Management and Nutrition of Beef Bulls and Impacts on Fertility

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Over the next 40 minutes…

- **Overview of observational studies evaluating the relationship between over conditioning and bull fertility**
- **Experimental evidence for the impact of bull over conditioning on fertility**
- **Recent developments on the impact of over conditioning on bull fertility**

2

Variation in Sire Field Fertility in Fixed-Time Artificial Insemination Programs - GERAR

Insemination records only included cows with adequate body condition scores and sires with at least 100 inseminations.

AI Center	Number of AI	Average PR/AI	Range in Sire PR/AI
A	45,231	54.8	38.3 to 79.1
B	128,443	55.4	30.9 to 70.2
C	9,434	50.5	38.1 to 57.9
D	19,311	56.7	42.8 to 76.9
E	25,522	54.8	28.2 to 72.4
F	32,397	52.5	32.1 to 62.7
G	7,042	54.9	22.8 to 81.3

3

Variation in Sire Field Fertility in Fixed-Time Artificial Insemination Programs– Controlled Study

n = 4,866

Sire	Number of AI	Average PR/AI
A	1,050	48.1
B	1,058	47.7
C	1,206	40.7
D	747	45.5
E	805	43.1

Factors influencing this variation in sire PR/AI are still poorly understood

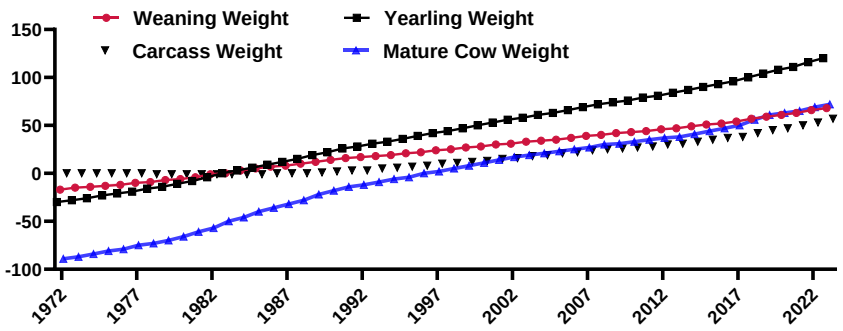
4

Georgia Bull Evaluation Program

GEORGIA BULL TEST
Tifton · Calhoun

5

Genetic Trends in Angus Cattle



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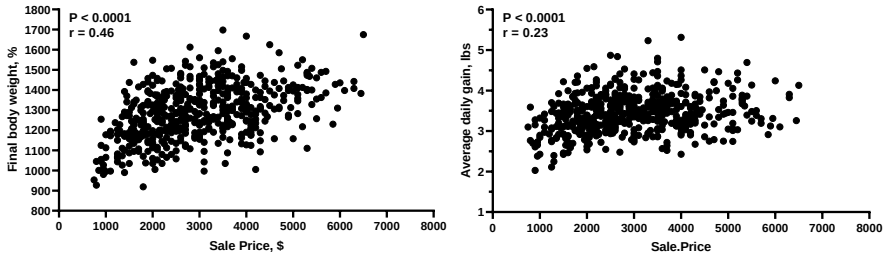
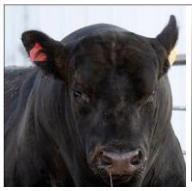
Factors Influencing Sale Prices at the University of Florida NFREC Bull Test



Final BW and ADG were significantly correlated with sale price
Residual feed intake (RFI) and feed to gain ratio (F:G) were not associated with sale price

7

ANGUS BEEF BULLETIN EXTRA



Even though buyers know that a bull should be fit, not fat, they tend to think there is something wrong with a bull that's not carrying extra weight at sale time. Bulls are likely to be too fat unless the breeder feeds just a growing ration — and some of the "growing rations" people claim to be feeding still contain too much energy.

Don't Buy a Fat Bull

Sale-season nutrition should prepare bull for work instead of beauty.

Bulls developed on growing rations usually carry more flesh than bulls raised on grass or wintered on hay, and it can be a major adjustment when they are turned out with cows. | HEATHER SMITH THOMAS PHOTO

Be leery about buying fat bulls

It may look good in the sale ring, but too much fat can lead to permanent damage

Grainews

Published: February 27, 2018
Cattleman's Corner, Livestock

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Is There a Relationship Between Sire Over Conditioning and Semen Quality?

