Fighting Foodborne Illness.

Salmonella: An Academic Perspective

USDA Agricultural Outlook Forum 2012
Crystal Gateway Marriott
Washington, DC, 23-24FEB2012
Outline of Presentation

• How *Salmonella* challenges our paradigms
  – Live animal to carcass contamination
  – A spectrum from commensal to pathogen

• Pre-harvest approaches to *Salmonella* control
  – Prevalence, incidence, and duration of infection

• How should we define risk?
  – Different definitions drive different actions

• From the perspective of beef production
Salmonella as a Food-borne Pathogen

• The sky is not falling
  – The US enjoys a very safe food supply but all agree that there is room for improvement

• Salmonella continues to cause significant morbidity in the US as well as globally
  – US incidence ~17 reported cases/100,000/yr
    • CDC ‘counted’ cases
  – With under reporting/diagnosis, incidence estimated to be closer to 1 case/300 person-yr
    • Scallan et al. Emerg Infect Dis. 2011 17:7-15

• Clearly we have room for improvement
  – Particular with Salmonella
E. coli O157: FoodNet

- CDC FoodNet Estimate
- 2010 HP Objective
- 2020 HP Objective

- 50% decline from baseline years
Salmonella: FoodNet

Incidence of Salmonella

- CDC FoodNet Estimate
- 2010 HP Objective
- 2020 HP Objective

Graph showing the incidence of Salmonella over the years from 1996 to 2011, with a line graph indicating the CDC FoodNet Estimate, 2010 HP Objective, and 2020 HP Objective.
E. coli O157: USDA/FSIS

• >90% decline from 2001
Salmonella: USDA/FSIS

- No observable change from baseline years
  - 2.2% of 9,256 GB samples positive for *Salmonella*
  - Montevideo #1 serotype

![Graph showing annual percentage of Salmonella positives from 1998 to 2010. The graph indicates a slight increase in positive samples from 2003 to 2007, followed by a decrease.]
Challenging our Paradigms

- Why observe meaningful improvements in one pathogen yet not in another?
  - *Salmonella* is similarly susceptible to interventions
    - Many studies validate interventions against *Salmonella*
    - Improbable that it tolerates HACCP plans

- *Salmonella* may be evading our system by hiding out in the lymph nodes
  - Harhay, Loneragan, Edrington, Brashears, Gragg
FIGURE 34–1. Superficial lymph flow of the cow.

1, Mandibular ln.; 2, parotid ln.; 3, lateral retropharyngeal ln.; 4, superficial cervical ln.; 5, subiliac ln.; 5', ln. of paralumbar fossa; 6, gluteal ln.; 7, popliteal ln.; 8, tuberal ln. (After Baum, 1912.)
Salmonella in Lymph Nodes
Challenging our Paradigms

- Collected lymph nodes from 8 plants
- 3,327 lymph nodes assayed to date
  - 8.0% positive
Salmonella in Lymph Nodes
Challenging our Paradigms

<table>
<thead>
<tr>
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### Salmonella in Lymph Nodes
Challenging our Paradigms

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Number 1 and 2 in ground beef but rarely, if ever, cause outbreaks.
How Does *Salmonella* get to the Nodes?

- Traditional paradigm is from intestines
- We have observed diversity of serotypes between feces and hides of cattle
  - Some serotypes (e.g., Montevideo) much more likely to be recovered from hides than feces
- It is possible (even probable) that some *Salmonella* gets to the nodes transdermally
  - Biting flies in the summer and fall
  - Montevideo has gene(s) that facilitate survival within insects
The Challenge

- We should reassess our paradigm of how beef might become contaminated with *Salmonella*
  - Focus has been on preventing hide to carcass
    - Prevent and remove contamination
    - Inspection and PR/HACCP

- *Salmonella*-positive beef samples might not always result from failure of sanitary slaughter
  - Sanitary conditions may result in *Salmonella*

