Feeding the Calf from Weaning to First Lactation

James K. Drackley

Professor of Animal Sciences

University of Illinois at Urbana-Champaign, USA
Importance of Heifer Enterprise on Dairy Farms

• Need quality replacements for cows leaving herd
  • How many?
    • ~85% of cow numbers
    • But affected by pregnancy rates, cow longevity, facility constraints, feed availability, lending relationships, working capital…

• Second largest cost center on farm (behind feed costs for lactating herd)
  • 15-20% of total costs
  • 600-cow dairy with full heifer enterprise = ~$0.75 million annually
Heifer Rearing Costs

24 Months $2,260

- Feed Costs: 54%
- Livestock Costs: 12%
- Labor Costs: 12%
- Facilities and Equipment: 8%
- Ownership Costs: 10%
- Initial Calf Value: 12%

(Slide courtesy of P. A. LaPierre)
Heifer Raising is a Huge Investment

- Iowa State University (Tranel, 2014) projected the cost to raise heifers in 2014:
  - $2.37 heifer/day
  - $2.73 heifer/day including labor expenses
  - Total $2,260 to freshening at 24 months of age

- Pre-weaned heifers cost $5-$6 per day
  - ~ Double the average cost for post-weaned heifers ($2.47/day)

(Slide courtesy of P. A. LaPierre)
Daily costs for Wisconsin farms, 2013
Phases of heifer enterprise

- Day 1 (calving and colostrum)
- Day 2 through weaning (milk feeding period)
- Weaning transition
- Pre-pubertal growth
- Breeding group
- Pregnant heifers to calving
Management embedded in all phases

- Animal’s biology
- Nutrition
- Health
- Labor efficiency
- Housing and facilities
- Reproduction and subsequent milk production
Heifer growth is modeled as a linear increase in body weight, birth to calving.

42 kg at birth
575 kg at calving
533 kg gained in 22 mo (660 d)
= 0.8 kg/d = 1.8 lb/d

From Hoffman, 1996
What is the most cost efficient and biologically efficient time to attain growth of heifers?
Percentage BW increase (open bar) relative to previous 2-mo period and feed costs per kilogram of BW gain per 2-mo phase (closed bar)

Kertz et al, 1998
Percentage increase in Withers Height (open bar) relative to previous 2-mo period and ratio of BW to WH (closed bar) for Holsteins from birth to 24 mo
Feed costs per increase in Withers Height for Holsteins from birth to 24 mo
Conclusions from Kertz et al.

• Feed costs per unit of BW and WH gain are lowest in the first 6 months of life.

• Conversion of nutrients into BW and WH gain is most efficient in the first 6 mo of life.

• Maintenance costs are higher and growth efficiency lower at heavier weights.

• *Early growth is most efficient*
Management of calves from birth to weaning offers huge potential for improving efficiency of producing replacement heifers!

Maternity care, colostrum, milk and starter feeding, hygiene
Heifer Rearing Costs by Category

- Feed Costs: 54% (24 Months $2,260)
- Livestock Costs: 10%
- Ownership Costs: 8%
- Facilities and Equipment: 12%
- Initial Calf Value: 4%
- Labor Costs: 4%

Feed is over half of total costs

$70/head for Vet & Medicine Fees

(Slide courtesy of P. A. LaPierre)
How should we evaluate feed costs?

- Cost per day for feeding calves/heifers?
- Cost per kilogram of BW gain?
- Cost per day of life until enters the milking herd?
- Cost or investment?
Feed is the major cost of heifer raising: How do we optimize the system?
Weaning: The “other” transition period

• Period preparing for and adapting to weaning

• Critical stage of heifer’s life representing many stressors
Changes around weaning

- **Diets**
  - Removal of milk, total reliance on dry feed and free water, change from starter to grower

- **Environment**
  - Moving to different pen

- **Social**
  - Grouping with other calves
  - Removal of “surrogate mom” and suckling/milk feeding

Photos courtesy of Jim Quigley
Weaning distress compromises welfare

• Growth slumps
  – Attributable to lower nutrient intake and stress

• Adverse behavioral stress
  – Vocalization, decreased resting

• Increased disease susceptibility
  – Particularly respiratory and coccidiosis
  – Impaired immunity due to suboptimal nutrition and weaning stressors

Photos courtesy of Jim Quigley
Meeting the nutrient requirements of calves around weaning
What are the calf’s requirements at weaning?