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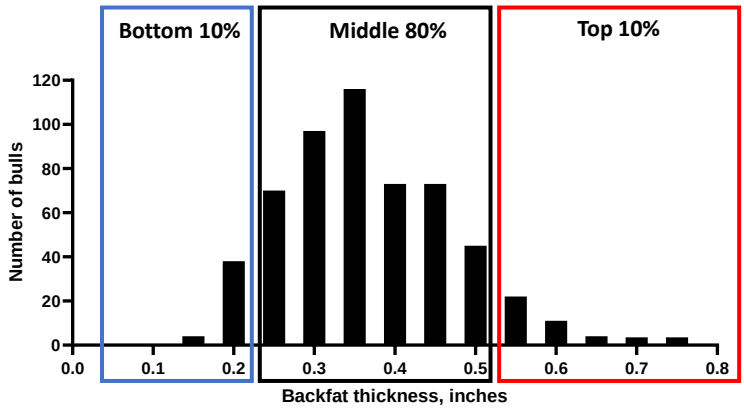
Distribution of Bulls According to Ultrasound Backfat Thickness Measurements



n = 557

UNIVERSITY OF GEORGIA Georgia Historical BSE Data. Not published 10

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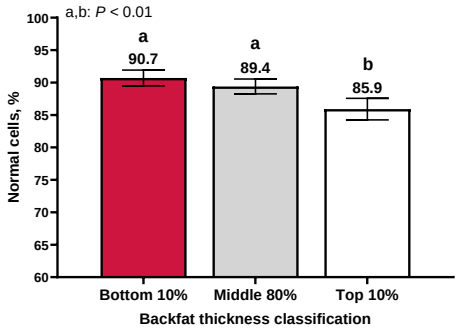
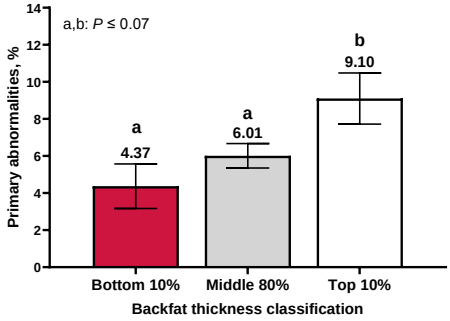
Impact of Back Fatness Classification on Sperm Morphology





No differences in secondary abnormalities (*P* = 0.44)

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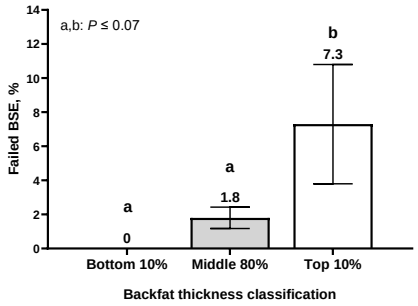
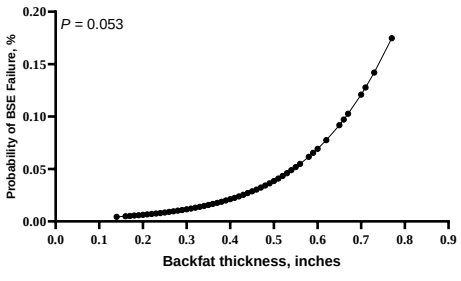
Impact of Back Fatness Classification on BSE Results





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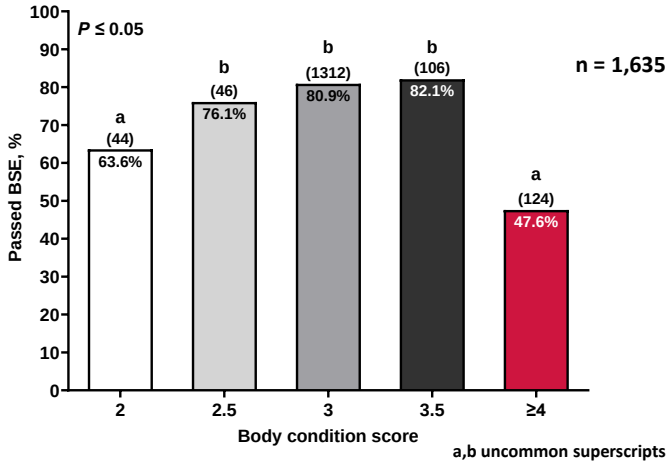
Impact of Body Condition Score on Breeding Soundness Examination Results



