Genetic and Physiological Approaches to Improve Reproductive Fitness of Brahman-Influenced Cattle

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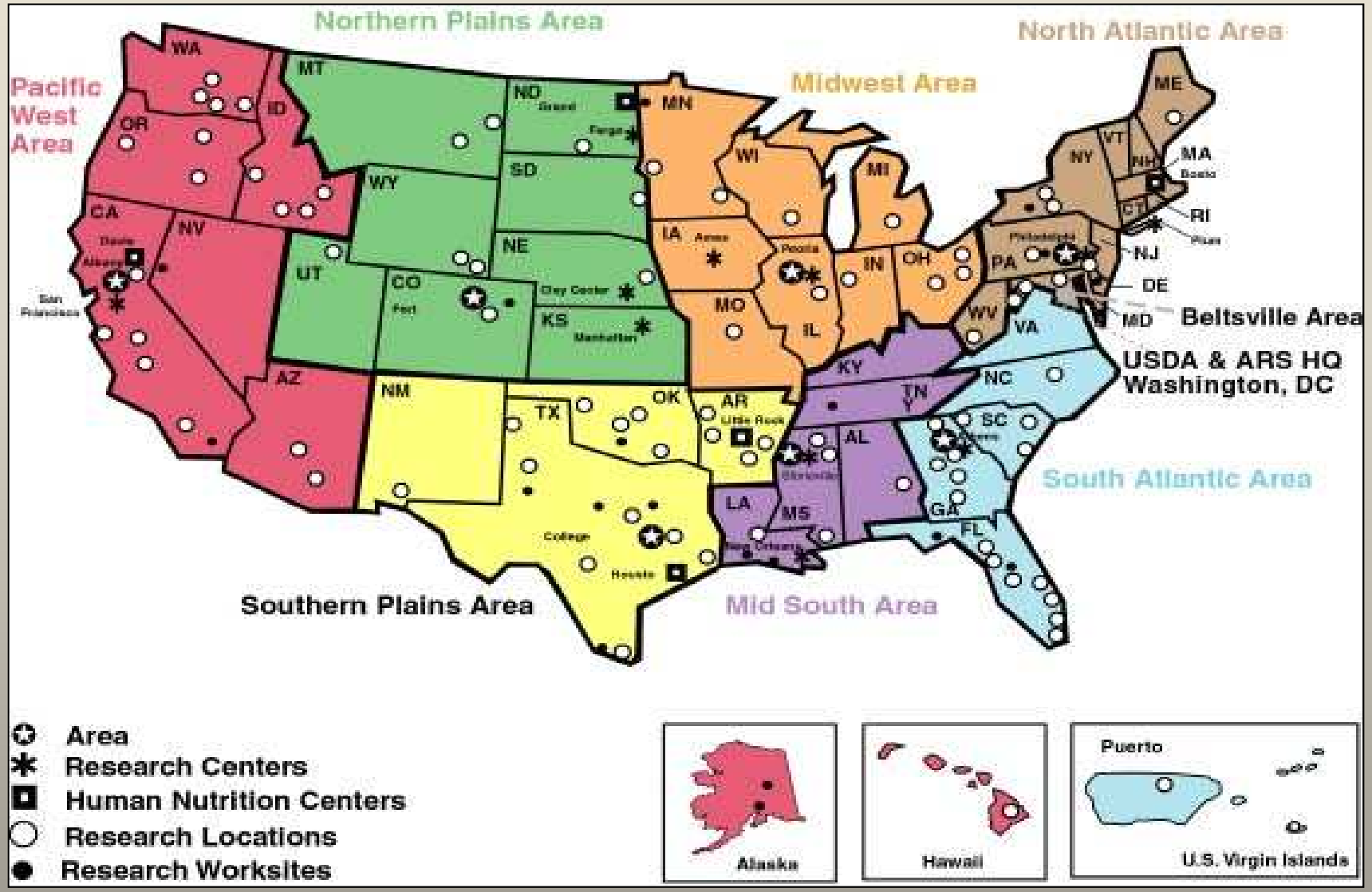
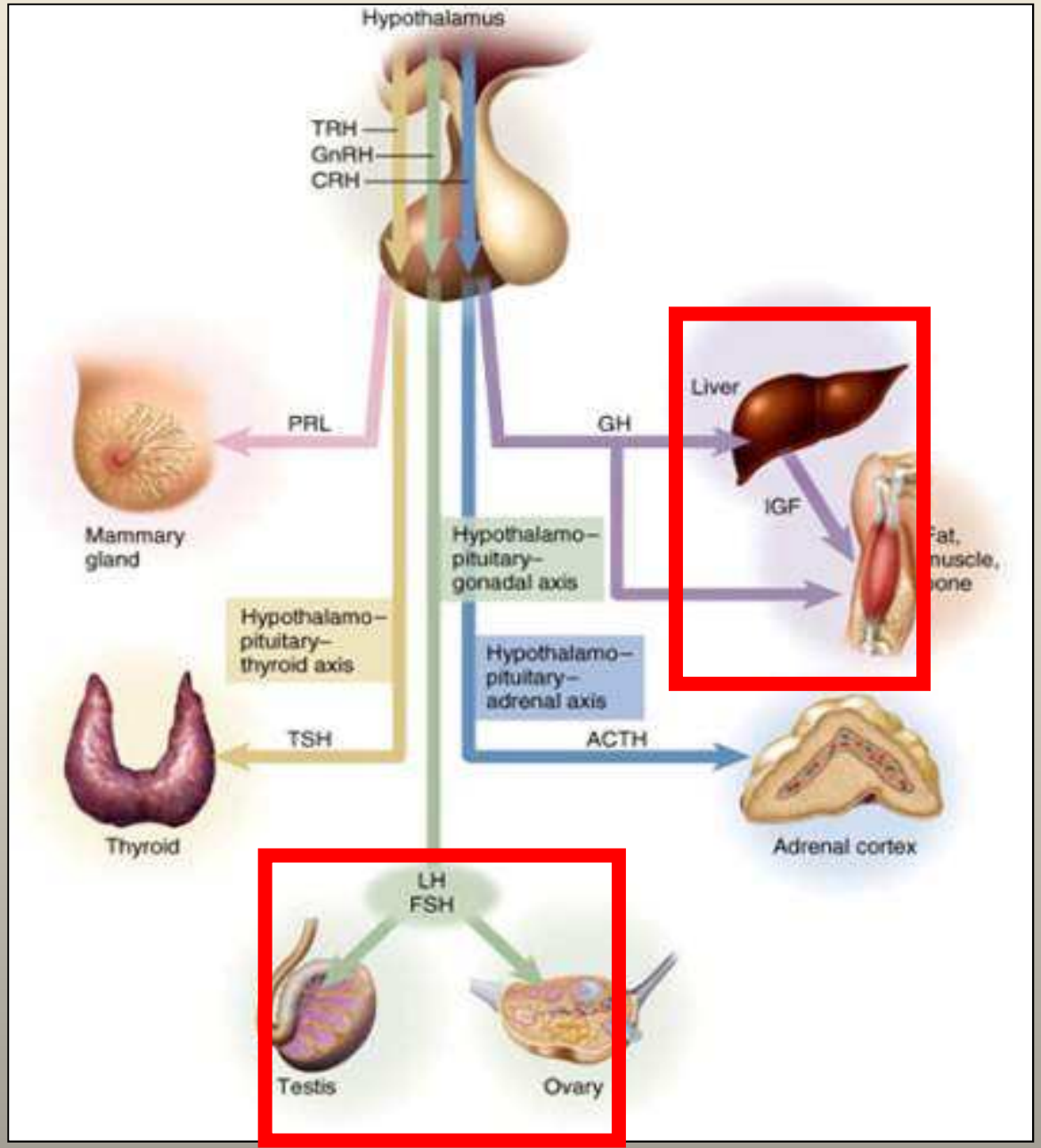