- Tissue requirements for energy and protein (amino acids) do not change from preweaning to postweaning, if we want same growth rate!

- Problem is we must supply them from dry feed rather than milk…
Starter dry matter intake (DMI) required to support various rates of gain in weaned calves

<table>
<thead>
<tr>
<th>BW (kg)</th>
<th>ADG (g/d)</th>
<th>Starter required (kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>600</td>
<td>1.53</td>
</tr>
<tr>
<td>60</td>
<td>800</td>
<td>1.90</td>
</tr>
<tr>
<td>80</td>
<td>600</td>
<td>1.80</td>
</tr>
<tr>
<td>80</td>
<td>800</td>
<td>2.18</td>
</tr>
</tbody>
</table>

Based on starter containing 3.1 Mcal ME/kg DM (NRC 2001)
Adequate starter intake is key to avoid nutritional stress at weaning

- Composition and form of starter
- Optimize forage intake
- Water management
- Don’t wean too early
- Wean gradually
Water: the most important, and most neglected, nutrient
Water and starter intake patterns are almost identical!

Water and starter intake patterns are almost identical!

- **Early - starter**
- **Late - starter**
- **Early - water**
- **Late - water**

Eckert et al., 2015

Courtesy M. Steele, University of Alberta
Forage management during the weaning transition
Summary of arguments for forages

- Calves “crave” forage fiber. Satisfies behavioral needs, prevents stereotypic behaviors (tongue rolling, mouthing objects, etc).

- Small amounts of hay increase starter intake and feed efficiency.

- Hay particles keep rumen papillae healthier and prevent abnormal growth.

- **Therefore, feed small amounts of hay with concentrates before weaning**
Forage to concentrate ratio selected by calves given free choice of both

<table>
<thead>
<tr>
<th>Forage</th>
<th>F:C</th>
<th>ADG (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>---</td>
<td>0.72\textsuperscript{c}</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>14:86</td>
<td>0.76\textsuperscript{bc}</td>
</tr>
<tr>
<td>Oat hay</td>
<td>8:92</td>
<td>0.93\textsuperscript{a}</td>
</tr>
<tr>
<td>Barley straw</td>
<td>5:95</td>
<td>0.88\textsuperscript{a}</td>
</tr>
<tr>
<td>Rye-grass hay</td>
<td>4:96</td>
<td>0.84\textsuperscript{ab}</td>
</tr>
<tr>
<td>Corn silage</td>
<td>5:95</td>
<td>0.82\textsuperscript{ab}</td>
</tr>
</tbody>
</table>

Conducted in Spain. Hay or straw chopped. Gain:feed was not different among diets.

From Castells et al., 2012
Calves will choose high-quality alfalfa hay over starter concentrates.

Photo by J. K. Drackley
Forage to concentrate ratio selected by calves given free choice of both

<table>
<thead>
<tr>
<th>Forage</th>
<th>F:C</th>
<th>ADG (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>---</td>
<td>0.72&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>14:86</td>
<td>0.76&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oat hay</td>
<td>8:92</td>
<td>0.93&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Barley straw</td>
<td>5:95</td>
<td>0.88&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rye-grass hay</td>
<td>4:96</td>
<td>0.84&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Corn silage</td>
<td>5:95</td>
<td>0.82&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

For 1.5-kg total DM intake, forage intake would be only 75 g/d for barley straw vs. 210 g/d for alfalfa hay.

Conducted in Spain. Hay or straw chopped. Gain:feed was not different among diets.

From Castells et al., 2012
Summary of forage recommendations

• Do not feed free choice alfalfa (lucerne) hay
  – decreases starter intake, very palatable but low digestibility (high lignin)

• Small amounts of chopped grass hays or straw (<200 g/d or 5% of total “TMR”) may increase starter consumption and feed efficiency.