a,b uncommon superscripts differ: $P < 0.05$

Barth and Waldner, 2002. Can. Vet. J. 43:274-284

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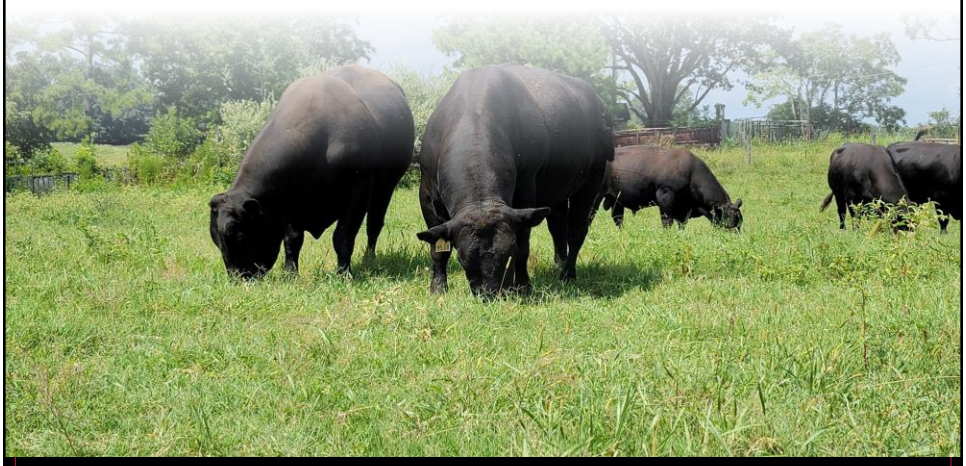
Can We Experimentally Induce This Phenotype?



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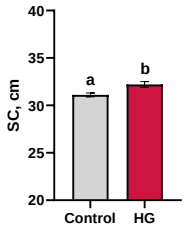
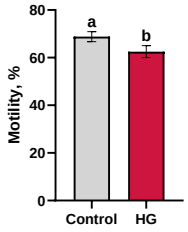
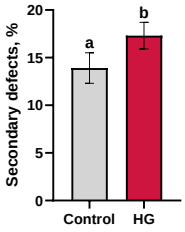
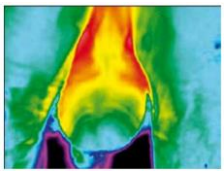
Effects of Dietary Energy on Sperm Parameters of Young Bulls









Infrared scrotal thermography:
HG had decreased temperature gradient compared with control bulls

Control: 100% forage
HG: 80% concentrate, 20% forage

Bulls were fed their respective diets for 165 days
a,b uncommon superscripts differ: $P < 0.05$

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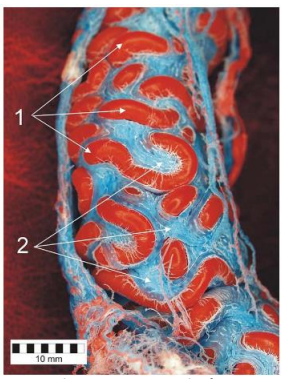
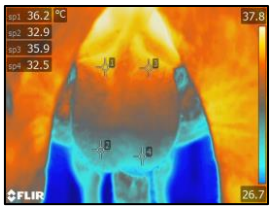
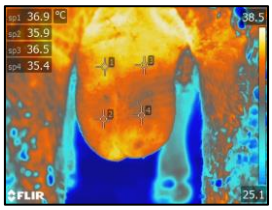
Representative Figure of Fat Accumulation in the Scrotum



Corrosion cast: 1 = testicular artery and 2 = veins of pampiniform plexus
Polguj et al., 2011. J. Morph. 272: 492-502





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Do We Need to Push Them for Puberty Purposes?