Reproductive fitness

- **Estrus, follicular dynamics, pregnancy/calving rate**
- **Numerous environmental factors influence reproduction**
  - Nutrition can be controlled by cattle producer *(Dunn and Moss, 1992)*.
- **Nutritional status of the bovine is communicated within the hypothalamic-pituitary-ovarian axis**


Hypothalamus
TRH
GnRH
CRH
PRL
GH
Liver
IGF
Mammary gland
Hypothalamo–pituitary–gonadal axis
Hypothalamo–pituitary–thyroid axis
Hypothalamo–pituitary–adrenal axis
TSH
ACTH
Thyroid
Adrenal cortex
LH
FSH
Testis
Ovary

Research Goal

A 10% increase in the annual calf crop (85%) would allow the production of the same kilograms of beef from 12% fewer cows.

Less stored feed, less water usage, less animal waste.

Minimize the carbon footprint of beef production while producing same amount of beef.

Energy intake regulates reproductive fitness

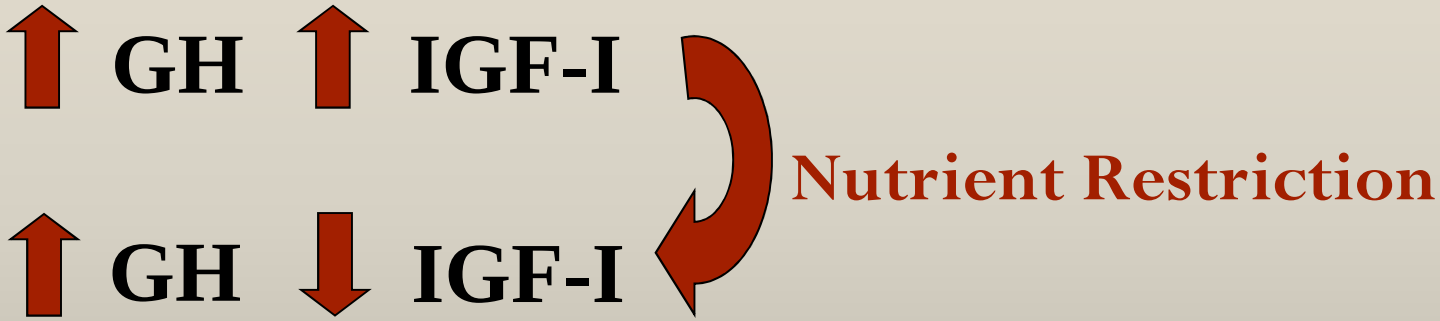
Priority of energy use by the cow

1. **Basal metabolism**
2. **Grazing and other physical activities**
3. **Growth**
4. **Supporting basic energy reserves**
5. **Maintaining pregnancy**
6. **Milk production**
7. **Adding body fat**
8. **Estrous cycle/initiating pregnancy**
9. **Storing excess energy**

