Causes of Reproductive Inefficiency in Lactating Dairy Cattle

Ricardo C. Chebel
Veterinary Medicine Cooperative Extension
University of California Davis
Introduction

• Physiological changes
• Energy demands
• Body condition score (BCS) and BCS change
• Impact of disease on fertility
• Timed AI protocols
  - Critical steps
Physiological Factors Affecting Reproductive Performance
Estimated Lactation Curve For The "Average" Cow in The U.S.

2.2 lb increment in peak = 440 lb increment per lactation

Courtesy of J.E.P. Santos
Lucinda's Lactation: 67,914 lb

At Peak Production: 229 lb/d
- 82 Mcal NEI: ~ 33 lb of body weight/d
- 6.2 kg of MP: ~ 45.3 lb of body weight/d

Current record = 75,117 lb/lactation
LA Foster Blackstar Lucy 607

Courtesy of J.E.P. Santos
Increased Steroid Metabolism = Low Fertility?

53 Mcal/d vs. 12.5 Mcal/d

Results:

- **Decr** estrous behavior
- **Incr** size of ovulatory follicle
- **Incr** double ovulation
- **Decr** embryonic development
- **Decr** preg rate
- **Incr** pregnancy loss

Decr. Estradiol
Decr. Progesterone

Wiltbank M. Bovine Reproduction Workshop - 2001
Effect of Milk Yield on Reproductive Performance
Relationship Among Milk Yield, Conception Rates and Pregnancy Loss

Santos et al. (2007)
### Embryo Quality: Dry vs. Lactating Cows

<table>
<thead>
<tr>
<th>Response</th>
<th>Dry</th>
<th>Lactating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilization Rate</td>
<td>89.5%</td>
<td>87.8%</td>
</tr>
<tr>
<td>% Grade 1-3</td>
<td>82.3%</td>
<td>52.8%</td>
</tr>
</tbody>
</table>

Embryos from lactating dairy cows are inferior to embryos from dry cows as early as 5 days after ovulation!

Sartori et al. (2002)
Energy Demands of Early Lactation
Dairy Cow Lactation Cycle

- **Early Lactation**: Energy demand and supply are high, with milk production peaking.
- **Mid Lactation**: Milk production decreases, body energy reserves increase, and dry matter intake remains stable.
- **Late Lactation**: Milk production continues to decline, body energy reserves decrease, and dry matter intake increases.
- **Dry Period**: Body energy reserves further decrease, and dry matter intake remains high.

Energy (demand and supply) decreases from early lactation to late lactation, reflecting the changes in milk production and physiological requirements.
Energy Balance

Inputs
- Nutrient Intake
- Body Condition Loss

Outputs
- Maintenance
- Milk Production
- Body Condition Gain
- Reproduction
The Cow is not Alone!

- Elephant
  - 28JdJlactation (fastening) – PupJbody weight gains = 10% of JBW/d – UseJofJmaternalJbodyJreserves
  - 42%JlossJofJbodyJweight (reductionJ of J58% in body fat and J14% in lean weight)

- BaleenJwhales
  - 50JxJ10 kgJbody weight gainJduringJ pregnancy
  - 7JmoJlactationJproducingJ90Jkg/dJofJ milkJatJ~40%JfatJandJ12%Jprotein
  - AlmostJnoJfeed intake
Energy Balance

First 7 weeks of Lactation

Weeks 8-9 of Lactation

Week 10+ of Lactation
Partitioning of Nutrients

1. Basal metabolism
2. Activity
3. Growth
4. Energy reserves
5. Pregnancy
6. Lactation
7. Additional energy reserves
8. Estrous cycle and initiation of pregnancy
9. Excess energy reserves
Association Between BCS and Cyclic Status
Proportion of Cyclic Cows at 65 DIM According to BCS and BCS Change (6396 lactations)

Santos et al. (2008)
Effect of BCS at 65 DIM on Proportion of Anovular Cows

n = 6936 lactations

$r^2 = 0.97$

$P < 0.01$

Santos et al., 2008
Association Between Resumption of Estrous Cycles and Fertility
Resumption of Cyclicity Influences Time to Pregnancy

Effect of day of resumption of cyclicity: $P < 0.001$

Effect of day of resumption of cyclicity: $P < 0.001$

$n = 967$ cows

Median days open:
- Cyclic 49 = 123
- Cyclic 62 = 135
- Anovular = 170

R.C. Chebel
Correlation Between BCS and Change in BCS and Fertility of Lactating Dairy Cows
Effect of BCS at 60 DIM on AI Submission Rate After Presynchronization

