
- 28-34 days
- 35-41 days
- 42-48 days

AGE IN DAYS
Lesion Score Effects
Coccidiosis Lesions vs. Performance

- High correlation between each species (E. acerulina, E. maxima and E. tenella) vs. lesion score

- **Inverse Correlation For**
  - Gain (P<0.01)
  - Feed Cons. (P<0.01)
  - Feed Efficiency (P<0.01)

- **Direct Correlation For**
  - Metabolic HP (P<0.01)
  - Malabsorption (P<0.01)
**Predicted Daily ME Cons Using Fixed Lesion Scores (Kcal)**

- **Score 0**
  - @ 800 g: 357 Kcal
  - @ 3000 g: 636 Kcal
  - (-10.1%)

- **Score 1**
  - @ 800 g: 299 Kcal
  - @ 3000 g: 491 Kcal
  - (-22.7%)

- **Score 2**
  - @ 800 g: 265 Kcal
  - @ 3000 g: 445 Kcal
  - (-25.7%)

**Live Bird Mass (g)**

**Pred. ME Cons (Gross Lesions Model)**

**Age:**
- 20d
- 27d
- 30d
- 34d
- 41d
- 48d
Predicted Average Daily Gain Using Fixed Lesion Scores

Age: 20d  27d  30d  34d  41d  48d

<table>
<thead>
<tr>
<th>Score 0</th>
<th>800 g</th>
<th>3000 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score 1</td>
<td>63.9</td>
<td>48.9</td>
</tr>
<tr>
<td>Score 2</td>
<td>42.6</td>
<td>-0.18</td>
</tr>
</tbody>
</table>
Average Daily Gain (ADG) Rule Of Thumb:

For each increase in coccidiosis score, ADG decreases approximately 1.5% of body weight (g)

Score 1  2000g bird x 0.015 = - 30 g ADG
Score 2  2000 g bird x 0.03 = - 60 g ADG
The graph illustrates the predicted feed efficiency using fixed lesion scores. The x-axis represents live bird mass in grams, ranging from 500 to 3000 g. The y-axis shows the predicted feed efficiency (Gross Lesion Model) from 0.00 to 1.00.

The graph includes data points for different lesion scores and their corresponding scores at various ages:

- **Score 0**:
  - Age: 20d - 0.64
  - Age: 27d - 0.64
  - Age: 30d - 0.50
  - Age: 34d - 0.50
  - Age: 41d - 0.50
  - Age: 48d - 0.50

- **Score 1**:
  - Age: 20d - 0.64 (0 %)
  - Age: 27d - 0.64 (0 %)
  - Age: 30d - 0.50 (-21.9 %)
  - Age: 34d - 0.50 (-21.9 %)
  - Age: 41d - 0.06 (- 86.4 %)
  - Age: 48d - 0.06 (- 86.4 %)

- **Score 2**:
  - Age: 20d - 0.50 (-21.9 %)
  - Age: 27d - 0.50 (-21.9 %)
  - Age: 30d - 0.06 (-113 %)
  - Age: 34d - 0.06 (-113 %)
  - Age: 41d - -0.06 (-113 %)
  - Age: 48d - -0.06 (-113 %)

The table summarizes the predicted feed efficiency (Fdeff) at 800 g and 3000 g for different lesion scores and ages.
Feed Efficiency (Gain/Feed)

Rule Of Thumb:

For each increase in coccidiosis score, Fd Eff decreases approximately 0.0084% of body weight (g)

\[
2000 \text{ g bird} \times \frac{0.0084}{100} = -0.168
\]

In FCR terms: 2.0 → 3.02
Predicted ME Consumption =

Maintenance Energy + Accretion Energy

MEI = ME\textsubscript{m} + \frac{1}{k_p} \times \text{RPE} + \frac{1}{k_f} \times \text{RLE}

(McKinney and Teeter, 2005)
Predicted vs. Actual ME consumption
Lesion Score Addition Enables ME Consumption Estimation
OSU Energy Model To Predict Malabsorbed Energy

Energy Added To Excreta =

ME Consumed
- Maintenance Energy
- Accretion Energy

(Brown and Teeter, 2007)
**Added Excreta Energy (Kcal) Using Fixed Lesion Scores**

