Economics of Animal Welfare

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Historical Perspective of Animal Welfare

• “The Jungle” – Upton Sinclair (1906)
  – Novel describing the hardship encountered by immigrants arriving in industrialized cities (e.g. Chicago) and working in the meatpacking stockyards
  – Descriptions of poor work conditions and hygiene promoted changes in the food industry (“Pure Food and Drug Act” and “Meat Inspection Act”)

• “Animal Machines” – Ruth Harrison (1965)
  – Report of animal conditions during a period of increasing scale and mechanization of food producing systems (e.g. veal calves, battery cages)
  – British government commissioned Roger Brambell (1965) to investigate welfare of intensively farmed animals
Five Freedoms
(UK’s Farm Animal Welfare Council, 1979)

Five Domains of Potential Welfare Compromise

The Struggle of Animal Welfare

Public Perception
A growing number of people are calling for more "humane practices" in the treatment of animals. These individuals are generally of nonfarm background (Albright, 1983)

Profitability
Farmers perceive animal welfare standards as:
- Means of achieving economic results
- Means of satisfying moral and ethical considerations (Cornish et al. Animals 6:74-91)

- The public have a rudimentary understanding of animal welfare. To improve welfare we must address the shortcomings in the public’s understanding, knowledge and awareness of the environmental, social, human health and animal welfare impacts of all animal production systems (Cornish et al. Animals 6:74-91)
SUSTAINABILITY

Areas of Animal Welfare Concern

- According to the World Organization for Animal Health:
  - Good animal welfare is present when animals are healthy, comfortable, well nourished, safe, able to express innate behavior, and are not suffering from pain, fear, and distress
  - Animal-based measureable outcomes (beef): behavior, morbidity and mortality, changes in BCS, reproductive efficiency, and physical appearance

Fraser et al. (1997)

Cattle Losses

Stillbirth
1992 = 1.6%
2007 = 5.6%

Mortality
1992 = 7.6%
2007 = 7.8%

*Culled = 28.4%
*Died = 4.8%

**Mortality = 1.8%

NAHMS (1992, 2007** and 2014*)
**Colostrum**

Do all calves receive colostrum or colostrum replacer soon after birth even if immediately transported off the farm?

**Colostrum Management**

- Prevention of diseases in new born calves and promote proper growth
- Colostrum composition

<table>
<thead>
<tr>
<th>Components</th>
<th>Colostrum</th>
<th>Transition</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1(^{st}) milking</td>
<td>2(^{nd}) milking</td>
<td>3(^{rd}) milking</td>
</tr>
<tr>
<td>Fat</td>
<td>6.7%</td>
<td>5.4%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Total protein</td>
<td>14%</td>
<td>8.4%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Lactose</td>
<td>2.7%</td>
<td>3.9%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Insulin</td>
<td>65.9%</td>
<td>34.8%</td>
<td>15.8%</td>
</tr>
</tbody>
</table>

El-Fattah et al. BMC Vet Res 8:19-25


Colostrum Management

- A calf needs ~15 g of IgG per L of serum
  - 88 lb (40 kg) body weight
  - Blood = 10% of BW (25 to 30% hematocrit)
  - 40 kg x 0.10 = 4.0 L of blood (4.0 L x (1-0.25) = 3.0 L of serum)
  - 3.0 L of serum = 45 g of IgG
- Absorption of IgG (and other substances) depends on time of feeding of colostrum
  - Absorption in the first 2 h ~ 35%
  - IgG concentration in good colostrum = 50 to 70 g/L
    - Only 36% of colostrum (Besser et al. JAVMA 198:419)
  - 2 L at birth = 42 g of IgG (border line)
  - Recommendation = 4 L at birth and 2 L within 6 h of birth

IgG Serum Concentration and Calf Survival

- When the price of a female calf is $250 to $500, failure of passive transfer costs the dairy additional $27.8 to $88.2 per calf raised in the herd

