Managing Bull Development to Optimize Fertility
Albert Barth
Western College of Veterinary Medicine
University of Saskatchewan, Saskatoon

Rearing bulls for fertility

Effect of post weaning nutrition (after “normal” calf hood nutrition)
- testis size
- age at puberty
- semen quality

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy level in bulls aged 6 -11.5 mo
(Maunul, 1991)
(Two 77-day feeding periods, n ~25/gp)

<table>
<thead>
<tr>
<th>Energy Level</th>
<th>Scrotal Circumference</th>
<th>Abnormal Sperm **</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-high</td>
<td>38.3</td>
<td>24.2%</td>
</tr>
<tr>
<td>High-low*</td>
<td>36.4</td>
<td>15.2%</td>
</tr>
<tr>
<td>Low-high</td>
<td>36.4</td>
<td>17.1%</td>
</tr>
<tr>
<td>Low-low</td>
<td>35.3</td>
<td>16.4%</td>
</tr>
</tbody>
</table>

* High – 3.39 Mcal DE, Low – 2.33 Mcal DE
** Abnormal Sperm ??? Bulls were only 11.5 mo old

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo

Effect of energy intake on testicular development
Seidel, 1980
Fed Angus bulls from 7-11 mo of age at 95% and 133% of TDN requirements
The higher energy diet resulted in:
• Larger scrotal circumference
• No difference in testis weight (P >0.05)
• Heavier scrotal weight

Effect of energy intake on scrotal circumference
Ohl, 1996
Feeding period = 11.6 - 15.3 mo of age
High gain 1.7kg/d Low gain 0.86kg/d
SC 34.0 cm 31.7 cm
Testes Wt 532g 425g **
No histological differences in testes at 15.3 mo
Pruitt and Corah, 1986

Higher levels of energy in the postweaning period resulted in no increase in SC and did not hasten the age at puberty.

Summary:
Effect of postweaning nutrition
- ± ↑ SC at 12 mo (partly fat in scrotum)
- Not clear whether age at maturity advanced
- Higher energy has no effect on semen quality until fat deposition in scrotum after 12 mo of age

Why so much variation in outcomes of postweaning feeding experiments?

Effect of Calfhood nutrition

Evidence for an effect of calfhood nutrition
- SC was 1.5 cm smaller in yearling bulls with 1st-parity dams (Lunstra et al., 1988)
- SC was 2.4 cm smaller in 11 mo. old bulls with 1st-parity dams (Bagu, 2004)
- Less milk in calf hood?
- An in-utero effect?

Effect of energy levels in feed on pubertal development in Holstein bulls
Bratton et al., 1956
Calfes fed from 1-80 wk of age, semen collected every 14d

<table>
<thead>
<tr>
<th>% of recommended intake</th>
<th>60-75</th>
<th>100</th>
<th>140-160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (wk) at Puberty</td>
<td>57</td>
<td>49</td>
<td>43</td>
</tr>
<tr>
<td>Weight at puberty</td>
<td>562</td>
<td>634</td>
<td>727</td>
</tr>
<tr>
<td>60-90 day preg. rate</td>
<td>74.1</td>
<td>72.9</td>
<td>74.2</td>
</tr>
</tbody>
</table>
The main basis of the calfhood effect on age at onset of puberty is gonadotrophin secretion from 8 to 16 weeks of age.

**Effects of augmenting LH before the early gonadotrophin rise**

*Chandolia et al., 1997*

**Treatment**
- 200 ng LHRH every 2h for 14d from 4-6 wk of age
- Blood samples every 15 min for 10h at 4, 6, 12, 18, 24 wk of age

**Results**
- ↑ d LH pulse frequency
- ↑ d mean LH and T

**All Year**
- ↑ testis size, 30.6 vs. 28.6 cm
- ↑ sperm concentration
- ↑ spermatogenesis
- ↑ Sertoli cells (n)

**Effect of inhibiting the early LH rise**

*Chandolia et al., 1997*

**Treatment**
- Leuprolide (GnRH agonist) at 6, 10, 14 wk of age
- Blood samples every 15 min for 10 h at 12 wk

**Results**
- ↓ LH and FSH pulse frequency and amplitude
- ↓ FSH and T at 14, 16, 18 wk
- ↑ mean LH and LH/FSH pulse freq. at 24 wk (delayed rise)
- ↓ Scrotal Circumference, Spermatids and Sp’ cytes

FSH has been considered the main driver of Sertoli cell proliferation in prepubertal animals

Mean FSH in blood samples collected every 15 min for 10 h, at 4 week intervals from 4 to 32 weeks of age

*Bagu 2006*
Calves ($n=6$) castrated at 5, 13, 21, 25, 33, and 56 wk of age. Sertoli cell numbers (open circles) and their progenitor cells (solid circles) per section of seminiferous tubule.