• Control amount of hay offered through at least 6 months so that calves consume all programmed concentrates
Grouping post-weaning

• First group should be small (4 to 6 calves)
  – Allows social adaptation

• By 4 mo can be housed in larger groups
Post-weaning nutritional considerations

• Metabolizable protein must be adequate
  – Use one of the models (NRC, CPM, etc) to predict

• Energy must be limited (maize silage) or increased (grass hay)
Ration principles

- **Weaned heifers 3-4 months to breeding**: intake capacity limited, need concentrates plus forage

- Grass silage or corn silage, grain, minimum of 0.5 kg dry hay

- Lactation TMR can work with additional starter or grower concentrate early
Feeding Heifers – General Practices

- *ALL* heifers should be force-fed a balanced mineral and vitamin pack with grain or forage
- *ALL* heifers need water
- *Cold and mud increase feed required or decrease growth*
## Dietary guidelines for large-breed dairy heifers gaining 0.82 kg/d

<table>
<thead>
<tr>
<th>Variable</th>
<th>125</th>
<th>250</th>
<th>375</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter intake, kg/d</td>
<td>3.9</td>
<td>5.7</td>
<td>8.1</td>
<td>11.0</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>17</td>
<td>15</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>RUP, % of CP</td>
<td>39</td>
<td>34</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>RDP, % of CP</td>
<td>61</td>
<td>66</td>
<td>70</td>
<td>74</td>
</tr>
<tr>
<td>ME, Mcal/kg</td>
<td>2.46</td>
<td>2.41</td>
<td>2.34</td>
<td>2.25</td>
</tr>
</tbody>
</table>

From NRC, 2001
<table>
<thead>
<tr>
<th>Group</th>
<th>Age (mo)</th>
<th>Strategy for the group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 - 4</td>
<td>Ration 1, smaller groups for less competition (2-mo age spread)</td>
</tr>
<tr>
<td>2</td>
<td>4 - 6</td>
<td>Ration 2, smaller groups for less competition (3-mo age spread)</td>
</tr>
<tr>
<td>3</td>
<td>6 - 9</td>
<td>Ration 2, smaller groups for less competition (3-mo age spread)</td>
</tr>
<tr>
<td>4</td>
<td>9 - 12</td>
<td>Ration 3, AI breeding group</td>
</tr>
<tr>
<td>5</td>
<td>12 - 15</td>
<td>Ration 3, pregnant</td>
</tr>
<tr>
<td>6</td>
<td>15 - 21</td>
<td>Dry cow ration</td>
</tr>
<tr>
<td>7</td>
<td>&gt; 21</td>
<td>Dry cow ration</td>
</tr>
</tbody>
</table>
### Example Ration Guidelines for Heifer Growth

<table>
<thead>
<tr>
<th></th>
<th>Ration 1 (3-6 mo)</th>
<th>Ration 2 (6-12 mo)</th>
<th>Ration 3 (&gt;12 mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg</td>
<td>3 - 7</td>
<td>7 - 9</td>
<td>9 - 12</td>
</tr>
<tr>
<td>CP, % of DM</td>
<td>17 - 18</td>
<td>15 - 16</td>
<td>13 - 14</td>
</tr>
<tr>
<td>RUP, % of CP</td>
<td>35 - 40</td>
<td>25 - 30</td>
<td>15 - 20</td>
</tr>
<tr>
<td>ME, MJ/kg</td>
<td>10.2 – 10.4</td>
<td>9.9 – 10.1</td>
<td>9.4 – 9.8</td>
</tr>
</tbody>
</table>
Feeding Strategies

• Limit silage and pasture for youngest group

• Groups 1 and 2 need supplemental grain (1-3 kg) and a protein supplement (0.25 to 0.5 kg); lactation TMR may work well

• Groups 3 and 4 may need supplemental grain (0.5-2 kg) depending on forage quality

• Groups 5 and 6 may need little grain (but must monitor total diet composition)
Potential areas for optimizing feed costs

• Develop a ration based on nutrient needs.
• Avoid overfeeding minerals, vitamins and protein.
• Utilize efficient bunk feeding techniques.
• Control forage costs.
• Analyze forages being fed.
• For some operations, intensive rotational grazing may reduce feed costs.
• Feed high-quality and palatable concentrates to younger heifers.
• Monitor size, age and weight variation.
• Keep weight gains steady.
• Adjust rations to changing environments without overconditioning.

http://www.hoards.com/E_calf_heifer/HR08
What is the optimum age at first calving (AFC)?