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High BW Gain and Puberty Achievement

2 weeks of age

High 2.6 lb/d

Low 1.1 lb/d

24 weeks of age (6 months)

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Effects of Treatment on Bull Sexual Development

- Diets successfully induced changes in body weight
- Diets successfully induced changes in metabolic hormones (IGF-1, insulin, leptin)

Item	Plane of Nutrition			
	Hi-Hi	Hi-Lo	Lo-Lo	Lo-Hi
Age at Puberty, d	298 + 6.3[a]	283 + 5.6[a]	319 + 3.9[b]	323 + 6.5[b]
Age at sexual maturation, d	331 ± 7.1[a]	314 ± 7.5[a]	343 ± 7.1[b]	352 ± 3.7[b]
Paired testis weight at 72 wks of age, g	660 ± 28.5	659 ± 19.8	629 ± 19.7	594 ± 26.6

a,b: uncommon superscript differ ($P < 0.05$)

Age at puberty: 50 million sperm with at least 10% motility
Age at sexual maturation: Passed a breeding soundness examination

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Influence of Diet on Semen Production in the Context of Artificial Insemination

Effects of early life nutrition on semen production from 13-15 months of age

Item	Plane of Nutrition			
	Hi-Hi	Hi-Lo	Lo-Lo	Lo-Hi
Number of straws*	308	205	177	92
Commercial value,$**	4619	3073	2662	1377

* 10 million sperm/straw
**Assumes $15 per semen straw

Take home message

Post-weaning growth have less impact on puberty than pre-weaning growth

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Bull Management After Purchase

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Bull Management After Purchase

- Changing from a concentrate to forage-based diet
- Placed in larger pastures
- Hierarchy in multi-sires pastures
- Breeding cows is a physically demanding activity
- Can lose 100-200 lbs during the breeding season

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Effects of Plane of Nutrition on Mature Bull Fertility

- Treatments (112-day feeding period):
  - Positive Energy Balance - gain 12.5% of body weight
  - Negative Energy Balance - lose 12.5% of body weight

	Treatment			
Item	NEG	POS	SEM	*P*-value
Rump fat, cm				
Beginning	0.42	0.48	0.09	0.68
End	0.29	0.90	0.11	0.001
Rib Fat, cm				
Beginning	0.38	0.40	0.05	0.76
End	0.25	0.64	0.10	0.02
LM area, cm				
Beginning	95.7	91.5	3.74	0.43
End	84.5	106.1	3.42	<0.001
Intramuscular fat,%				
Beginning	3.21	3.31	0.29	0.81
End	2.55	3.49	0.36	0.08

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Effects of Plane of Nutrition on Mature Bull Fertility

- Computer assisted sperm analysis (CASA)

  Frozen-thawed semen:
  - Negative energy balance (NEG) bulls had greater motility
  - Sperm classified as motile and progressively motile had greater velocity in NEG bulls

- Flow cytometry
  - Positive energy balance (POS) bulls had a greater proportion of sperm staining positive for reactive oxygen species
  - POS bulls had decreased mitochondrial membrane potential compared with NEG bulls

Over conditioning had a more pronounced detrimental effect compared with under conditioning

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Are There Post-Fertilization Consequences of High Energy Diets?

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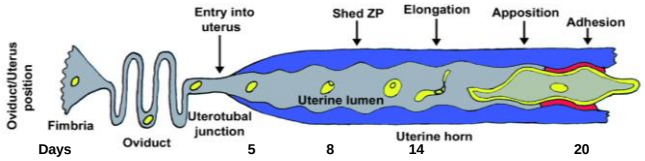
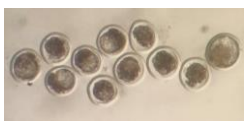
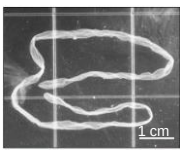
Early Pregnancy Development in Cattle



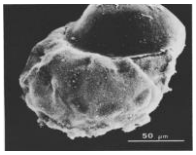


Day 7
Spherical

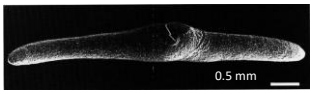
Day 13
Tubular



Day 17
Filamentous



Day 8
Spherical



Day 14

Spencer et al., 2004. Reproduction. 128:657-668
Guillomot, 1995. J. Reprod. Fert. 49: 39-51
Betteridge and Flechon, 1988. Theriogenolgy. 29:155-187
Moraes et al., 2018. PNAS. E1749-1758

