Predicting and promoting fertility in beef bulls

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Challenges in the beef industry

- Tradition is a good thing (up to a point)!
- Historically beef cows calved in May and beef bulls were sold at 2 years of age
- Now many cows calve in winter→calving barns, crowding, scours and respiratory disease, cows bred prior to emergence of grass
- Many bulls are sold as yearlings and often in late winter or early spring

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Bull requirements

- Identify cows in estrus, mount and breed, deliverlarge numbers of normal, fertile sperm
- Larger testes produce more and better sperm
- Feed bull to reach genetic potential for testis size
- Functional breeder for many years

Effects of bull nutrition

- Control group of medium nutrition from 10 – 70 wk
- Two experimental groups: both fed low nutrition during calfhood (10 – 26 wk) and medium or high nutrition during peripubertal period (27 – 70 wk)
- Three nutrition groups
  - Medium-medium (n = 15);
  - Low-medium (n = 15);
  - Low-high (n = 14)

(NRC): low =70%, medium =100%, high =130% [energy and protein, all bulls got adequate vitamins & minerals]

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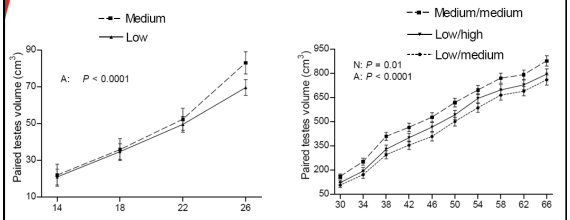
Testes



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Puberty and testes

	Med/Med	Low/High	Low/Med
Puberty (d)	293 ± 8[a]	334 ± 12[b]	334 ± 9[b]
PTW (g)	597 ± 11[a]	548 ± 19[ab]	503 ± 22[b]

PTW = paired testes weight
[a,b] P<0.05

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Effects of pre-weaning nutrition

- Calfhood period (10 – 30 wk)
  - Medium nutrition (n = 16)
  - High nutrition (n = 17)
- Peripubertal period (30-74 wk): medium nutrition
- Two nutrition groups
  - Medium-medium
  - High-medium

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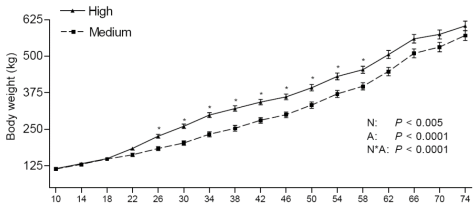
Body weight



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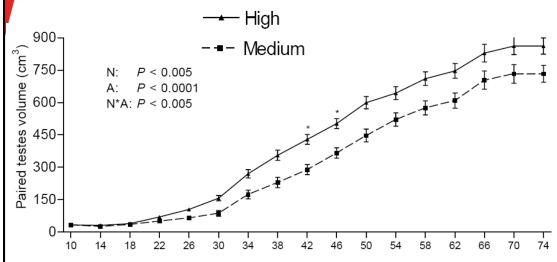
Testes



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Puberty, testes, sperm

	Medium	High
Puberty (d)	327 ± 9	314 ± 8
PTW (g)	531 ± 18[a]	611 ± 28[b]
DSP (x10^9)	7.4 ± 0.4[a]	9.5 ± 0.7[b]

PTW = paired testes weight
DSP = daily sperm production
[a,b] P<0.05

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Summary of nutrition studies

- Beef bulls fed high nutrition during calfhood had more LH, earlier puberty (~1 mo), and larger testes with greater sperm production (~20-25%) than bulls on low nutrition
- No indications that high nutrition during calfhood reduced semen quality or fertility
- Nutrition after 30 wk had limited effects on reproductive development, including an inability to overcome earlier deficits

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Brito et al. 2007

Excessive dietary energy after weaning

- Abnormal foot growth (laminitis) (Greenough et al 1990)
- Abnormal bone and cartilage growth (lameness), rumenitis, liver abscesses and seminal vesiculitis (Dargatz et al 1987)
- In bulls fed primarily a forage diet after weaning, bulls with genetics for fastest and most efficient growth will still have best growth performance
- DO NOT OVERFEED BULLS AFTER WEANING!