NAHMS. National dairy heifer evaluation project. (USDA-APHIS Veterinary Services; 1993)

Perdomo et al. J. Dairy Sci. in-review
Effect of Volume of Colostrum Fed at Birth and Lactation Performance

- Brown Swizz calves fed 2 or 4 L of colostrum at birth
- Identical management thereafter

<table>
<thead>
<tr>
<th>Amount of colostrum fed at birth</th>
<th>2 L (n = 37)</th>
<th>4 L (n = 31)</th>
<th>P – value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, kg/d</td>
<td>0.8 ± 0.02</td>
<td>1.0 ± 0.03</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Milk yield 1st lactation, kg (305-d ME)</td>
<td>8,952 ± 341</td>
<td>9,907 ± 335</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Milk yield 2nd lactation, kg (305-d ME)</td>
<td>9,642 ± 341</td>
<td>11,294 ± 335</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Survival to the end of 2nd lactação, %</td>
<td>75.3</td>
<td>87.1</td>
<td>NS</td>
</tr>
</tbody>
</table>

- Veterinary costs for calves fed 2 L nearly doubled compared with 4 L
- Over two lactations, milk yield of calves fed 4 L of colostrum was 1,210 lb greater than the milk yield of calves fed 2 L
- If the difference in survival is true, the cost of culling would be nearly $93.70/cow in the herd when the cost of replacement is $700


Lameness

- The FARM Program has several evaluation points for foot health:
  - 95 percent of the lactating and dry dairy herd scores a 2 or less, where 1 is sound, 2 is moderately lame and 3 is severely lame
  - The dairy farmer is taking action to improve animals with severe lameness
  - A lameness prevention protocol is in place
- Severely lame cow being defined as an animal either unable to move, or able to move, but barely able to bear weight on the affected limb. Signs may also include back arch, poor body condition, head bob and an inability to flex the lower leg joints
Prevalence of Lameness and associated Risk Factors in Canadian Herds

- Experiment conducted in 141 freestall Canadian dairies
- ~40 cows between 10 and 120 DIM sampled (~29% of the herd)
- Cows scored for lameness = limping present (score of ≥ 3 on a 5-point scale)
- Cows were scored for leg cleanliness, BCS, hock injuries, and claw length
- Additional information collected:
  - Pen space and flooring (type of flooring, width of feed alley, floor cleanliness, and floor slipperiness)
  - Stall management (stocking density, stall dimensions, stall base, stall bedding type, cleanliness, quantity, and dryness)
  - Footbath (Length, depth, and width were measured, frequency of use, frequency of changing solutions, products used and their concentrations)

Solano et al. (2015) JDS (98):6978-6991
Prevalence of Lameness according to Parity and Body Condition Score

Causal-Web of Factors Hypothesized to affect Lameness in Dairy Cows

Solano et al. (2015) JDS (98):6978-6991
Lameness associated Loss in Milk Production

- New York data: 2,520 Holstein cows from 2 herds (Warnick et al., 2001)
  - First event of lameness treatment and foot lesion/hoof overgrowth recorded (incidence = 48.6%)
  - As much as 5.7 lb/d loss in milk yield after diagnosis

- Florida data: 465 Holstein cows from 1 herd (Hernandez et al., 2005)
  - Locomotion score of cows (0 to 5) weekly from calving to 100 DIM
  - Lame cows classified into low (22 to 42), medium (43 to 47), and high (48 to 63) cumulative sums of weekly locomotion score
  - Association of severity of lameness and 305-d milk yield:
    - High vs. medium scores = \(-668\) lb less 305-d milk \((P = 0.17)\)
    - Medium vs. low scores = \(-976\) lb less 305-d milk \((P = 0.09)\)
    - High vs. low scores = \(-1,643\) lb less 305-d milk \((P = 0.01)\)