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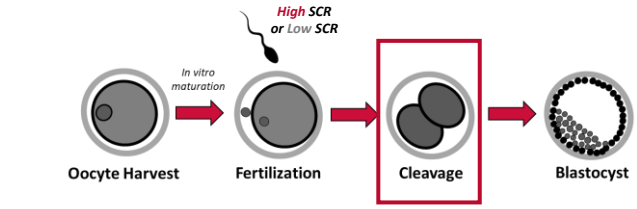
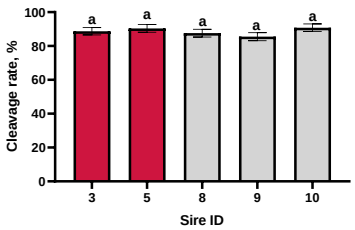
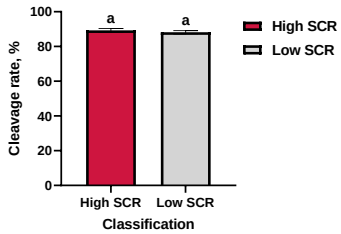
Influence of Sire Conception Rate (SCR) on Post-Fertilization Outcomes – IVP

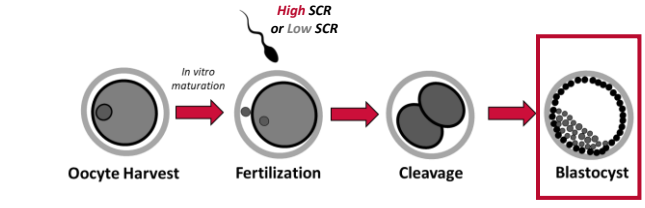


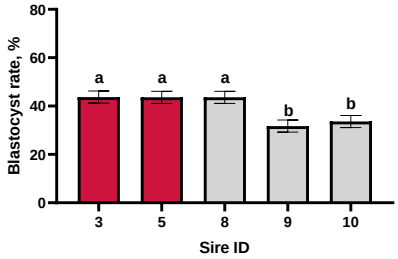


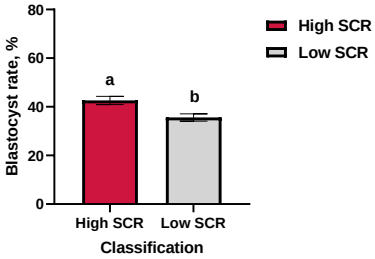


27

Influence of Sire Conception Rate (SCR) on Post-Fertilization Outcomes – IVP







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High Adiposity and Male Fertility - Humans

- Erectile disfunction
- Increased scrotal temperature
- Germ cell apoptosis
- Sperm oxidative stress
- Sperm DNA fragmentation
- Altered sperm parameters
- Decrease embryo production

Male Sub-fertility

Oliveira et al., 2017. Reproduction. 153: R173-R185 29

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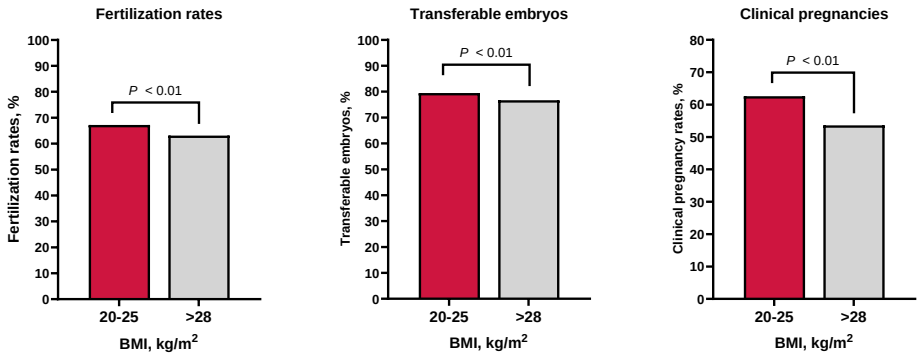
Paternal Body Mass Index (Adiposity) and Embryo Development - Human IVF Clinics



Yang et al., 2016. Sci. Ref. 6:29787 30

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Paternal High Fat Diets and Embryo Development and Pregnancy Establishment

Item	Control	High Fat	P-value
Cleavage rate[1], %	79.1	50.5	< 0.001
Early blastocysts[2], %	57.0	26.6	< 0.001
Hatched blastocysts[3], %	46.0	25.5	< 0.001
Implantation/transfer, %	86.7	73.3	< 0.05
Fetal development/transfer, %	38.7	21.3	< 0.05