- A consideration of how we approach control
Salmonella – Commensal or Pathogen

Challenging our Paradigms

• ‘A Rose by Any Other Other Name’ – re-quoted from Dayna Harhay (and Shakespeare)

• Some Salmonella variants are potent pathogens
  – S. Newport, Typhimurium, Enteritidis, Heidelberg
  – Some in both animals and people

• Salmonella prevalence increases in a southerly gradient (in the northern hemisphere)
  – Most of the increase is not in these serotypes
    • Cerro, Reading, Anatum, Montevideo, Mbandaka
  – ‘The most common consequence of infection [in animals] is continued good health’ - Hancock
    • May well be part of good health in southern climates
North to South

- **Region**
  - Canada 1.0% 21 feedlots (*FPD* 2010;7:449)
  - TX 30.0% 37 sites (*AEM* 2008;74:345)

- 27% of ~5,100 dairy fecal samples

- Texas Tech 2011 4-feedlot study
  - 60.5% of summer/fall samples positive
    - 30.6, 37.5, 78.8, and 97.0% for the feedlots

- Mexico
  - >80% of fecal samples typically positive
How Might We Approach Control?

• Traditional approach in the plant continues to serve us well
  – Many plans excelling at microbial process control
    • Tremendous improvements in *E. coli* O157

• *Salmonella* might evade systems
  – As sanitary slaughter processes improves, remaining failures not a consequence of sanitary slaughter issues

• Opportunities for control during harvest
  – Selective lymph node removal?

• It might be that effective control requires an evaluation of upstream or downstream options
How Might We Approach Control?

- *Prevalence = incidence * duration of infection*
  
  Decrease incidence &/or DOI will decrease prevalence
Salmonella Vaccine

Association with prevalence ($P=0.05$)

Prevalence, %

<table>
<thead>
<tr>
<th>SRP Vaccine used</th>
<th>No SRP vaccine</th>
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<tr>
<td>8.0</td>
<td>36.8</td>
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Funded by the Beef Checkoff
Salmonella Vaccine

28.3 versus 16.6%; \( P < 0.05 \)
How Might We Approach Control?

• Encouraging early signs that some interventions may decrease prevalence of *Salmonella* in herds of cattle
  – More work is clearly needed
Need for a Discussion of *What is Risk?*

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<th>Operational Reality of Today</th>
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<td>1. All <em>Salmonella</em> pose a risk</td>
<td>• Effectively the approach now when USDA/FSIS performs its microbiological performance testing of establishment</td>
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<td></td>
<td>• Treats <em>Salmonella</em> as equal</td>
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<td>• Some are pathogenic &amp; some apathogenic</td>
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<tr>
<td>2. A subset of serotypes pose a risk (e.g., CSPI’s petition: Newport, Hadar, Typhimurium, &amp; Heidelberg)</td>
<td>• At present, no means to identify these with specificity (i.e., exclude others) at the speed needed for commerce</td>
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<td>3. Other subsets pose a risk (e.g., highly drug resistant – ACSSuT, or MDR-AmpC – Newport, Typhimurium, Reading, Agona, Anatum, Montevideo, etc.)</td>
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<td>• Captures apathogenic variants</td>
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<td>• Excludes broadly susceptible pathogens such as some Newport and Enteritidis</td>
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  – The US enjoys a very safe food supply but all agree that there is room for improvement

• How do we capture that improvement?

• When it comes to Salmonella
  – We need to work outside of our paradigms
    • Hide to carcass
    • Salmonella can be both commensal and a pathogen

• Opportunities for control
  – Harvest plant (maybe?)
  – Upstream and downstream of harvest plant
    • Approaches that reduce incidence or DOI
• USDA Ag Outlook Forum organizers (USDA/FSIS)
• Colleagues and funding
  – Dayna Harhay, Sara Gragg, Tom Edrington, Mindy Brashears, and Kendra Nightingale
  – Beef Checkoff Program
  – USDA/NIFA/NIFSI
    • Contract # 2011-51110-31081
    • Texas Tech & USDA/ARS

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