Nutritional Development of Beef Heifers

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Start with end in mind

- I want nearly all first-calf heifers to have the opportunity to conceive during the first 21 days of the breeding season for their 2nd pregnancy
- Length of average first-calf heifer post-partum anestrus is 80-120 days (limited research supports this estimate)
  - Add 20 days for 90% of first-calf heifers to be cycling (100 to 140 days post-calving for 90% to be cycling)
  - Therefore, to expect 90% of first-calf heifers to be cycling by the 21st day of the breeding season requires that heifers are bred to calve 0 to 40 days prior to the start of mature cow calving season

<table>
<thead>
<tr>
<th>Day relative to start of Mature Cow Calving Season</th>
<th>Number of Days from Calving to Start of Breeding Season</th>
<th>Number of Days from Calving to 21st Day of Breeding Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>82</td>
<td>102</td>
</tr>
<tr>
<td>-7</td>
<td>89</td>
<td>109</td>
</tr>
<tr>
<td>-14</td>
<td>96</td>
<td>116</td>
</tr>
<tr>
<td>-21</td>
<td>103</td>
<td>123</td>
</tr>
<tr>
<td>-28</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>-35</td>
<td>117</td>
<td>137</td>
</tr>
<tr>
<td>-42</td>
<td>124</td>
<td>144</td>
</tr>
</tbody>
</table>

Target: 100-140 days

Another Reason to Calve Heifers Ahead of Mature Cows

- Onset of puberty is primarily influenced by age and weight within breed
- The average age at which cohorts of Bos taurus heifers reach puberty is reported to be from 303 days to 429 days (10 to 14 months)
- Having more than 50% of the cohort reach puberty by the start of the breeding season is often desired
- Add about 30-40 days to the cohort’s average age at puberty to achieve 90% having fertile cycles

Start with end in mind

- OK – If I want to start breeding heifers ahead of the mature cows, will the heifers reach puberty in time?
- How old do heifers need to be to reach puberty?
Age at Puberty

• My expectation is that 90% of heifers in many cohorts of crossbred beef heifers reach puberty by 13 months of age
  • Some herds have earlier puberty
  • Some herds have later puberty
  • Genetics and nutrition combine to influence age at puberty

### Age at Puberty

<table>
<thead>
<tr>
<th>Age at Puberty (mean or median)</th>
<th>Angus-Simmental (n=33)</th>
<th>Various Breeds</th>
<th>Various Breeds</th>
<th>Various Breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control: 303</td>
<td>303</td>
<td>303</td>
<td>303</td>
</tr>
<tr>
<td></td>
<td>DDG Tx: 330</td>
<td>330</td>
<td>330</td>
<td>330</td>
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<td></td>
<td></td>
<td>330</td>
<td>330</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td>Anglia-Simmental</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Angus (n=38): 247 d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belgian Blue (n=31): 240 d</td>
<td></td>
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<td></td>
<td></td>
<td>240 d</td>
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<td></td>
<td></td>
<td>240 d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freetly JAS 2011</td>
<td></td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hereford (n=28): 349 d</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Angus (n=38): 347 d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belgian Blue (n=23): 347 d</td>
<td></td>
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<td></td>
<td></td>
<td>347 d</td>
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<td></td>
<td></td>
<td>347 d</td>
<td></td>
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<tr>
<td>Freetlysw JAS 1997</td>
<td></td>
<td>19</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Hereford (n=149): 355 d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Angus (n=128): 351 d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belgian Blue (n=23): 347 d</td>
<td></td>
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<td></td>
<td></td>
<td>347 d</td>
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<td>347 d</td>
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<tr>
<td></td>
<td></td>
<td>347 d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferrell JAS 1982</td>
<td></td>
<td>20</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Angus (n=76): 410 d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hereford (n=84): 429 d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red Poll (n=61): 355 d</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Brown Swiss (n=47): 317 d</td>
<td></td>
<td></td>
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<td></td>
<td>Charolais (n=36): 388 d</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Simmental (n=91): 348 d</td>
<td></td>
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</tr>
</tbody>
</table>

Onset of Puberty

• Onset of puberty is primarily influenced by age and weight within breed
  • Heifers that calve in the first 42 days of the calving season are the most likely to be old enough to reach puberty early enough to be bred ahead of the mature cows
  • How much will heifers have to weigh to reach puberty?