[1] Day 2 of embryo culture
[2] Day 4 of embryo culture
[3] Day 5 of embryo culture

Mitchell et al., 2011. Fertility and Sterility. 95:1349-1353 31

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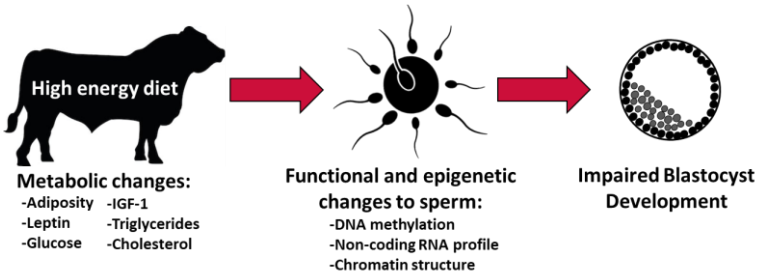
Effects of Sire High Energy Diets on Post-Fertilization Outcomes

Working hypothesis:



Seekford et al., 2023. Reproduction. 166:149-159 32

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Influence of Sire Diet on In Vitro Embryo Production

- Eight sires were randomly assigned to the same diet (NEm = 2.10, NEg = 1.44, CP = 14.1%, NDF = 16.6%, DM basis) fed at two different inclusion rates while having ad libitum access to bermudagrass hay (NEm = 1.02, NEg = 0.45, CP = 10.2%, NDF = 71.6).
- **High gain (HG): 1.25% of BW daily**
- **Maintenance (MAINT): 0.5% of BW daily**

67 days feeding period

Seekford et al., 2023. Reproduction. 166:149-159

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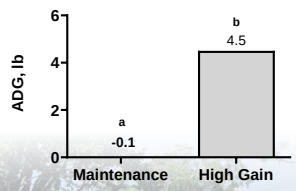
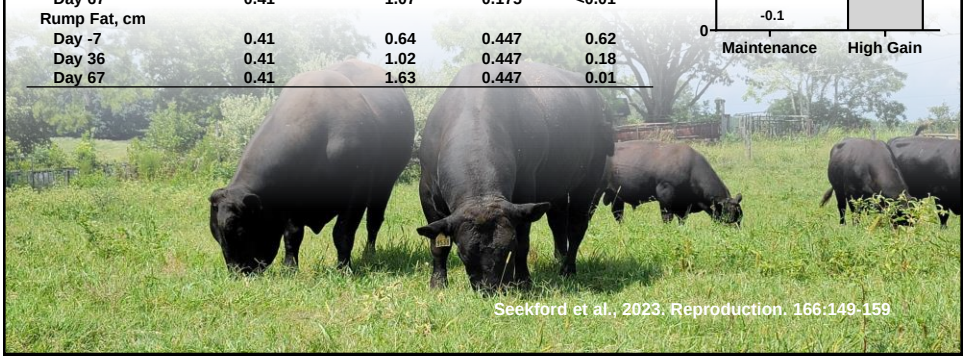
Effects of Sire Diet on Body Weight and Carcass Ultrasound Measurements

	Treatment			
	MAINT	HG	SEM	*P*-value
Body weight, kg				
Day -7	956	941	39.3	0.79
Day 36	951	1,009	39.3	0.31
Day 67	953	1,095	39.3	0.02
Subcut. Fat, cm				
Day -7	0.38	0.46	0.175	0.63
Day 36	0.36	0.64	0.175	0.13
Day 67	0.41	1.07	0.175	<0.01
Rump Fat, cm				
Day -7	0.41	0.64	0.447	0.62
Day 36	0.41	1.02	0.447	0.18
Day 67	0.41	1.63	0.447	0.01





Seekford et al., 2023. Reproduction. 166:149-159

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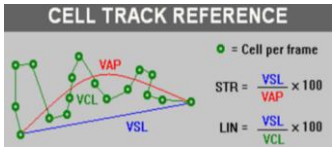
Computer Assisted Sperm Analysis (CASA)