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Summary of nutritional management

- Management to optimize reproductive function should be focused on calfhood (starting at birth)
- **Preweaning** average daily gain should exceed 1.2 kg/d (2.65 pounds/d)
- Consider creep feeding (energy and protein)
- After weaning, feed for a moderate growth rate (avoid high-energy diets and fat bulls)

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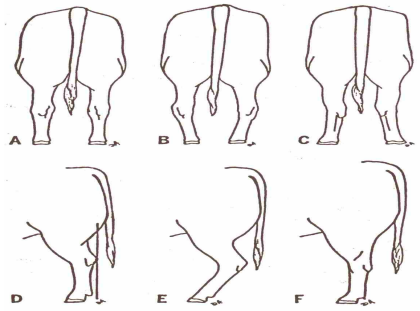
Rear leg conformation



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Abnormal feet



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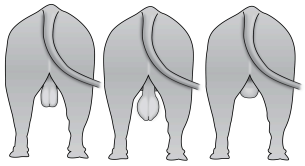
Testicular physical characteristics

- The scrotum should have a distinct neck
- Testis should be freely movable and similar in size, firm and resilient
- Minor rotation of one testis is generally tolerated



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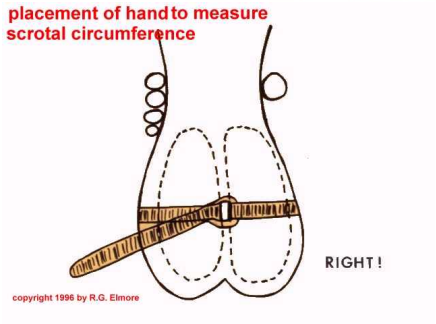
placement of hand to measure scrotal circumference



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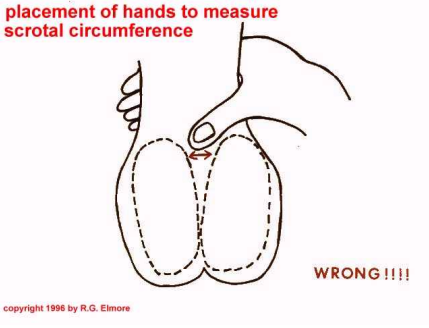
placement of hands to measure scrotal circumference



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Minimum SC (all breeds)

Age (mo)	SC (cm)
☒ 15	30
☒ 15 ☒ 18	31
☒ 18 ☒ 21	32
☒ 21 ☒ 24	33
☒ 24	34

(SFT, 1992)

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Bull selection at weaning

- Culling at weaning for low SC, epididymal aplasia, cryptorchidism, confirmation, etc.
- 13 beef breeds at 200 days of age (Coe and Gibson, 1993)
  - more than 23 cm, 95% probability of 34 cm at 365 d
  - less than 23 cm, 54% probability of 34 cm at 365 d

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Scrotal circumference (SC)

- Force testes to bottom of the scrotum, apply moderate tension at largest circumference
- SC is correlated with paired testis weight and daily sperm production and semen quality and is highly heritable (r^2~0.7)
- Bulls with large weaning and yearling SC will have sisters and daughters with earlier puberty
- Minimum SC is not optimal SC; huge SC risky??
- Bulls with excessive frame score may have delayed puberty, reduced SC at weaning and 1 year, but adequate mature SC

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Pre-pubertal male reproductive traits and correlations to reproductive function

Traits measured	Correlated traits	Correlation	Reference
SC (12 mo)	(1) Motility (2) % normal sperm	0. 25 (*rg*) 0.58 (*rg*)	Brinks et al., 1978
FSH (2-3 mo)	Sertoli cell no.	-0.51 to -0.54 (*rp*)	Moura and Erickson, 1997
FSH (2-12 mo)	Yearling SC	-0.53 to -0.74 (*rp*)	Moura and Erickson, 1997
LH pulse (2.5 mo)	Age at puberty	-0.67 (*rp*)	Aravindakshan et al., 2000
GnRH-induced LH (16-24 mo)	Pregnancy rate	0.71-0.45 (*rp*)	Perry et al., 1990
GnRH-induced T4 (3 mo)	Yearling SC	0.48 (*rp*)	Moura and Erickson, 1997
IGF-I (5-6 mo)	Adult SC	0.24 (*rg*)	Yilmaz et al., 2004

Burns et al., Reprod Dom Anim 2011;46:534-53

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Goal of a BBSE

- Identify subfertile bulls
- Decide whether subfertility is transient or permanent
- Difficult or impossible to determine relative fertility of bulls that are deemed satisfactory
- Expected use of bull may influence decision (requirements for a bull breeding a few heifers differ from future herd sire)
- Global assessment of bull confirmation, health, integrity of the reproductive tract and sperm morphology/motility
- Desire (libido) and ability to breed are not assessed; remind bull owner that these should be assessed in the field

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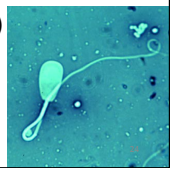
Minimum sperm characteristics

- >70% normal sperm (<20% head defects)
- >30% progressively motile sperm
- Urine will reduce or eliminate sperm motility (withhold water for a few hours before examination, if possible)



Puberty and semen quality

- Puberty: >50 million sperm, >10% progressively motile (scrotal circumference ~28 cm)
- Numerous defects: DMR, proximal droplets, head defects, etc.
- Semen characteristics that increase for up to 4 mo after puberty:
  - Sperm concentration
  - Progressively motile sperm (%)
  - Morphologically normal sperm (%)

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Yearling bulls (n=254) with satisfactory semen