<table>
<thead>
<tr>
<th>Score</th>
<th>Pred. Exc. Energy @ 800 g</th>
<th>Pred. Exc. Energy @ 3000 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>15.5</td>
<td>30.2</td>
</tr>
<tr>
<td>1</td>
<td>35.5 (+129%)</td>
<td>62.4 (+106%)</td>
</tr>
<tr>
<td>2</td>
<td>46.4 (+199%)</td>
<td>114 (+277%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Live Bird Mass (g)</th>
<th>Pred. Exc. Energy @ 800 g</th>
<th>Pred. Exc. Energy @ 3000 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>20d</td>
<td>20.0 (+5.4%) ME cons</td>
<td>32.2 (+5.0%) ME cons</td>
</tr>
<tr>
<td>27d</td>
<td>30.9 (+8.4%) ME cons</td>
<td>83.8 (+13.2%) ME cons</td>
</tr>
<tr>
<td>30d</td>
<td>40.4 (+11.3%) ME cons</td>
<td>114 (+277%) ME cons</td>
</tr>
<tr>
<td>34d</td>
<td>50.0 (+13.9%) ME cons</td>
<td>144 (+32%) ME cons</td>
</tr>
<tr>
<td>41d</td>
<td>60.9 (+18.1%) ME cons</td>
<td>174 (+41%) ME cons</td>
</tr>
<tr>
<td>48d</td>
<td>71.8 (+22.4%) ME cons</td>
<td>204 (+50%) ME cons</td>
</tr>
</tbody>
</table>

*Intestinal Health*
Predicted Net Energy (%) Using Fixed Lesion Scores

Percent Net Energy (Gross Lesions Model)

Live Bird Mass (g)

Age: 20d  27 d  30d  34d  41d  48d

<table>
<thead>
<tr>
<th>Score</th>
<th>Pred. Net Energy @ 800 g</th>
<th>Pred. Net Energy @ 3000 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.49 Kcal / ME</td>
<td>0.50 Kcal / ME</td>
</tr>
<tr>
<td>1</td>
<td>0.51 (+ 4.1 %)</td>
<td>0.15 (- 70.0 %)</td>
</tr>
<tr>
<td>2</td>
<td>0.425 (- 13.3 %)</td>
<td>0.05 (- 90.2 %)</td>
</tr>
</tbody>
</table>
Dietary Effective Caloric Value Change Using Fixed Lesion Scores

<table>
<thead>
<tr>
<th>Score</th>
<th>Pred. ECV @ 800 g</th>
<th>Pred. ECV @ 3000 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>49 Kcal / ME</td>
<td>10 Kcal / ME</td>
</tr>
<tr>
<td>1</td>
<td>-125 (+ 4.1 %)</td>
<td>-625 (- 70.0 %)</td>
</tr>
<tr>
<td>2</td>
<td>-596 (- 13.3 %)</td>
<td>-2277 (- 90.2 %)</td>
</tr>
</tbody>
</table>

Live Bird Mass (g)

Age: 20d  27d  30d  34d  41d  48d
Summary

- Cocci challenge lesion scores are associated with significant energy and performance costs

- Lesion consequences are markedly elevated during grower-finisher phases versus the starter phase
Conclusion

**EARLY coccidiosis stress = minor negative affect on:**

- Feed Consumption
- Average Daily Gain
- Live Weight Yield
- Feed Conversion
- Maintenance Energy Cost
- Malabsorption
Conclusion Continued

**LATE coccidiosis stress = major negative affect on:**

- Feed Consumption
- Average Daily Gain
- Live Weight Yield
- Feed Conversion
- Maintenance Energy Cost
- Malabsorption
Conclusion Continued

Loss in performance can be explained by:

• Reduced Appetite
• Elevated Maintenance cost
• Increased Malabsorption cost
• Reduced Effective Caloric Value
FINAL CONCLUSION

When coccidiosis challenge occurs during the final 2 weeks of the growth cycle, minor lesions (+ 0.5 to +2) can significantly reduce flock profitability.