	Maintenance		High Gain			P-value		
	Fresh	Frozen	Fresh	Frozen	SEM	TRT	Semen	TRT*Semen
Total Motility,%	73.81	29.98	72.60	21.15	8.32	0.63	<0.01	0.39
Progressive motility, %	71.58	24.39	67.38	16.28	8.58	0.53	<0.01	0.51
Local motility, %	3.65	5.16	5.13	4.96	0.75	0.75	0.35	0.26
Immotile, %	24.66	70.13	27.37	78.88	8.23	0.58	<0.01	0.46
VCL, microm/s	134.56	90.84	130.79	84.96	10.63	0.72	<0.01	0.90
VAP, microm/s	5.97	3.94	4.23	3.91	0.89	0.36	0.24	0.37
VSL, microm/s	46.04	37.42	45.55	38.14	2.84	0.97	0.02	0.83



VCL = Curvilinear velocity
VAP = Average velocity path
VSL = Straight-line velocity

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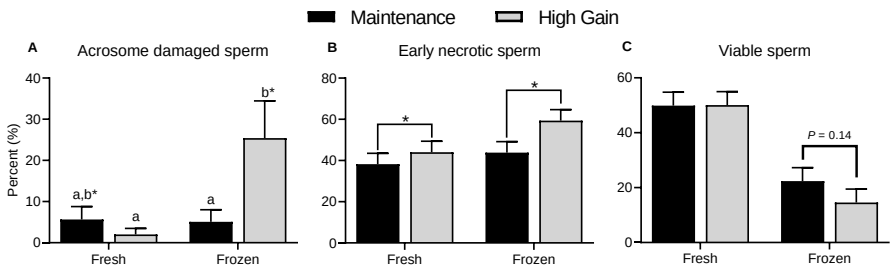
Impact of Treatment on Flow Cytometry Outcomes

	Maintenance		High Gain				P-value	
	Fresh	Frozen	Fresh	Frozen	SEM	TRT	Semen	TRT*Semen
Acrosome damaged sperm, %	5.64	5.09	2.00	25.42	9.04	0.62	0.02	0.02
Membrane intact sperm, %	69.69	32.31	56.62	33.60	8.77	0.59	<0.01	0.26
Viable sperm, %	47.90	22.37	50.09	14.56	4.90	0.43	<0.01	0.09
Necrotic sperm, %	0.41	0.20	0.40	0.17	0.10	0.79	<0.01	0.72
Early apoptotic sperm, %	38.21	43.86	44.03	59.38	5.31	0.09	0.09	0.41
Apoptotic sperm, %	13.18	33.18	5.23	25.05	6.99	0.17	<0.01	0.36



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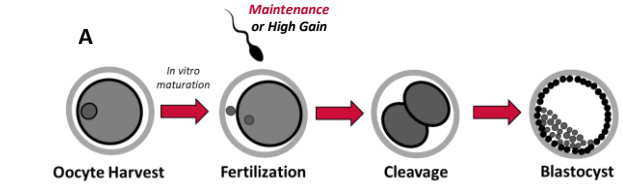
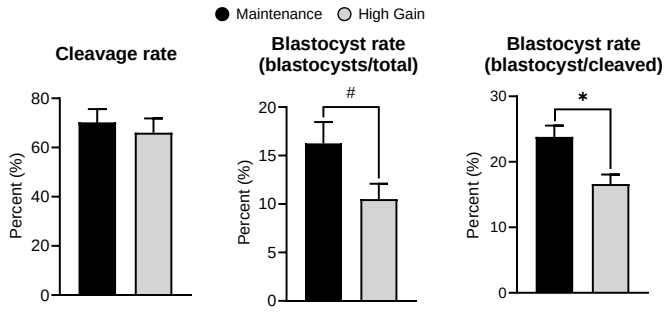
Influence of Sire Diet on In Vitro Embryo Production





# $P < 0.10$
* $P < 0.05$

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Seekford et al., 2023. Reproduction. 166:149-159 37

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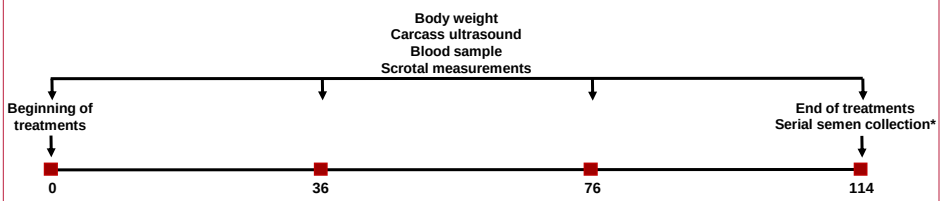
Impact of Bull Development Program on Sire Fertility – Experimental Design