Short et al., 1990

Nutrition and growth hormone

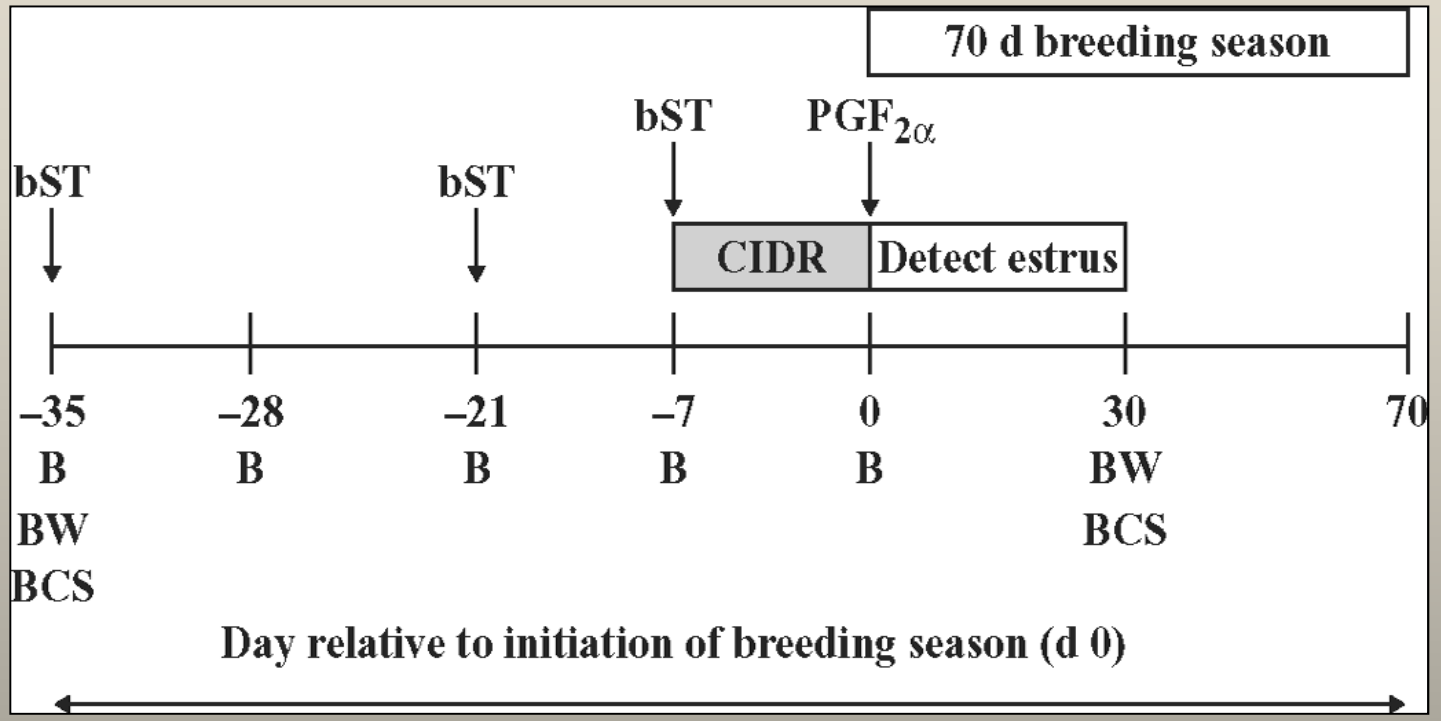
- **Nutrient restriction uncouples the positive relationship of the GH:IGF-I axis (Butler et al., 2003):**



- **One of the endocrine signals likely to inform the reproductive axis of the nutritional status in cattle is IGF-I (Meikle et al., 2004).**