P < 0.01

Santos et al., 2003
Effect of BCS at AI on Pregnancy per AI and Pregnancy Loss

Santos et al. (2008)

P < 0.01
P = 0.04

Pregnancy per AI
Effect of BCS Change on Pregnancy per AI and Pregnancy Loss

Santos et al. (2008)

P < 0.01

P < 0.01

P = 0.01
BCS and Change in BCS During the Dry Period
Effect of BCS Prepartum on DMI

Average BCS:
- 2.84
- 3.57
- 4.36

Day Relative to Calving
Proportion of Cows Loosing BCS According to BCS at Dry-off

\[ y = 76.344x - 226.05 \]

\[ R^2 = 0.9578 \]
# Effect of BCS Change during the Dry Period on Health

<table>
<thead>
<tr>
<th></th>
<th>No Change</th>
<th>Lost</th>
<th>Gained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactations</td>
<td>2972</td>
<td>2951</td>
<td>1109</td>
</tr>
<tr>
<td>RFM, %</td>
<td>3.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Metritis, %</td>
<td>15.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.8&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Postpartum treatment, %</td>
<td>25.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>% Pregnant 90 DIM</td>
<td>35.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>33.9&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>% Pregnant 150 DIM</td>
<td>63.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>62.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Effect of BCS Change During the Dry Period on Pregnancy Risk

Median days open:
- No Change = 118
- Lost = 126
- Gained = 120

Cox proportional hazard ratio – $P < 0.01$
Association Between Days Open and BCS at Dry-off

\[ R^2 = 0.9283 \]
Mastitis and Periparturient Events Affect Fertility of Lactating Dairy Cows
Impact of Mastitis on Pregnancy Risk

Median days to conception:
- Control = 114
- Mastitis = 134

Effect of mastitis – $P < 0.001$

Impact of Mastitis on Abortion in Dairy Cows

- No Mastitis
- Mastitis

Pregnancy loss, %

- 45 to 135 d
- 28 to 35 d
- 30 to 45 d

Risco et al., 1999
Chebel et al., 2004
Moore et al., 2005
Effect of Uterine Pathogen Load on Resumption of Cyclicity

Williams et al., 2007 (Therio)
Effect of Uterine Discharge Score on Fertility

![Graph showing the effect of uterine discharge score on fertility with survival distribution function and calving to conception interval (days) on the x-axis and proportion of cows not pregnant on the y-axis. Diagram includes vaginal mucus score images with scores 0 to 3.]
## Subclinical Endometritis and P/AI after 1st AI

<table>
<thead>
<tr>
<th>Reference</th>
<th>Yes</th>
<th>No</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvao et al. (2006)</td>
<td>28.8</td>
<td>41.3</td>
<td>0.06</td>
</tr>
<tr>
<td>Gilbert et al. (2005)</td>
<td>11.0</td>
<td>36.0</td>
<td>0.01</td>
</tr>
<tr>
<td>Kasimanickam et al. (2004)</td>
<td>18.0</td>
<td>32.0</td>
<td>0.05</td>
</tr>
<tr>
<td>Rutigliano et al. (2006)</td>
<td>18.3</td>
<td>35.7</td>
<td>0.002</td>
</tr>
</tbody>
</table>

**Graph:**
- **Sub. Endometritis:** \(P = 0.10\)
Events around calving have a profound impact on fertility!

<table>
<thead>
<tr>
<th>Condition</th>
<th>Odds Ratio</th>
<th>P/AI (%)</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>1.00</td>
<td>50</td>
<td>40.0 - 60.0</td>
</tr>
<tr>
<td>Metritis, chronic</td>
<td>0.63</td>
<td>32</td>
<td>1.00 - 23.00</td>
</tr>
<tr>
<td>Acute metritis</td>
<td>0.68</td>
<td>34</td>
<td>6.5 - 8.3</td>
</tr>
<tr>
<td>Retained placenta</td>
<td>0.72</td>
<td>37</td>
<td>4.5 - 8.6</td>
</tr>
<tr>
<td>Ketosis</td>
<td>0.90</td>
<td>46</td>
<td>7.4</td>
</tr>
<tr>
<td>Lameness</td>
<td>0.83</td>
<td>43</td>
<td>0.3 - 3.7</td>
</tr>
<tr>
<td>Ovarian dysfunction</td>
<td>0.71</td>
<td>36</td>
<td>1.6 - 8.6</td>
</tr>
</tbody>
</table>

Data from: Ouweltjes et al. (1996), Lee et al. (1989), Grohn et al. (1990), Francos and Mayer (1988a; 1998b), Harmon et al. (1996).
Adapted from Ferguson et al., 2002
Correlation Between Occurrence of Metritis and DMI Pre- and Post-Partum