Locomotion Score associated Loss in Milk Production

- UK data: 7 herds with at least 100 milking cows (Archer et al., 2010)
  - Cows repeatedly score for locomotion (0 to 3) during a 12 month period
  - From 11,735 records: LS 0 = 1.7%, LS 1 = 34.6%, LS 2 = 37.1%, and LS 3 = 26.6%
  - 93% of cows were LS 2 or 3 on at least 1 visit
  - Cows assessed in consecutive months: chronic cases = 50% (lame on both occasions), new cases = 13%, recovered = 15%, and unaffected = 22%
Association between Lameness Postpartum and Reproductive Efficiency

- Lame cows within 30 DIM had prolonged (34 vs. 29 d) anovular period (Garbarino et al., 2006)
- Lame cows within 70 DIM had longer interval from calving to conception (Bicalho et al., 2007)

Lameness associated Performance Inefficiencies

- Economic losses due to clinical lameness
  - Guard (2008) = $267
  - Liang et al. (2017): Primiparous = $185.10 ± 64.46, multiparous = $333.17 ± 68.76
### How Much Do Diseases Cost for a Dairy Herd?

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Disease</th>
<th>Country</th>
<th>Obs.</th>
<th>Cost/case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gohary et al. (2016)</td>
<td>Ketosis SC (1.4 mmol/L)</td>
<td>Canada</td>
<td>Incidence, treatment, death, production, metritis, DA, reproduction, replacement</td>
<td>$203</td>
</tr>
<tr>
<td>McArt et al. (2015)</td>
<td>Ketosis SC (1.2 mmol/L)</td>
<td>USA</td>
<td>Incidence, death, treatment, DA, reproduction, production, replacement</td>
<td>$289</td>
</tr>
<tr>
<td>Bar et al. (2007)</td>
<td>Mastitis</td>
<td>USA</td>
<td>Incidence, death, treatment, reproduction, production, replacement</td>
<td>$179</td>
</tr>
<tr>
<td>Rolli et al. (2015)</td>
<td>Mastitis 30 DIM</td>
<td>USA</td>
<td>Incidence, death, treatment, reproduction, production, replacement</td>
<td>$444</td>
</tr>
<tr>
<td>Overton and Fetrow (2008)</td>
<td>Metritis</td>
<td>USA</td>
<td>Treatment, reproduction, production, replacement</td>
<td>$360</td>
</tr>
<tr>
<td>Mahnani et al. (2015)</td>
<td>Metritis</td>
<td>Iran</td>
<td>Treatment, reproduction, production, replacement</td>
<td>$162.3</td>
</tr>
<tr>
<td>Oetzel (2005)*</td>
<td>HypoCa</td>
<td>USA</td>
<td>Treatment, production, replacement</td>
<td>$300</td>
</tr>
<tr>
<td>HypoCa SC</td>
<td>USA</td>
<td>Treatment, production, replacement</td>
<td>$125</td>
<td></td>
</tr>
<tr>
<td>DA</td>
<td>USA</td>
<td>Treatment, reproduction, production, replacement</td>
<td>$494</td>
<td></td>
</tr>
<tr>
<td>RP</td>
<td>USA</td>
<td>Treatment, metritis risk, reproduction, production, replacement</td>
<td>$315</td>
<td></td>
</tr>
<tr>
<td>Lameness</td>
<td>USA</td>
<td>Treatment, reproduction, production, replacement</td>
<td>$469</td>
<td></td>
</tr>
</tbody>
</table>

### Body Condition Score

- The FARM Program questions whether:
  - 99% or more of the animals have a Body Condition Score of 2 or more?
As for the Negative Energy Balance …
The Cow is not Alone!