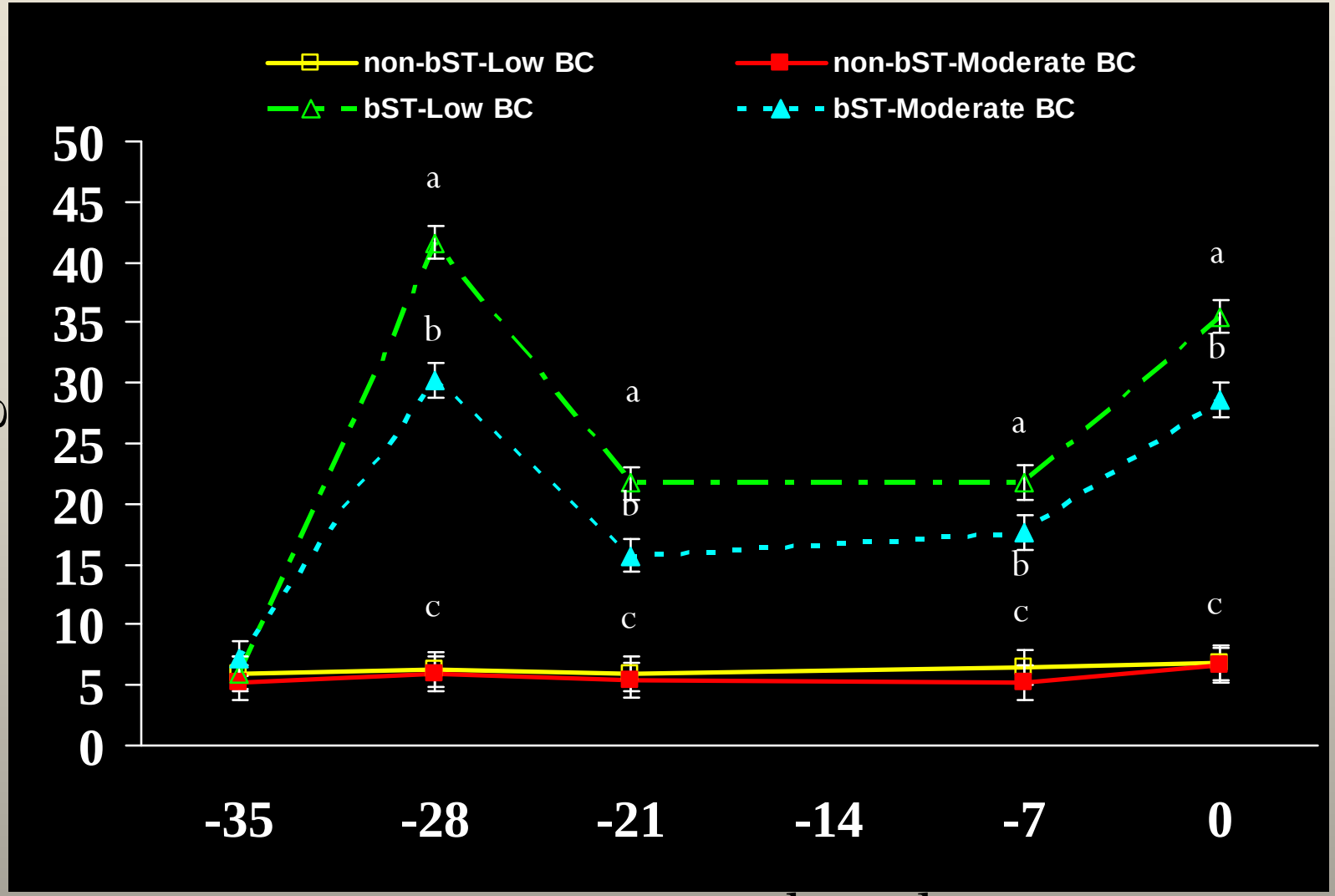
Methods

- **Spring-calving multiparous Brahman-influenced cows (n = 99; 32 ± 2 d postpartum)**
  - **Low BC (BCS = 4.2 ± 0.1)**
  - **Moderate BC (BCS = 6.1 ± 0.1)**