Huzzey et al., 2007 (JDS)
Does Fixed Time AI Reduce Fertility?
Relationship Among AI Protocol, Pregnancy per AI (P/AI) and Pregnancy Loss

Santos et al. (2007)
The Ovsynch Protocol

Plasma P₄ (ng/ml)

Ovulation

28±4h

GnRH

PGF

GnRH

TAI

7 d

56 h

14±2 h

PGF₂α
Timing of First GnRH and Ovulation Response

GnRH

Vasconcelos et al. (1999)
Follicle Growth and Timing of Treatments

- GnRH
- D3
- D6

Diameter of follicle (mm)

Day of estrous cycle

Ovulation

In heat
### Effect of Synchronization Protocol on Ovarian Dynamics

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>OV3</strong></td>
<td><strong>OV6</strong></td>
</tr>
<tr>
<td><strong>Follicle Size at G1, mm</strong></td>
<td>9.5$^c$</td>
<td>15.4$^a$</td>
</tr>
<tr>
<td></td>
<td>($\pm$ 0.39)</td>
<td>($\pm$ 0.41)</td>
</tr>
<tr>
<td><strong>Ovulation Rate, %</strong></td>
<td>7.1$^b$</td>
<td>87.3$^a$</td>
</tr>
<tr>
<td><strong>Ovulatory follic. dominance, d</strong></td>
<td>8.1$^a$</td>
<td>5.8$^c$</td>
</tr>
<tr>
<td></td>
<td>($\pm$ 0.16)</td>
<td>($\pm$ 0.16)</td>
</tr>
<tr>
<td><strong>Follicle size at AI, mm</strong></td>
<td>20.7$^a$</td>
<td>18.1$^c$</td>
</tr>
<tr>
<td></td>
<td>($\pm$ 0.37)</td>
<td>($\pm$ 0.36)</td>
</tr>
<tr>
<td><strong>Synchronization rate at AI, %</strong></td>
<td>82.2$^b$</td>
<td>85.8$^b$</td>
</tr>
</tbody>
</table>

Cerri et al. (2005)
Effect of Ovulation to GnRH1 on Quality of Embryos and Pregnancy Rates

*P* < 0.01

**EmbG1&2**

*Cerri et al. (2008)*

**PR31d**

*Chebel et al. (2006)*

**PR60d**

*No Ovulation*
Take Home Messages

- Lactation is associated with reduced fertility
  - Occurrence of diseases impact fertility
  - Immunodeficiency closely related to DMI and energy balance before and after calving
  - Cross-breeding, possible benefits:
    - Reduced incidence of post-parturient diseases
    - Improved fertility
    - Increased longevity
Take Home Messages

• BCS management
  - In general
    • Minimize overcrowding (offer enough water and feed bunk space)
    • House primiparous and multiparous cows separately
    • Minimize pen movement and improve cow comfort
  - BCS at dry-off and loss of BCS during dry period
    • Improve reproductive efficiency
    • Early dry-off = change to more energy dense diet 3 wk pre-partum
  - BCS loss during early lactation
    • Best quality feeds (consistency in formulation)
Take Home Messages

- TAI programs
  - Does not reduce fertility
  - To be used in situations where estrous detection < 55%
  - Assure increased ovulation to first GnRH of TAI protocol
    • Presynchronization of non-bred cows with PGF2α, PGF2α+GnRH, or double-Ovsynch
    • Presynchronization of bred cows with GnRH one week before pregnancy check
  - Use of CIDR insert during TAI increases P/AI in ~5%
  - Reduce interval from GnRH to PGF2α increases P/AI in ~8%
    • 2 injections of PGF2α are needed
### Optimal Body Condition Scores

<table>
<thead>
<tr>
<th>Stage of Lactation</th>
<th>BCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calving</td>
<td>3.25 - 3.75</td>
</tr>
<tr>
<td>Early Lactation (Peak Milk)</td>
<td>2.50 - 3.00</td>
</tr>
<tr>
<td>Mid Lactation</td>
<td>2.75 - 3.25</td>
</tr>
<tr>
<td>Late Lactation</td>
<td>3.00 - 3.50</td>
</tr>
<tr>
<td>Dry Period</td>
<td>3.00 - 3.50</td>
</tr>
</tbody>
</table>
• 4th Conference
• November 12th and 13th in Saint Paul, MN
• November 19th and 20th in Boise, ID

• http://www.dcrcouncil.org
THANK YOU!

Ricardo C. Chebel

Veterinary Medicine Cooperative Extension
University of California - Davis

Department of Veterinary Population Medicine
University of Minnesota

rcchebel@ucdavis.edu