- **Elephant seals**
  - 28 d lactation (fasting)
  - Pup body weight gains = 10%/d
  - Use of maternal body reserves
    - 42% loss of body weight (reduction of 58% in body fat and 14% in lean weight)

- **Baleen whales (i.e. blue whale)**
  - 110 x 10³ lb body weight gain during pregnancy
  - 7 mo lactation producing 198 lb/d of milk at ~40% fat and 12% protein
  - Almost no feed intake

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  - 7 mo lactation producing 198 lb/d of milk at ~40% fat and 12% protein
  - Almost no feed intake

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**3.5% FCM vs Live Body Weight:**
- Blue whale = 1,030 kg / 180,000 kg = 0.6%
- High Producing dairy cow = 45 kg / 650 kg = 6.5%
**Body Condition Scoring**

- Most meaningful biological phases
  - Dry-off
  - Calving
  - 30 and 60 DIM

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**Association between Body Condition Score Loss in the Dry Period and Performance**

- Data from 16,104 lactations (9,950 cows) of parous cows from 2 herds
- Cows received body score at dry-off and at calving
- Evaluation of:
  - Association between loss of BCS in the dry period and health, reproduction and production
  - Risk factors for BCS change in dry period
  - Factors associated with BCS drying

Chebel et al. (JDS submitted)
Association between Body Score Change and Diseases and Treatments

<table>
<thead>
<tr>
<th>Item, %</th>
<th>BCS Change</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ -0.75</td>
<td>-0.5 a -0.25</td>
</tr>
<tr>
<td>Lactations</td>
<td>1,604</td>
<td>6,430</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>4.6</td>
<td>4.7</td>
</tr>
<tr>
<td>Uterine diseases</td>
<td>15.8</td>
<td>13.6</td>
</tr>
<tr>
<td>Metabolic diseases</td>
<td>1.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Indigestion</td>
<td>2.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>14.1</td>
<td>12.4</td>
</tr>
<tr>
<td>Anti-inflammatory</td>
<td>13.7</td>
<td>10.0</td>
</tr>
<tr>
<td>Supportive therapy</td>
<td>8.1</td>
<td>8.4</td>
</tr>
<tr>
<td>Culling within 60 DIM</td>
<td>2.7</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Chebel et al. (JDS submitted)
Association between Body Score Change and Reproductive Performance and Milk Production

<table>
<thead>
<tr>
<th>Item, %</th>
<th>BCS Change</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ -0.75</td>
<td>-0.5 a -0.25</td>
</tr>
<tr>
<td><strong>1st AI</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy at 38 d</td>
<td>24.6</td>
<td>31.6</td>
</tr>
<tr>
<td>Pregnancy at 75 d</td>
<td>20.8</td>
<td>28.3</td>
</tr>
<tr>
<td>Pregnancy loss</td>
<td>15.6</td>
<td>10.5</td>
</tr>
<tr>
<td><strong>2nd IA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy at 38 d</td>
<td>24.8</td>
<td>29.4</td>
</tr>
<tr>
<td>Pregnancy at 75 d</td>
<td>22.1</td>
<td>26.8</td>
</tr>
<tr>
<td>Pregnancy loss</td>
<td>11.0</td>
<td>8.9</td>
</tr>
<tr>
<td>Milk yield by 60 DIM, kg/d</td>
<td>42.4 ± 0.3</td>
<td>43.4 ± 0.1</td>
</tr>
</tbody>
</table>

- Body condition at dry-off and BCS loss during the dry period impacts performance in the subsequent lactation
- Cows should dry-off between 2.75 and 3.25

Chebel et al. (JDS submitted)
Association between BCS at AI and Pregnancy per AI and Pregnancy Loss

- Study funded by the USDA to identify genes associated with cyclicity and reproductive outcomes
  - Cows (n = 5,260) from 9 commercial dairy herds (CA, FL, MN, TX, WI)
    - BCS at 7 ± 3 and 35 ± 5 DIM
    - Health events: calving events, uterine and metabolic diseases, mastitis, respiratory disease, and displaced abomasum