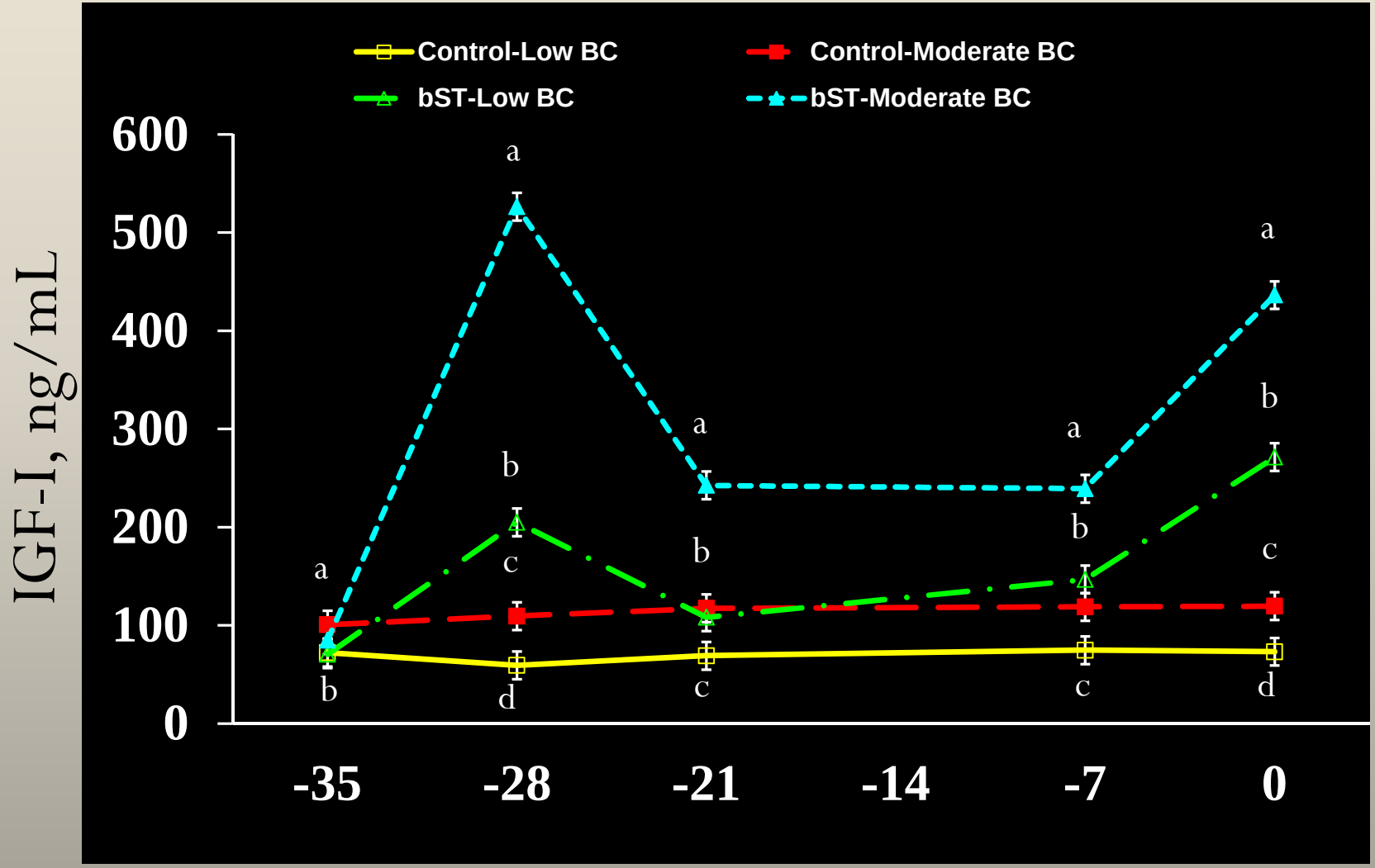


Flores et al., 2007

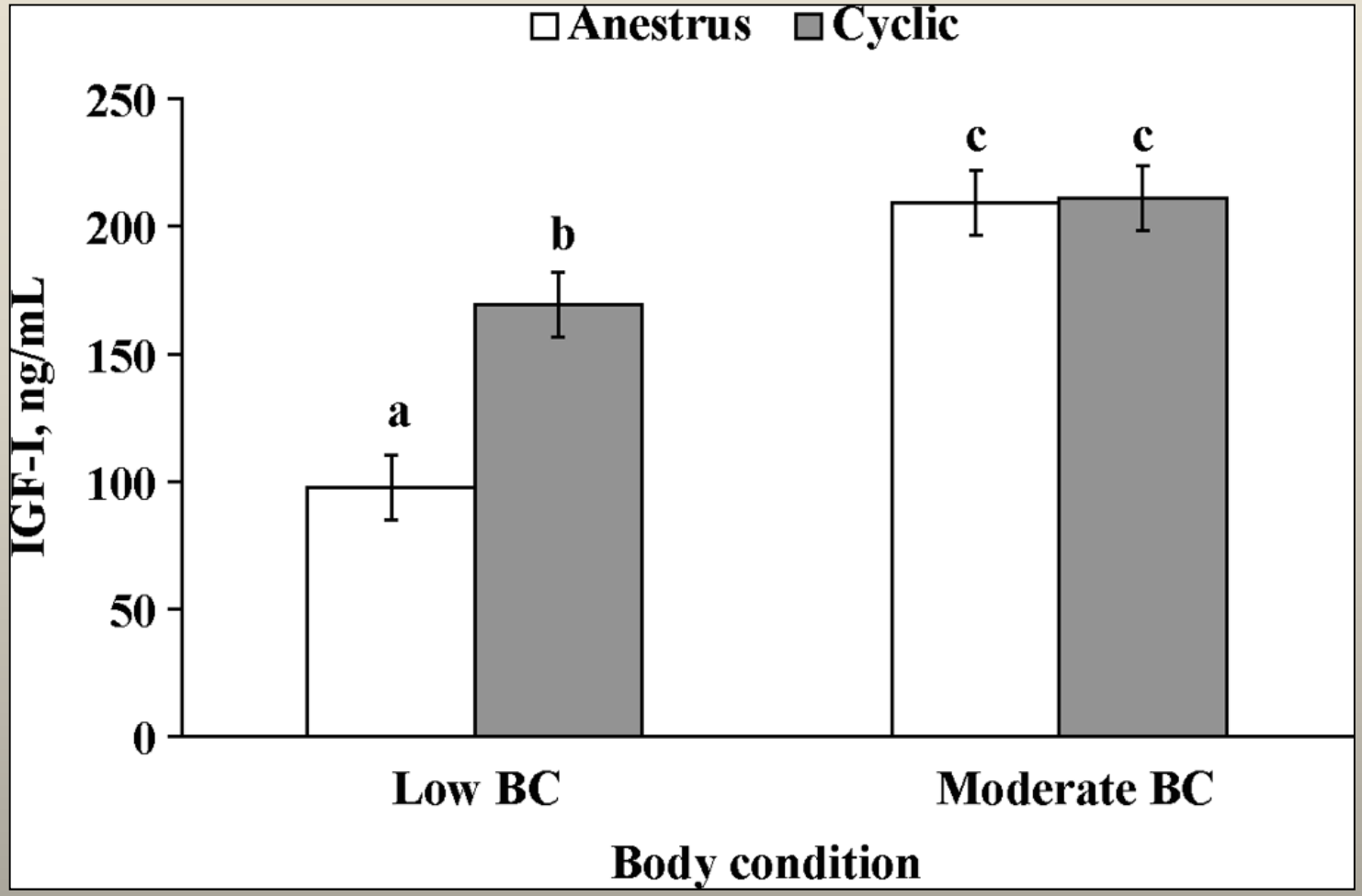
Influence of treatment, body condition (BC), and day on concentrations of GH



Influence of treatment, body condition (BC), and day on concentrations of IGF-I



Luteal status x body condition effects on concentrations of IGF-I



Flores et al., 2008

Influence of body condition (BC) and bovine somatotropin (bST) on synchronization, first-service conception, and pregnancy rate of cows during the first 3 d of the breeding season

	Treatment				P value		
	Non-bST		bST				
Variables	Low BC	Moderate BC	Low BC	Moderate BC	Trt	BC	Trt x BC
No. of cows	25	24	25	25	-	-	-
Synch. rate, %	40	54	56	52	0.31	0.29	0.13
Conception rate, %	30	15	50	62	0.01	0.52	0.49
Pregnancy rate, %	12	8	28	32	0.02	0.85	0.60