<table>
<thead>
<tr>
<th>Reference</th>
<th>Optimal AFC (mo)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pirlo et al., 2000</td>
<td>23-34</td>
<td>Italy</td>
</tr>
<tr>
<td>Teke and Murat, 2013</td>
<td>23</td>
<td>Turkey</td>
</tr>
<tr>
<td>Nilforooshan and Edriss, 2004</td>
<td>24</td>
<td>Iran</td>
</tr>
<tr>
<td>Cooke et al., 2013</td>
<td>23-25</td>
<td>UK</td>
</tr>
<tr>
<td>Gardner et al., 1988</td>
<td>26.9 &gt; 19.7</td>
<td>USA</td>
</tr>
<tr>
<td>Van Amburgh et al., 1998</td>
<td>21.3 &lt; 22, 24.5</td>
<td>USA</td>
</tr>
<tr>
<td>Ettema and Santos, 2004</td>
<td>23-24.5</td>
<td>USA</td>
</tr>
<tr>
<td>Hoffman et al., 1996</td>
<td>24.6 &gt; 21.7</td>
<td>USA</td>
</tr>
</tbody>
</table>

Table 1. Selected references and reported optimal AFC.
Effect of age at first calving on lifetime milk production based on number of times milked daily and herd rolling herd average

Figure 1. Lifetime milk production as affected by age at first calving. Adapted from Curran et al., 2013.

From Quigley 2014 (Calf Note 180; calfnotes.com)
Relationship between ADG and protein deposition in growing Holsteins

Protein deposition, g/d

Body weight, kg

ADG=0.8 kg/d

ADG=1.0 kg/d

NRC, 1996
Target Growth Rate Concept: Integrating Management and Biology

Determined by: Mature body weight (MBW) (when dairy cattle reach the third lactation)

Concept of physiologic maturity: puberty occurs at a given percentage of mature size (45% to 50%)

Pregnancy should occur by 55% MBW

Herd goals for age at first calving
Selection for milk yield has increased size of US Holstein heifers

Milk yield difference between groups ~3,639 kg (1990)
Selection for milk yield has increased size of US Holstein heifers

Murphy et al., JDS 74:262 (1992)
## Target weight system for heifer growth

<table>
<thead>
<tr>
<th>Stage</th>
<th>% of mature wt.</th>
<th>Target weight, kg</th>
<th>Mature weight, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>pregnancy</td>
<td>55%</td>
<td>220</td>
<td>400</td>
</tr>
<tr>
<td>1\textsuperscript{st} calf</td>
<td>85%</td>
<td>340</td>
<td>600</td>
</tr>
<tr>
<td>2\textsuperscript{nd} calf</td>
<td>92%</td>
<td>368</td>
<td>800</td>
</tr>
<tr>
<td>3\textsuperscript{rd} calf</td>
<td>96%</td>
<td>384</td>
<td></td>
</tr>
</tbody>
</table>

Input AFC – sets breeding age for you; breeding weight is a function of the mature size. Requirements are then calculated to meet the targets.

NRC, 2001
Full versus Target Feeding for Target ADG

Example: 225 kg Holstein heifers – target growth 0.9 kg/d

Diet:
- Alfalfa silage: 45 % NDF, 21% CP
- Corn silage: 40 % NDF, 50% grain
- Roasted soya meal
- High moisture maize, ground
- Vitamins and minerals

Can consume >6.6 kg DM/d, but due to forage quality only require ~ 5.7 kg DM to achieve target growth. If they consume >5.7 kg, what happens?
Why is body composition more important than weight or age alone?

• Are two 550-kg heifers always the same?
  • Example, postpartum BW for two heifers:
    • Heifer A: 550 kg, BCS 3.0
    • Heifer B: 550 kg, BCS 4.0
  • The difference in one body condition point is approximately 45 to 68 kg body weight.
  • The LEAN body weight of Heifer B is much lower than Heifer A, and so B has lower maintenance and lower predicted intake.
Effect of Mature Body Weight on Nutrient Requirements for Growth

- 750 kg mature weight
- 600 kg mature weight

- Similar composition – similar % of mature size
- Same weight – different % of mature size
What is the optimal ADG?

