Mixed Species and Crops Considerations

Pastured Poultry Workshop
October 27, 2015

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Background

- Extension Specialist for Urban Agriculture & Food Safety, UC ANR CE, UC Davis School of Veterinary Medicine
- Veterinary Epidemiologist, research in Food Safety and Epidemiology of Infectious Diseases, CADMS, UC Davis School of Veterinary Medicine; College of Veterinary Medicine, Michigan State University
- Food Animal Clinician (small to large scale farms) and Lecturer, School of Veterinary Medicine, UC Davis & Portugal
Mixed Crop-Livestock Systems

- Mixed/integrated crop-livestock systems are farms where animals and crops are raised with the goal of utilizing the products of one for the growth of the other (Hilimire, 2011)

Adapted from www.ars.usda.gov
Adapted from UC Berkley News
Mixed Crop-Livestock Systems

Specialized systems

Integrated systems

Courtesy of Monique Gunther

Adapted from wikipedia
Mixed Crop-Livestock Systems

Spatially Separated

Rotational

Fully Combined

Adapted from reuters.com
Mixed Crop-Livestock Systems Benefits

- Fertilize the soil with on-farm input, livestock manure
- Encourage and allow growers to maintain semi-permanent pasture fields, which can improve soil quality
- Increase crop yield
- Enhance on-farm bio-diversity and related ecosystem services: pollination, weed/pest management
- Enhance economic gain to growers
- Confer social benefits to growers and communities (Hilimire, 2011)
Mixed Crop-Livestock Systems

Challenges

• Confronting a loss of animal husbandry knowledge*
  • Animal Health
  • Cross-species Transmission & Cross-contamination
    • Parasites
    • Enteric/Foodborne Pathogens
  • Regulations designed for specialized agro-ecosystems*
    • Food Safety

• Erosion of animal genetic diversity*
  • Heirloom species

• Limited meat processing infrastructure for small-scale production* (*Hilimire, 2011)
Mixed Crop-Livestock Systems Challenges

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Mixed Crop-Livestock Systems
Foodborne Pathogens

• CDC estimates that each year roughly 1 in 6 Americans (or 48 million people) gets sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases (www.cdc.gov)

• *Salmonella*, *E. coli* O157:H7 and *Campylobacter* are major causes of foodborne diseases in the United States

• Livestock species
CDC estimates that each year roughly 1 in 6 Americans (or 48 million people) gets sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases (www.cdc.gov). Salmonella, E. coli O157:H7 and Campylobacter are major causes of foodborne diseases in the United States. The top 5 enteric pathogens are: Norovirus (58%), Salmonella (11%), Clostridium perfringens (10%), Campylobacter spp (9%).

**Foods Linked to Outbreak-Associated Illnesses, 1998 - 2008**

- Other: 37%
- Vine-Stalk Vegetables: 10%
- Fruits and Nuts: 11%
- Poultry: 17%
- Leafy Vegetables: 13%
- Beef: 12%

Food Categories and Number of Illnesses:
- Poultry: 11,302
- Leafy Vegetables: 8,836
- Beef: 8,033
- Fruits and Nuts: 7,590
- Vine-Stalk Vegetables: 6,963
- Other: 25,028

Impact of Outbreaks Traced to Contaminated Foods

These snapshots show how many outbreaks, and outbreak-associated illnesses, hospitalizations, and deaths occurred in the United States during 1998-2008.

- **Outbreaks**
  - Leafy vegetables and norovirus
  - Poultry and Salmonella
  - Fish and ciguatoxin
  - Fish and histamine fish poisoning

- **Outbreak-Associated Hospitalizations**
  - Leafy vegetables and Shiga toxin-producing E. coli
  - Beef and Shiga toxin-producing E. coli
  - Vine-stalk vegetables and Salmonella
  - Fruits and nuts and Salmonella

- **Outbreak-Associated Illnesses**
  - Beef and *Clostridium perfringens*
  - Vine-stalk vegetables and Salmonella
  - Poultry and *Clostridium perfringens*
  - Leafy vegetables and norovirus

- **Outbreak-Associated Deaths**
  - Leafy vegetables and Shiga toxin-producing E. coli
  - Fruits and nuts and Salmonella
  - Poultry and *Listeria*

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Foodborne Pathogens

- Few outbreaks linked to small-farms & farmers markets
  - Oregon Strawberry Outbreak (E. coli O157:H7, 2011)
  - Guacamole-based products, Iowa (Salmonella Newport, 2010)
Mixed Crop-Livestock Systems
Foodborne Pathogens

• Few outbreaks linked to small-farms & farmers markets
  • Oregon Strawberry Outbreak (*E. coli* O157:H7, 2011)
  • Guacamole-based products, Iowa (*Salmonella* Newport, 2010)