### BCS at calving

<table>
<thead>
<tr>
<th>BCS at calving</th>
<th>Gained</th>
<th>No change</th>
<th>Moderate loss (0.25-0.75)</th>
<th>Excessive loss (≥ 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 3.00</td>
<td>34.4 ± 0.3a</td>
<td>37.1 ± 0.3b</td>
<td>38.2 ± 0.3c</td>
<td>34.4 ± 4.4b,c</td>
</tr>
<tr>
<td>3.25 - 3.5</td>
<td>35.4 ± 0.5a</td>
<td>36.3 ± 0.3a</td>
<td>37.9 ± 0.2c</td>
<td>39.1 ± 1.0c</td>
</tr>
<tr>
<td>≥ 3.75</td>
<td>26.0 ± 2.3a</td>
<td>35.0 ± 1.0b</td>
<td>37.5 ± 0.4c</td>
<td>38.5 ± 0.9c</td>
</tr>
</tbody>
</table>

- It is OK for cows to lose BCS in early lactation, as long as BCS remains > 2, otherwise ~ 6 lb/d of milk may be lost

Chebel et al. (2015)
Stocking Density
Feed bunk and Water trough

• Is sufficient feed bunk space provided allowing all animals to feed at the same time or are sufficient quantities of feed available for all animals during a 24-hour period?
• Do all age classes of animals (including milk-fed dairy calves) have access to clean, fresh water as necessary to maintain proper hydration?

Association between Stall Stocking Density and Productivity

• Survey of 47 dairy herds (~ 3,129 lactating cows) from NE of Spain
  – Herds offered the exact same lactating ration
  – Survey data collected
    • Owners’ profile: future intentions, number of workers, and time devoted to the dairy
    • Animals: reproductive performance, incidence of diseases, culling rate, etc.
    • Facilities: number of feeders, waters, stalls, cleanliness, etc.
    • Management practices: numbers of daily milkings, feed deliveries, feed push-ups, cleaning frequency, etc.
    • Feed delivered, daily total milk production, and milk quality data obtained for each herd for a period of 8 mo before the survey was applied

Bach et al. (2008) JDS 91:3259
Association between Stall Stocking Density and Productivity

Bach et al. (2008) JDS 91:3259

Effect of Stocking Density on DMI according to Parity

Effect of Feed Bunk Space on Feeding Behavior of Dairy Cows

Effect of Stocking Density on Relative Resting Time

Cow Time Budget – Basic Behavioral Needs

- Eating = 3 to 5 h/d
- Lying (resting) = 10 to 14 h/d
- Standing/walking (grooming, agonistic, estrous activity) = 2 to 3 h/d
- Drinking water ~ 0.5 h/d
- Total = 20.5 to 21.5 h/d
- Time left for milking (exit to return to the pen) = 2.5 to 3.5 h

Economic Evaluation of Stall Stocking Density of Lactating Cow Barns

- Model evaluating the effect of the change in stocking (over 100%) on farm profitability ($/stall per year) according to several scenarios:
  - Probability of slaughter and death, insemination, conception, abortion and childbirth
  - Lactation curve, DMI, live weight, dry period and maximum number of inseminations
  - Prices of milk, value of animals slaughtered and sold, cost of food and other variable costs
  - Fixed costs (e.g. barn)
- According to available publications, the effect of increasing stocking (for every 10% above 100%):
  - ↓ 0.5 kg/cow per day in milk production
  - ↓ 0.1 percentage points in the probability of conception
  - No effect on probability of disposal

De Vries et al. (2016)
Maximum Profit per Stall per Year (dprofit) according to Milk Loss and Milk Price