- Eatonton Beef Research Unit
- n = 44 bulls – Half siblings
- Age: 359.4 ± 3.71 (mean ± SD)
- Dietary treatment was designed to achieve:
  - High gain: Target gain = 4 lbs/d (1.8 kg/d)
  - Moderate gain: Target gain = 2.7 lbs/d (1.2 kg/d)

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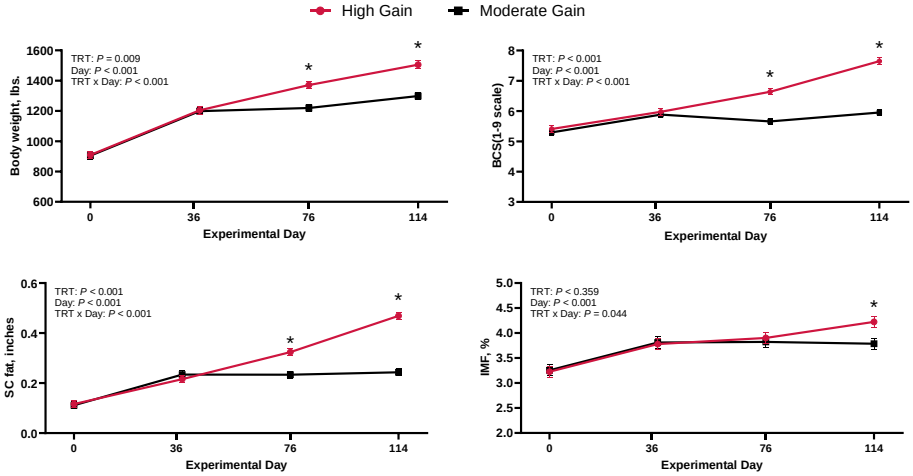
Effect of Treatment on Body Weight and Carcass Composition



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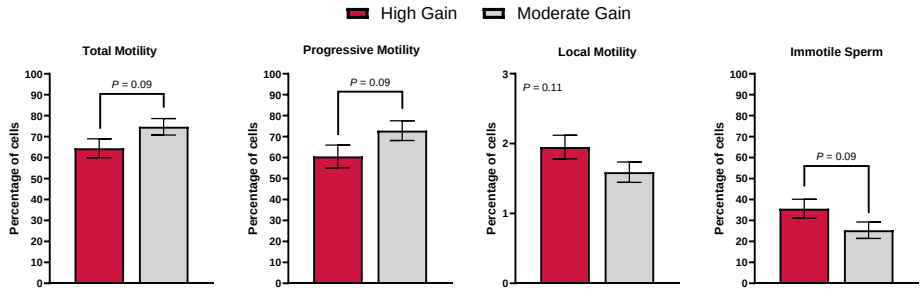
Impact of Treatment on Sperm Motility Using CASA



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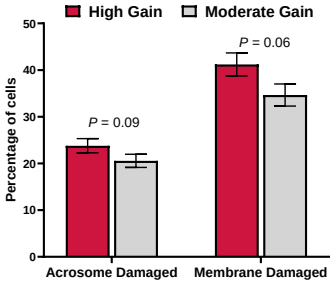
Impact of Treatment on Flow Cytometry Outputs

Item	Treatments		SEM	*P*-value
	High Gain	Moderate Gain		
0 min in-vitro culture				
Acrosome damaged sperm, %	14.8	12.3	1.24	0.14
Membrane damaged sperm, %	26.0	22.4	2.43	0.28
30 min in-vitro culture				
Acrosome damaged sperm, %	25.3	21.8	1.45	0.09
Membrane damaged sperm, %	41.2	34.6	2.46	0.06



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Davis et al., (not published) 41

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Summary

- Nutritional programs can focus on promoting growth: however, excessive fat deposition can have detrimental effects on fertility
- Extreme anabolic conditions can negatively impact sire fertility
  - Decreased semen quality
  - Increased sensitivity to stressors (freezing and thawing process)
- Extremely anabolic conditions appear to negatively impact early embryonic development in cattle
- Consequences of extreme anabolic conditions to conceptus development past the blastocyst stage remains unknown

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Thank you!

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