Low Risk ??
Underreporting ????
Mixed Crop-Livestock Systems
Foodborne Pathogens

- **Salmonella**
  - Can be found in the gastro-intestinal tract of a wide variety of domestic animals and wild (>2,500 serovars)
  - Colonizes poultry, cattle, small ruminants and swine
  - High infectious dose
  - Leading cause of foodborne bacterial illness
  - Poultry and poultry products

Adapted from WebMD
Mixed Crop-Livestock Systems
Foodborne Pathogens

- **Campylobacter**
  - Can be found in the gastro-intestinal tract of a wide variety of domestic animals and wild
  - Colonizes poultry as commensal
  
- 2\textsuperscript{nd} cause of foodborne bacterial illness
- Low infectious dose (~ 500 bacteria may cause human disease)

- Outbreaks associated with raw milk
- Poultry and poultry products
- High susceptible to stress
• **E. coli O157: H7**
  - *E. coli* is a normal inhabitant of the intestine of all animals
  
  • Shiga-toxin-producing *E. coli* (STEC)- *E. coli* O157:H7 <50 total organisms may cause human disease
  - Cattle, Goats, Sheep, Swine (Cattle is the main reservoir)
  - Outbreaks associated with raw ground beef, spinach, lettuce, cheese curds, alfalfa sprouts
  
  • *E. coli* O157:H7 rarely reported in poultry
Crop-Contamination

Introduction of Foodborne pathogens in produce crops (vegetables & fruits)
Crop-Contamination

Introduction of Foodborne pathogens in produce crops (vegetables & fruits)
### Mixed Crop-Livestock Systems

**Foodborne Pathogens & Pasture Poultry**

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Poultry type</th>
<th>Organic/pasture (%)</th>
<th>Conventional (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Campylobacter</em></td>
<td>Broiler</td>
<td>30</td>
<td>32 to 68</td>
<td>Hanning et al., 2010; McCrea et al., 2006</td>
</tr>
<tr>
<td></td>
<td>Laying hen</td>
<td>25.8</td>
<td>7.6</td>
<td>Salaheen et al., unpublished data</td>
</tr>
<tr>
<td><em>Salmonella</em></td>
<td>Broiler</td>
<td>5.6</td>
<td>38.8</td>
<td>Alali et al., 2010</td>
</tr>
<tr>
<td></td>
<td>Laying hen</td>
<td>20.2</td>
<td>13.9</td>
<td>Almario et al., unpublished data</td>
</tr>
</tbody>
</table>

- *Salmonella* prevalence on farm is lower in organic (5% vs 38.8% in conventional) (Alali et al, 2010)

- *Salmonella* prevalence is higher on organic poultry carcass (Melendez et al, 2010)

- They are the same—prevalence is a function of producer not rearing type (Hardy et al, 2013)
Mixed Crop-Livestock Systems
Foodborne Pathogens & Pasture Poultry

- *Salmonella* in the processing environment of small-scale farm pastured broiler farms (Timble et al, 2013)
Mixed Crop-Livestock Systems
Foodborne Pathogens & Pasture Poultry

- *Campylobacter* in the processing environment of small-scale farm pastured broiler farms *(Timble et al, 2013)*
Mixed Crop-Livestock Systems
Foodborne Pathogens & Pasture Poultry

**Soil**

- Enteric Pathogens can persist for long periods in the soil:
  - *Salmonella* can persist in the litter applied to fields almost **4 months**
  - *Campylobacter* can persist for about **25 days**

- Factors affecting the survival in the soil (& compost): livestock species, pathogen, manure type, composition (e.g., humidity, dry matter), soil type, environmental conditions (e.g. season, ambient temperature, rainfall, sunlight, etc.)
Mixed Crop-Livestock Systems
Foodborne Pathogens & Pasture Poultry

**Composting**

- Heat treatment of poultry litter before land application
- Heat inactivation of pathogens at composting temperature (≈ 140°F)
- Factors affecting the survival: C:N ratio (organic source), temperature, humidity, O2, bedding (straw, rice hulls, wood shavings, etc.), turning, time

- Efficacy of composting litter on small-scale farms
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Food Safety Risks

• Because poultry may carry foodborne pathogens, such as *E. coli*, *Salmonella*, or *Campylobacter* in their gastrointestinal tract

• There is an increased risk of pathogen spread via food products (e.g., vegetables, fruits and nuts) when manure is applied to crop fields
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Food Safety Risks

- **Rotational Grazing or Pasture?**
- Integration of sustainable practices such as the use of grazing animals in fields destined for vegetable cultivation may introduce additional food safety risks ??
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Food Safety Risks

• Regulations to prevent crop microbial contamination of crops are based on time-interval criteria between the application of animal-based soil amendments (manure & compost) and time of crop harvesting.