<table>
<thead>
<tr>
<th>Milk loss (kg/d)</th>
<th>Milk price ($/kg)</th>
<th>Maximum dprofit (optimum SSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>$0.40</td>
<td>6 (110%)</td>
</tr>
<tr>
<td>0.5</td>
<td>$0.45</td>
<td>145 (148%)</td>
</tr>
<tr>
<td>0.5</td>
<td>$0.50</td>
<td>371 (150%)</td>
</tr>
<tr>
<td>0.75</td>
<td>$0.40</td>
<td>0 (100%)</td>
</tr>
<tr>
<td>0.75</td>
<td>$0.45</td>
<td>29 (118%)</td>
</tr>
<tr>
<td>0.75</td>
<td>$0.50</td>
<td>145 (137%)</td>
</tr>
<tr>
<td>1.0</td>
<td>$0.40</td>
<td>0 (100%)</td>
</tr>
<tr>
<td>1.0</td>
<td>$0.45</td>
<td>0 (100%)</td>
</tr>
<tr>
<td>1.0</td>
<td>$0.50</td>
<td>38 (117%)</td>
</tr>
</tbody>
</table>

- $0.40/kg = $18.2/cwt
- $0.45/kg = $20.5/cwt
- $0.50/kg = $27.7/cwt

De Vries et al. (2016)

Break-even Total Milk Change per Cow per Day according to Stocking Density and Milk Prices

- Economic return according to stocking is highly dependent on the decrease of milk production, the cost of dry matter, and the price of milk
- In general, from the economic standpoint the ideal stall stocking density of lactating cows is between 110 and 130%

De Vries et al. (2016)
Associations among Herd-level Feeding Management Practices and Feed Sorting and Milk Production

- Observational study in 24 Canadian herds (66 to 570 lactating cows, mean = 161.8 ± 120 lactating cows)
  - Average feedbunk space = 21" (14" to 39")
  - No description of grouping strategy
- Management associated with DMI:
  - Milking frequency: 2x vs 3x milking = ↑ DMI by 3.1 lb/d
  - Feeding frequency: 1x vs 2x feeding = ↑ DMI by 2.6 lb/d
- Management associated with milk yield:
  - Milk frequency: 2x vs 3x milking = ↑ milk yield by 13 lb/d
  - Feeding frequency: 1x vs 2x feeding = ↑ milk yield by 4.4 lb/d
  - Linear water space: ↑ linear water through space by 0.4" (1.5 to 4.6")= ↑ milk yield by 0.84 lb/d

Sova et al. (2013)

What is the Ideal Stocking Density in the Prepartum Period?
Effect of Prepartum Stocking Density on Performance

- Evaluation of behavior, metabolites, immune function, and performance of Jersey cows housed at 100 vs 80% stocking density (headlocks) during the prepartum period
- Nulliparous (n = 324) and parous (n = 404) animals assigned to one of two treatments at 28 d before expected calving date
  - 80SD = 38 animals, 48 headlocks, and 44 stalls
  - 100SD = 48 animals, 48 headlocks, and 44 stalls
  - Nulliparous and parous animals separate throughout the study
- After calving, animals from different treatments were commingled in the same pens

Prepartum Pen Design

SD80: 38 cows, 80% headlocks, 86% stalls
SD100: 48 cows, 100% headlocks, 109% stalls
Stocking Density According to Stalls

Effect of Stocking Density on Health and Removal from the Herd

- No effect on innate and adaptive immunity or concentrations of haptoglobin

<table>
<thead>
<tr>
<th></th>
<th>80SD</th>
<th>100SD</th>
<th>P – value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFM, %</td>
<td>5.1</td>
<td>7.8</td>
<td>0.19</td>
</tr>
<tr>
<td>Acute metritis, %</td>
<td>9.9</td>
<td>9.4</td>
<td>0.64</td>
</tr>
<tr>
<td>Metritis, %</td>
<td>21.2</td>
<td>16.7</td>
<td>0.11</td>
</tr>
<tr>
<td>Endometritis, %</td>
<td>5.8</td>
<td>7.9</td>
<td>0.35</td>
</tr>
<tr>
<td>DA up to 60 DIM, %</td>
<td>1.0</td>
<td>0.7</td>
<td>0.78</td>
</tr>
<tr>
<td>Removed within 60 DIM, %</td>
<td>6.1</td>
<td>5.1</td>
<td>0.63</td>
</tr>
<tr>
<td>1st Al P/AI, %</td>
<td>36.8</td>
<td>44.0</td>
<td>0.29</td>
</tr>
<tr>
<td>Milk yield, kg/d (±SEM)</td>
<td>34.2 ± 0.5</td>
<td>33.8 ± 0.5</td>
<td>0.56</td>
</tr>
</tbody>
</table>
Stocking Density in the Prepartum Period and Performance