Effects of 4 mg FSH, 3 mg LH, or saline every 2nd day from 4-8 wk of age on the attainment of puberty (Puberty: when SC ≥ 28cm) 

Bagu, 2006

Mean Sertoli and germ cell counts in calves treated every 2nd day with 4 mg FSH, 3 mg LH or saline from 4 - 8 wk of age 

Bagu, 2006

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sertoli (x ± SE)</th>
<th>Spermatids (x ± SE)</th>
<th>Spermatocytes (x ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSH</td>
<td>$6 ± 0.3^a$</td>
<td>$38 ± 3^a$</td>
<td>$57 ± 8^a$</td>
</tr>
<tr>
<td>LH</td>
<td>$5 ± 0.2^a$</td>
<td>$31 ± 3^a$</td>
<td>$42 ± 2^b$</td>
</tr>
<tr>
<td>Saline</td>
<td>$5 ± 0.3^b$</td>
<td>$29 ± 2^b$</td>
<td>$38 ± 5^b$</td>
</tr>
</tbody>
</table>

The magnitude of the early gonadotrophin rise is a critical factor in pubertal development

Sertoli cell numbers in bulls reach a final maximum life-time number at 20 to 25 wk of age

Final testis size is determined before weaning!

Why so much variation in outcomes of postweaning feeding experiments?

- Sertoli cell numbers no longer increase in the post weaning period
- Sertoli cells can run at half empty

Does calfhood nutrition have an effect on age at onset of puberty and maturity?

(Does nutrition affect the early gonadotrophin rise?)
Nutrition, metabolic hormones, and sexual development in bulls


Bulls
- Angus and Angus x Charolais (1st-parity dams)
- Weaned at 8 wk

Stages of development
- Calfhood 10 - 26 wk
- Postweaning period 27 - 70 wk

Blood sampling (monthly from 10 - 20 wk and at 44 and 48 wk)
- Every 15 min for 10 h, then GnRH challenge with samples every 15 min for 90 min
- Single samples monthly

Effects of different levels of nutrition in calfhood or postweaning
Experiments I - IV, ~14 calves per group

Results Experiment I
Low, med and high postweaning nutrition after medium calfhood nutrition did not alter age at puberty or testis size

<table>
<thead>
<tr>
<th>Nutritional level</th>
<th>Low</th>
<th>Med</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age puberty (d)</td>
<td>301a</td>
<td>328b</td>
<td>299a</td>
</tr>
<tr>
<td>Pared Testes Wt</td>
<td>619</td>
<td>573</td>
<td>610</td>
</tr>
</tbody>
</table>

(Sertoli cell numbers are determined before weaning)

Results Experiment II
Nutritional level throughout calfhood and postweaning affected age at puberty and testis size

<table>
<thead>
<tr>
<th>Nutritional level</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puberty (d)</td>
<td>327a</td>
<td>305b</td>
<td>292a</td>
</tr>
<tr>
<td>PTW (g)</td>
<td>524a</td>
<td>552b</td>
<td>655b</td>
</tr>
</tbody>
</table>
**Results Experiment III**

Restricting nutrition in calfhood affected age at puberty and testis size

<table>
<thead>
<tr>
<th></th>
<th>Med/Med</th>
<th>Low/High</th>
<th>Low/Med</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puberty (d)</td>
<td>293a</td>
<td>334b</td>
<td>334b</td>
</tr>
<tr>
<td>Paired Testis Wt (g)</td>
<td>597a</td>
<td>548b</td>
<td>503b</td>
</tr>
</tbody>
</table>

**Results Experiment IV**

Augmented nutrition in calfhood hastened puberty and increased testis size

<table>
<thead>
<tr>
<th></th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puberty (d)</td>
<td>327</td>
<td>314</td>
</tr>
<tr>
<td>Paired Testis Wt (g)</td>
<td>531a</td>
<td>611b</td>
</tr>
</tbody>
</table>

**Conclusions**

- Nutrition regulates GnRH secretion during the early gonadotropin rise
- Delayed puberty in bulls raised by 1st parity dams likely has a strong nutritional component
- Management strategies to optimize reproductive function should be focused on calfhood
- Target ADG during preweaning period > 1.2 kg/d