• The National Organic Program (NOP) regulations, which require that untreated animal manure be applied at least 120 days or 90 days prior to the harvest of crops, depending on whether the edible portions come into direct or indirect contact with the treated soil.
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Food Safety Risks - FSMA

- FDA, Food Safety Modernization Act (FSMA)
- Prevention:
  - Preventive Controls for Food Facilities
  - Produce Safety Standards
  - Authority to prevent Intentional Contamination
- Inspection and Compliance
- Response
- Imports
- The final Produce Rule of the Food Safety Modernization Act (FSMA), expected final release in 2015
Mixed Crop-Livestock Systems
Food Safety Risks - FSMA

2. Manure strategy to be further studied

- The FDA is removing the nine-month proposed minimum-time interval between the application of untreated biological soil amendments of animal origin (including raw manure) and crop harvesting. The agency is deferring its decision on an appropriate time interval until it pursues certain actions. These include conducting a risk assessment and extensive research to strengthen scientific support for any future proposal, working with the U.S. Department of Agriculture and other stakeholders.

- At this time, the FDA does not intend to take exception to farmers complying with the USDA’s National Organic Program standards, which call for a 120-day interval between the application of raw manure for crops in contact with the soil and 90 days for crops not in contact with the soil.
Mixed Crop-Livestock Systems Food Safety Risks - FSMA

- The FDA’s proposed Produce Safety Rule states: “If animals are allowed to graze or are used as working animals in fields where covered produce is grown and under the circumstances there is a reasonable probability that grazing or working animals will contaminate covered produce, require, at a minimum, an adequate waiting period between grazing and harvesting for covered produce in any growing area that was grazed, and measures to prevent the introduction of known or reasonably foreseeable hazards into or onto covered produce (proposed § 112.82)”
Food Safety Risks - Rotational Grazing

Preliminary data:

Average generic *E. coli* MPN(mL)
Days Post Sheep
All Fields

Field A: Cultivated & Planted
Field B: Buried Drip/Planted
Field C: Buried Drip/Planted
Field A: Switched to Dripline & Buried Drip
Field B: Buried Drip/Planted
Food Safety Risks - Rotational Grazing

Preliminary data:

Average generic *E. coli* below MPN 1,000 (mL)
Prevention of Crop Contamination

- Good Agricultural Practices
- Good Husbandry Practices

- Water (source)
- Irrigation
- Animals/Manure (livestock & poultry)
- Compost (incomplete)
- Humans
- Insects & Pests
- Wild Animals (Deer, Feral Pigs, Reptiles, Birds, Rodents)

Introduction of Foodborne pathogens in crops (vegetables & fruits)
Mixed Crop-Livestock Systems
Mixed livestock species

Grazing turnips in the fall provides sheep and goats with “clean” grazing and excellent nutrition during breeding season. Photo: Linda Coffey, NCAT

Adapted from Pastured Poultry Nutrition and Forages, IP453, 2013 www.attra.ncat.org
Mixed Crop-Livestock Systems
Grazing behaviors

Dietary Preferences for different livestock species

Cows prefer grass; sheep prefer forbs; goats prefer trees and shrubs. Nevertheless, there is regular crossover among the three types of feeders.

<table>
<thead>
<tr>
<th>Species</th>
<th>Grass (%)</th>
<th>Weeds (%)</th>
<th>Browse (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horse</td>
<td>90</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Cattle</td>
<td>70</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Sheep</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Goats</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
</tbody>
</table>

Source: Multi-species Grazing can improve utilization of pastures.

Grazing buffer zones, lanes between tree rows, and riparian edges can help maintain the landscape while making these areas productive parts of the farm. Photo: Joan Burke, USDA, ARS.
Parasites

- Nematodes (Roundworms):
  - Abomasum:
    - Haemonchus spp (sheep, goats, cattle)
    - Ostertagia spp (cattle)
    - Trichostrongylus (ruminants, horses)
  - Small Intestine
    - Trichostrongylus
    - Cooperia
  - Lung
    - Dictyocaulus spp
- Protozoa (coccidia)
- Trematodes (flukes)
- Cestodes (tapeworms)
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Parasites of Ruminants

Parasites

Prevention:

• Pasture Rotation
• Animal Management
• Multi-species grazing
• Rotation between different anthelmintic
• Herd dogs (parasites)
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Parasites of Poultry

Parasites

Coccidea
- Host and site specific (GI)
- Occurs under conditions of warmth and humidity (e.g., wet litter)
- One sporulated oocyst can produce 100,000 offspring!
- Oocyst very resistant (can survive 18 months in the environment)
Thank you for your attention!

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Mixed Crop-Livestock Systems
Foodborne Pathogens & Pasture Poultry

**Composting**

- *Enclosed or within-vessel composting:*
  - Active compost must maintain a minimum of 131 F for 3 days

- *Windrow composting*
  - Active compost must maintain aerobic conditions for a minimum of 131F or higher for 15 days or longer, with a minimal of 5 turnings during this period

- *Aerated static pile composting*
  - Active compost must be covered with at least 12 inches of insulating materials and maintain a minimum of 137F for 3 days

- **Enteric pathogen criteria (LGMA)**
  - Fecal coliforms <1000 MPN/gram
  - Salmonella negative / <1/30gram
  - E. coli O157:H7 negative / <1/30gram