- 100% stocking density reduced lying time and increased displacement rate from the feedbunk
- Stocking density did not affect:
  - Innate immune parameters
  - Incidence of health disorders during the postpartum period
  - Body condition and locomotion score during the peripartum period
  - Energy corrected milk yield in the first 150 d postpartum
  - Reproductive performance
- Reduced close-up pen use in approximately 20%

Heat Stress

- Are all age classes of animals provided all reasonable means of protection from heat and cold?
Annual Production and Economic Losses Due to Heat Stress

<table>
<thead>
<tr>
<th>State</th>
<th>DMI (kg/cow yr)</th>
<th>Milk (kg/cow yr)</th>
<th>Days open</th>
<th>Repro cull (%)</th>
<th>Deaths (%)</th>
<th>Heat Stress (% annual hours)</th>
<th>Loss ($/cow yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ</td>
<td>611</td>
<td>1,233</td>
<td>37</td>
<td>4.5</td>
<td>1.0</td>
<td>28</td>
<td>437</td>
</tr>
<tr>
<td>CA</td>
<td>145</td>
<td>293</td>
<td>12</td>
<td>0.9</td>
<td>0.2</td>
<td>12</td>
<td>110</td>
</tr>
<tr>
<td>FL</td>
<td>894</td>
<td>1,803</td>
<td>59</td>
<td>8.0</td>
<td>1.7</td>
<td>49</td>
<td>676</td>
</tr>
<tr>
<td>Average</td>
<td>550</td>
<td>1,110</td>
<td>36</td>
<td>4.5</td>
<td>1.0</td>
<td>30</td>
<td>$408</td>
</tr>
</tbody>
</table>

St-Pierre et al. (2003)

Dairy Heat Stress Losses in USA

- Consequences of heat stress:
  - Feed intake ↓
  - Milk production ↓
  - Reproduction ↓
  - Repro culling ↑
  - Death ↑

- Average losses due to heat stress:
  - Without any heat abatement = $ 167/cow/year
  - With OPTIMAL heat abatement = $ 100/cow/year

St-Pierre et al. (2003)
Consequences of Heat Stress during the Prepartum period on Health and Production

- **Dry matter intake**
- **Immunity**
- **Mobilization of aa**
- **Disease incidences**
- **Regeneration of mammary tissue**
- **Colostrum IgG concentration**
- **Birth weight and viability of calf**
- **Milk yield**
- **Immunity**
- **Disease incidences**
- **Mobilization of aa**
- **Regeneration of mammary tissue**
- **Colostrum IgG concentration**
- **Birth weight and viability of calf**
- **Milk yield**

Milk Yield of Cows Cooled vs. Non-Cooled in the Dry Period

- **Weighted average:** ↓ 5 kg/d

<table>
<thead>
<tr>
<th>Cooled cows</th>
<th>Heat stressed cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>2.1</td>
</tr>
<tr>
<td>6.3</td>
<td>2.3</td>
</tr>
<tr>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>3.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Tao & Dahl (2013)

Courtesy: F. C. Ferreira
• Large economic losses if dry cows are under heat stress
• Cooling dry cows is very profitable when building a dry cow barn is not needed (except Alaska)
• Cooling dry cows may be profitable when a new barn needs to be built in approximately 89% of the scenarios evaluated
  – Under reasonable assumptions

Courtesy: F. C. Ferreira

Thank you!!!

Ricardo C. Chebel

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