Start with end in mind

• In order to be bred ahead of the mature cows, heifers must be born early in the calving season

<table>
<thead>
<tr>
<th>Age at the Start of Breeding Season</th>
<th>Born 1st 21 d</th>
<th>Born 2nd 21 d</th>
<th>Born 3rd 21 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Days before cows</td>
<td>428-448 d</td>
<td>407-427 d</td>
<td>386-406 d</td>
</tr>
<tr>
<td>7 Days Before Cows</td>
<td>421-441 d</td>
<td>400-420 d</td>
<td>379-399 d</td>
</tr>
<tr>
<td>14 Days Before Cows</td>
<td>414-434 d</td>
<td>393-413 d</td>
<td>372-392 d</td>
</tr>
<tr>
<td>21 Days Before Cows</td>
<td>407-427 d</td>
<td>386-406 d</td>
<td>365-385 d</td>
</tr>
<tr>
<td>28 Days Before Cows</td>
<td>400-420 d</td>
<td>383-403 d</td>
<td>365-385 d</td>
</tr>
<tr>
<td>35 Days Before Cows</td>
<td>393-413 d</td>
<td>365-385 d</td>
<td>344-364 d</td>
</tr>
<tr>
<td>42 Days Before Cows</td>
<td>386-406 d</td>
<td>365-385 d</td>
<td>344-364 d</td>
</tr>
</tbody>
</table>

>396 days (13 mo.)

Interpreting Target Weight for Puberty

**What is the appropriate target weight?**

• 50% - 55% - 60% - 65% of mature weight?

Real question is…

“**What ration should I feed cohort of replacement heifers to result in the desired number reaching puberty and becoming pregnant at the desired date?”**

Need to know target weight in order to determine desired average daily gain from weaning to breeding

ADG = (Target weight – Starting weight) / Number of days

I would rather know yearling wt. (not % of mature wt) that meets the herd’s goals

Interpreting Target Weight for Puberty

**What is the appropriate target weight?**

• How is target weight (as % of mature wt.) calculated?
  • Based on the average of the mature herd weight applied to all heifers in replacement pool?
  • Based on the expected mature weight of individual heifers (i.e. based on individual frame scores or wt. of dam)?
  • When is mature cow weight measured?
    140-200 lbs. difference in individual cow wt. at different times of the year
    It is possible that a heifer actually reached puberty at both 55% and 65% of her mature wt (depending on when mature wt was determined)
    Heifer reached puberty at 710 lbs.
    This is 55% of a 1290 lbs. cow weighed at her heaviest (summer/fall?)
    This is 65% of a 1100 lbs. cow weighed at her lightest (mid-winter?)
Interpreting Target Weight for Puberty

What is the appropriate target weight?

- How is target weight (as % of mature wt.) calculated?
  - Many papers actually measure: average weight of cohort of replacement heifers that reached puberty at a single evaluation time divided by average weight of mature cows in the herd (measured at weaning? breeding?)

My Current Thoughts:

- Estimated standard deviation for cow-herd body weight is 150 pounds (based on KSU database)
  - That means that 95% of cows in a herd will fall within the range described by the herd average +/- 300 lbs.

Average Body Weight for Mature Cows (lbs)

<table>
<thead>
<tr>
<th>Weight (lbs)</th>
<th>1,000</th>
<th>1,100</th>
<th>1,200</th>
<th>1,300</th>
<th>1,400</th>
<th>1,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>75% Range</td>
<td>775-815</td>
<td>800-840</td>
<td>900-935</td>
<td>1000-1050</td>
<td>1100-1150</td>
<td>1200-1250</td>
</tr>
<tr>
<td>60% for herd average</td>
<td>600</td>
<td>660</td>
<td>720</td>
<td>780</td>
<td>840</td>
<td>900</td>
</tr>
<tr>
<td>60% for range top</td>
<td>780</td>
<td>840</td>
<td>900</td>
<td>960</td>
<td>1020</td>
<td>1080</td>
</tr>
<tr>
<td>60% for range bottom</td>
<td>420</td>
<td>480</td>
<td>540</td>
<td>600</td>
<td>660</td>
<td>720</td>
</tr>
</tbody>
</table>