Age (mo)	No.	SC (cm)	Satisfactory (%)
12	40	33.8 (28.5 - 39.5)	40.0
13	100	34.5 (28-41)	55.0
14	84	34.1 (28-45)	55.9
15	30	34.9 (27-41)	73.3

-Challenge to get bulls to pass a BBSE for early bull sales
-Many bulls with apparent immaturity will subsequently pass, but some will not

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BBSE: Outcomes

- Satisfactory potential breeder
  - Healthy and physically sound
  - Meets the minimum in EACH category:
    - SC
    - ≥ 30% progressively motile
    - ≥ 70% morphologically normal, ≤ 20% head defects
- Unsatisfactory
  - Permanent deficits in health or soundness
  - Fail to meet the minimum in at least one category, unlikely to overcome deficit in near future
- Decision deferred
  - Fails to meet the minimum in ≥ 1 category, likely to overcome deficit soon (e.g. peripubertal, temporary lameness)
  - Recommend date for re-evaluation

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Summary of >1000 BBSE

Disposition	No.	% of Total
Satisfactory	802	62.9
Unsatisfactory	369	28.9
Deferred	105	8.2

Bob Carson and Jim Wentzel, 1995

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Reasons for unsatisfactory or deferred

Reason	No. bulls	Unsatisfactory or Deferred (%)
Physical exam	45	9.5
SC	59	12.4
Morphology	247	52.1
Motility	1	0.2
SC & Morph	52	11.0
SC & Motil	2	0.4
Motil & Morph	20	4.2

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Infrared thermography to assess scrotal surface temperatures

- Captures infrared radiation from skin
- Association of color and temperature
- Temperature ↓ from dorsal to ventral, but uniform left to right
- Bulls with abnormal pattern have impaired semen quality; not all bulls with a normal pattern have normal semen/fertility

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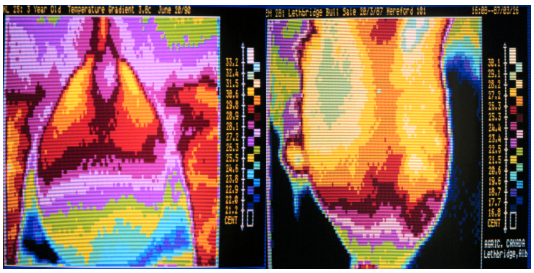

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Field trial (Lunstra & Coulter 1997)

- 73 yearling beef bulls
- IRT to assess scrotal surface temperature
- 30 bulls passed standard BBSE (SC, sperm motility and morphology) each exposed to ~18 heifers for 45 d

	Normal	Questionable	Abnormal
Bulls (%)	51	27	22
Pregnant (%)	83[a] (n=13)	85[a] (n=9)	68[b] (n=8)

[a,b] (P < .01)

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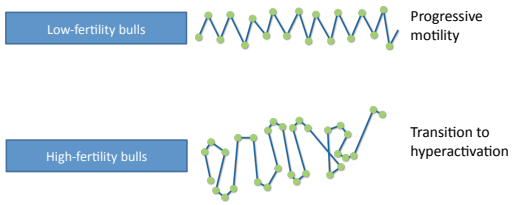
Advanced approaches to predict fertility

- Computer-assisted sperm analysis
  - —Objective evaluation of sperm kinematic parameters



Shojaei et al., Theriogenology 2012; 77:940-51

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Genetics and genomics for bull selection

- Genetic selection reduces generation interval, and increases prediction accuracy and selection intensity
- Need to determine effects of markers (SNP) on phenotype (estimated breeding value, EBV) from a large reference population
- Estimate direct genomic breeding values (DGV), enhance selection of specific genotypes and hasten genetic progress
- Genome-based selection is much more advanced in dairy than beef

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Genetics of semen quality

- SNPs for sperm motility, semen volume and total number of sperm in Holstein bulls
- Semen quality is apparently genetically controlled and genetic markers could be used for genomic selection
- Must ensure accuracy before culling calves based exclusively on genomic approaches
- Need accurate genetic correlations between reproductive and performance traits in beef cattle

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Summary

- Select good genetics and good phenotype
- Manage cows well during pregnancy and calving
- Grow bulls well prior to weaning, avoid excessive energy after weaning
- Assess bulls at weaning, castrate those that with structural defects, small SC
- Conduct BBSE, ensure bulls meet your needs, observe breeding behavior, limited breeding seasons, conduct pregnancy diagnosis

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Thank you!

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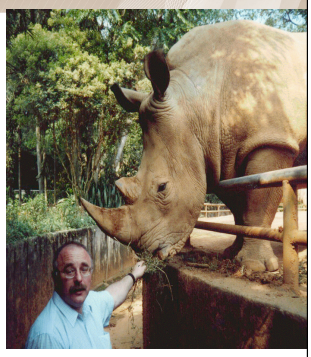

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