• Concern about too rapid growth decreasing future milk yield?
  – Increased growth rate increases fat in mammary pad and decreases DNA (epithelial cell number)

• More recent data suggest this doesn’t have to be a concern
# Reduced AFC & Milk Yield

<table>
<thead>
<tr>
<th>Study</th>
<th>Prepubertal ADG</th>
<th>AFC</th>
<th>First Lactation Milk Yield, lbs</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lin et al. 1.63</td>
<td>1.63</td>
<td>26.1</td>
<td>9,797</td>
<td>6.2</td>
</tr>
<tr>
<td>Gardner et al. NR1</td>
<td>NR</td>
<td>24.6</td>
<td>15,367</td>
<td>3.7</td>
</tr>
<tr>
<td>Hoffman et al. NR</td>
<td>NR</td>
<td>23.6</td>
<td>18,240</td>
<td>9.3</td>
</tr>
<tr>
<td>Hoffman et al. NR</td>
<td>NR</td>
<td>25.6</td>
<td>17,789</td>
<td>2.5</td>
</tr>
<tr>
<td>Bar-Peled 1.50</td>
<td>1.84</td>
<td>23.0</td>
<td>20,176x</td>
<td>+ 4.9</td>
</tr>
<tr>
<td>Van Amburgh et al.</td>
<td>2.07</td>
<td>24.5</td>
<td>21,721a</td>
<td>- 4.9</td>
</tr>
<tr>
<td>Radcliff et al.</td>
<td>2.46</td>
<td>23.6</td>
<td>18,962a</td>
<td>- 12.9</td>
</tr>
<tr>
<td>Vicini et al.</td>
<td>2.49</td>
<td>25.4</td>
<td>15,745a</td>
<td>- 4.9</td>
</tr>
<tr>
<td>Ettema and Santos</td>
<td>1.65</td>
<td>25.9</td>
<td>23,665a</td>
<td>- 3.7</td>
</tr>
<tr>
<td>Average</td>
<td>-</td>
<td>24.7</td>
<td>-</td>
<td>- 4.8</td>
</tr>
</tbody>
</table>

1Not reported.

~ 3 mo. decrease in AFC and ~ 5% reduction in milk.
Prepubertal ADG and mammary development

• Data from Cornell (Meyer and Van Amburgh, 2006) dispute this:
  – DNA accretion is a function of age (independent of nutrition)
  – Younger heifer at breeding size will have less DNA
  – Most mammary development occurs in late pregnancy
  – If fat in mammary pad, fat everywhere (too fat heifer!)
# Growth Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>E</th>
<th>R</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td></td>
<td>36</td>
<td>36</td>
<td>-</td>
</tr>
<tr>
<td>Lifetime ADG, kg/d</td>
<td></td>
<td>0.93&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.66&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.015</td>
</tr>
<tr>
<td>Number reaching puberty</td>
<td></td>
<td>10</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Age at puberty, months</td>
<td></td>
<td>8.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.39</td>
</tr>
<tr>
<td>BW at puberty, kg</td>
<td></td>
<td>270</td>
<td>289</td>
<td>10.4</td>
</tr>
</tbody>
</table>

<sup>a,b</sup>Means with non-common letters differ ($P < 0.05$)

Meyer and Van Amburgh, 2006
Parenchymal DNA

*Denotes treatment effect within slaughter weight.  (P < 0.05)

TRT: P < 0.01
BW: P < 0.01
TRT*BW: P = 0.10
Epithelial Cell Proliferation

**BrdU labeled epithelial cells, %**

- **TRT**: $P = 0.08$
- **BW**: $P < 0.01$
- **TRT*BW**: $P = 0.16$

*Denotes treatment effect within slaughter weight.  ($P < 0.05$)

Meyer and Van Amburgh, 2006
What is the optimal ADG?

• May depend on each farm’s goals and management ability

• Average daily gain of 0.8 kg/d is achievable with little risk

• ADG of 0.9 kg/d or more with proper nutrition (adequate metabolizable protein supply and **appropriate** energy supply)
Weak heifer programs have greater variation in size at any age

Within Range = 41 %

From P. Hoffmann
Good heifer programs minimize variation in size at any age

Within Range = 77 %
Success in heifer enterprises

- Approaching as a **system** (not thinking of calves and each heifer groups as separate entities)
- Setting goals and targets for system
- Measuring, recording, monitoring, adjusting to reach targets (= **MANAGING**)
- Evaluating past performance for updated goals
- **KISS** (**Keep It Simple, Stupid**)!
Thank you!

drackley@illinois.edu