- Example herd has 1,200 lbs. average mature cow weight
  - Heifer with an actual mature weight of 1,400 lbs. that reaches puberty at 55% of her mature weight (i.e. 770 lbs.) will be reported to reach puberty at 64% of herd mature weight
  - Heifer with an actual mature weight of 1,200 lbs. that reaches puberty at 55% of her mature weight (i.e. 550 lbs.) will be reported to reach puberty at 46% of herd mature weight

If the mature cow herd averages 1,200 lbs.
- And, heifers truly reach puberty at 55% of mature wt.
  - 23.5% of cohort reaches puberty at 50% of average mature cow wt. (600 lbs.)
  - 76.5% of cohort reaches puberty at 60% of average mature cow wt. (720 lbs.)
  - 92.7% of cohort reaches puberty at 65% of average mature cow wt. (780 lbs.)

What is the appropriate target weight?

- How is target weight calculated?
- What is your goal?
  - Nearly all heifers in replacement pool reach puberty?
    - Set a high target weight (actual lbs. or 65% of mature wt.)
  - Only small-framed heifers reach puberty?
    - Use herd average mature weight – and set a low target weight (actual lbs. or 55% of mature wt.)

Answer: Monitor herd – what weight is needed to reach targeted number of puberal heifers?
  - If I know – that is the target weight (assuming constant genetic potential for mature wt. and age-at-puberty)
  - If I don’t know – base target weight on producer’s goal
  - Recognize that the way I calculate could be quite different than the way someone else does the calculation (when cows are measured, individual vs. group estimate, etc.)
Birth to Weaning

- By 6 weeks of age – calves will consume 1.5% of body weight as forage (and increases from there)
- If forage is limited due to drought, consider early weaning and hand-feeding
- Do not creep-feed heifers
  - Unable to control intake
  - Some heifers get too fat (fat deposited in udder)

Puberty

- Express estrus + ovulate fertile egg + normal CL
- Follicular waves detected by 2 weeks of age
- Gradual increase in LH/FSH
- Gradual increase in progesterone (luteinized follicles even though they are not CLs)

Puberty

- Onset influenced primarily by:
  - Age
  - Weight
  - Breed
- Other factors:
  - Exposure to bulls
  - Time of year
  - Exposure to progestogens

Weaning to Breeding

“What ration should I feed cohort of replacement heifers to result in the desired number reaching puberty and becoming pregnant at the desired date?”

Assume that I want one ration for entire cohort

Determine desired average daily gain (ADG) from weaning to breeding

\[ ADG = \frac{(\text{Target weight} - \text{Starting weight})}{\text{Number of days}} \]

Balance Rations

- Heifer rations are largely determined by:
  1. Animal requirements
  2. Forage quality

Heifers are not cows!!

Heifers’ nutritional requirements from weaning to breeding are very different from mature cows’ primarily because heifers are still growing (require NE partitioned toward growth in addition to maintenance)
How about heifers in good body condition that need to gain 1.5 lbs per day (access to good quality forage)?

- Heifers weaned on Oct. 25 at 500 lbs
- Target weight is 780 lbs. (65% of 1200) by May 1
- 280 lbs./187 days = 1.5 lbs. per day weight gain

How about heifers in good body condition that need to gain 1.5 lbs per day (access to moderate quality forage)?

How about heifers in good body condition that need to gain 0.9 lbs per day (access to good quality forage)?

- Heifers weaned on Oct. 25 at 500 lbs
- Target weight is 660 lbs. (55% of 1200) by May 1
- 160 lbs./187 days = 0.9 lbs. per day weight gain
How about heifers in good body condition that need to gain 0.9 lbs per day (access to moderate quality forage)?

How about heifers in good body condition that need to gain 0.9 lbs per day (access to poor quality forage)?

How about heifers that are behind and need to gain 2.5 lbs per day (access to good quality forage)?

How about heifers that are behind and need to gain 2.5 lbs per day (access to average quality forage)?

How about heifers that are behind and need to gain 2.5 lbs per day (access to poor quality forage)?

Summary (moderate wt. gain):

<table>
<thead>
<tr>
<th>Situation</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers that need to gain 1.5 lbs, daily with</td>
<td>Needed ~4.5 lbs (as fed)</td>
</tr>
<tr>
<td>good quality forage</td>
<td>DOG to meet targeted gain</td>
</tr>
<tr>
<td>Heifers that need to gain 1.5 lbs, daily with</td>
<td>Needed ~5.5-6.0 lbs (as</td>
</tr>
<tr>
<td>average quality forage</td>
<td>fed) DOG to meet targeted gain</td>
</tr>
<tr>
<td>Heifers that need to gain 2.5 lbs, daily with</td>
<td>Needed ~7.5-8.0 lbs (as</td>
</tr>
<tr>
<td>average quality forage</td>
<td>fed) DOG to meet targeted gain</td>
</tr>
</tbody>
</table>
Summary (slow wt. gain):

<table>
<thead>
<tr>
<th>Situation</th>
<th>Outcome</th>
<th>Supplement Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers that need to gain 0.9 lbs. daily with</td>
<td>Need ~2.0 lbs (as fed) DDG</td>
<td>≈2.0 lbs (as fed)</td>
</tr>
<tr>
<td>good quality forage</td>
<td>to meet targeted gain</td>
<td>DDG to meet</td>
</tr>
<tr>
<td>Heifers that need to gain 0.9 lbs. daily with</td>
<td>Need ~3.0 lbs (as fed) DDG</td>
<td>≈3.0 lbs (as fed)</td>
</tr>
<tr>
<td>average quality forage</td>
<td>to meet targeted gain</td>
<td>DDG to meet</td>
</tr>
<tr>
<td>Heifers that need to gain 0.9 lbs. daily with</td>
<td>Need ~5.1 lbs (as fed) DDG</td>
<td>≈5.1 lbs (as fed)</td>
</tr>
<tr>
<td>poor quality forage</td>
<td>to meet targeted gain</td>
<td>DDG to meet</td>
</tr>
</tbody>
</table>

Summary (rapid wt. gain):

<table>
<thead>
<tr>
<th>Situation</th>
<th>Outcome</th>
<th>Supplement Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers that need to gain 2.5 lbs. daily with</td>
<td>Need ~11.0-11.5 lbs (as fed)</td>
<td>≈11.0-11.5 lbs (as</td>
</tr>
<tr>
<td>good quality forage</td>
<td>DDG to meet targeted gain</td>
<td>fed) DDG to meet</td>
</tr>
<tr>
<td>Heifers that need to gain 2.5 lbs. daily with</td>
<td>Need ~11.5-12.0 lbs (as fed)</td>
<td>targeted gain</td>
</tr>
<tr>
<td>average quality forage</td>
<td>DDG to meet targeted gain</td>
<td>(not much forage)</td>
</tr>
<tr>
<td>Heifers that need to gain 2.5 lbs. daily with</td>
<td>Need ~12.5-13.0 lbs (as fed)</td>
<td>≈12.5-13.0 lbs (as</td>
</tr>
<tr>
<td>poor quality forage</td>
<td>DDG to meet targeted gain</td>
<td>fed) DDG to meet</td>
</tr>
</tbody>
</table>

Other Nutritional Considerations

Energy

- High starch diet may hasten onset of puberty
  - High-starch diet resulted in younger age and lighter weight at puberty compared to heifers fed lower concentrate diet – even though diets resulted in same body weight and body fatness (Ciccioli, et. al. 2003; Gasser et.al. 2006)

Other Nutritional Considerations

Energy

- High starch diet may hasten onset of puberty
  - High-starch diet resulted in younger age but same weight at puberty compared to heifers fed lower concentrate diet (Marston, et. al. 1995)

Other Nutritional Considerations

Energy

- Energy restriction may result in anestrus
  - Short-term fasting is less disruptive than in monogastriacs
    - Hypothalamic pulse generator / gonadotropin secretion
    - Smaller maximum diameter of dominant follicle

Other Nutritional Considerations

Energy

- High starch diet may hasten onset of puberty
  - While high-grain diets resulted in younger age, weight at puberty was higher compared to heifers fed lower concentrate diet (Hall et. al. 1995; Short & Bellows, 1971)
Other Nutritional Considerations

Energy

- Energy restriction may result in anestrus
  - Long-term restricted heifers (>17% BW loss)
  - Heifers become anestrus
  - Lower LH concentration
  - Smaller maximum diameter of dominant follicle

Effect of Energy Restriction on Endocrine Function

- Energy restriction negatively affects growth rate, timing of puberty, and reproductive performance
- The onset of puberty and subsequent fertility are controlled by activity of the hypothalamic-pituitary axis
- Probable interactions between nutrition and function of the hypothalamic-pituitary axis
  - Gonadotropin-Releasing Hormone (GnRH): associated with luteinizing hormone release
  - Luteinizing Hormone (LH): associated with the onset of puberty

Prepubertal LH Profile in the Beef Heifer

Day et al., 1984

Luteinizing Hormone (LH) Secretion in Heifers Fed Low or High Energy Diets

- How does energy restriction followed by refeeding affect LH secretion and pulse frequency?
- Thirty yearling heifers were fed either 0.82 or 2.5 Mcal ME / 100 lbs body weight for 128 days
- Subsequently, all heifers were fed 2.5 Mcal ME / 100 lbs body weight for 68 days
- Body weight change and LH secretion were monitored

Body Weight Gain in Heifers Fed Low or High Energy Diets

Kurz et al., 1990

Luteinizing Hormone (LH) Secretion in Heifers Fed Low or High Energy Diets

Kurz et al., 1990
Effect of Timing of Post-Weaning Gain on the Development of Replacement Beef Heifers

Numerous studies have shown equal reproductive performance for heifers with slow followed by fast weight gain to achieve targeted weight for puberty

Clanton et al., 1983
Smith et al., 1995

Conclusions

- Heifers fed diets deficient in energy reach puberty later, have more difficulty conceiving and calving, have lighter calves at birth, rebreed later, and wean lighter calves than adequately fed contemporaries.
- Increased pulse frequency of LH prior to puberty appears to be the critical factor in pubertal onset.
- Inhibition of GnRH secretion prevents onset of puberty when dietary energy and postweaning growth are too low.
- Provided prebreeding target weights are met, the timing and rate of post-weaning gains are not critical to reproductive performance – this may be an avenue to cost savings.

Other Nutritional Considerations

Protein

- Protein supplementation will increase utilization of mature forage (↑energy)
- High UIP (undegradable intake protein) may delay onset of puberty (Laiman et al. 1993)

Breeding to Calving

- During this timeframe, heifers should gain sufficient body weight to reach 85% of mature weight
  - ≈ 225 to 275 lbs over 283 days
  - ≈ 0.75 to 1.0 lbs per day
  - Plus 150 – 180 lbs of conceptsus weight (primarily in late gestation)

Last 60 Days of Gestation

- Nutritional demands increase as gestation progresses, due to:
  - Fetal growth
  - Uterine/placental growth
  - Metabolism involved with the fetal/maternal interaction (exchange of nutrients and waste)

Early Lactation

- Maintenance requirement (NEm) for lactating heifers is about 20% higher than that for nonlactating heifers
  - Requirements greatly affected by milk production potential
  - Peak lactation occurs at approximately 60 days postpartum (beef cattle)
  - Maximum yield has been reported to range from 9 to 30 lbs/d
Early Lactation

• Take Home Messages:
  ▪ Don’t allow heifers to become thin in late gestation
  ▪ No viable options to ensure good reproductive performance if heifers calve in thin body condition
  ▪ Adding energy to the early lactation diet increases milk production, but has limited beneficial effect on body condition and reproductive performance