Flores et al., 2007

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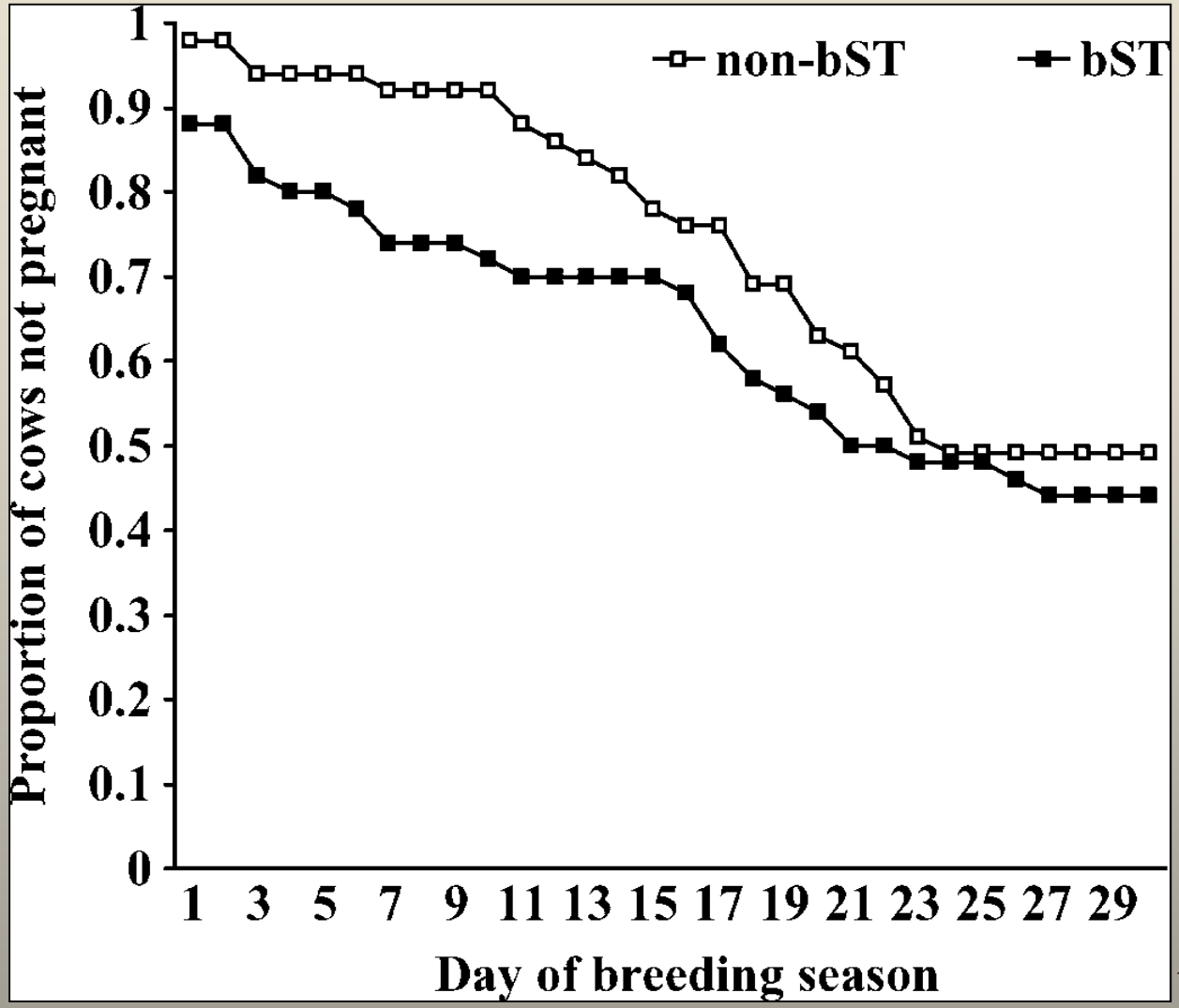
Flores et al., 2007

Influence of body condition (BC) and bovine somatotropin (bST) on interval to estrus and estrous characteristics during the first 3 d of the breeding season of cows

	Treatment				P value		
	Non-bST		bST				
Variables	Low BC	Moderate BC	Low BC	Moderate BC	Trt	BC	Trt x BC
No. of cows	25	24	25	25	-	-	-
Interval to estrus, d	6.4 ± 2.1	5.0 ± 2.1	3.7 ± 1.9	9.6 ± 1.8	0.63	0.28	0.07
Duration of estrus, h	5.4 ± 1.7	8.2 ± 1.2	3.0 ± 1.5	8.1 ± 1.2	0.37	0.01	0.40
No. of mounts received	15.6 ± 6.8	34.5 ± 4.9	3.4 ± 6.1	26.0 ± 5.0	0.07	0.002	0.73
Quiescence between mounts, h	0.4 ± 0.1	0.3 ± 0.1	0.8 ± 0.1	0.3 ± 0.1	0.03	0.004	0.05

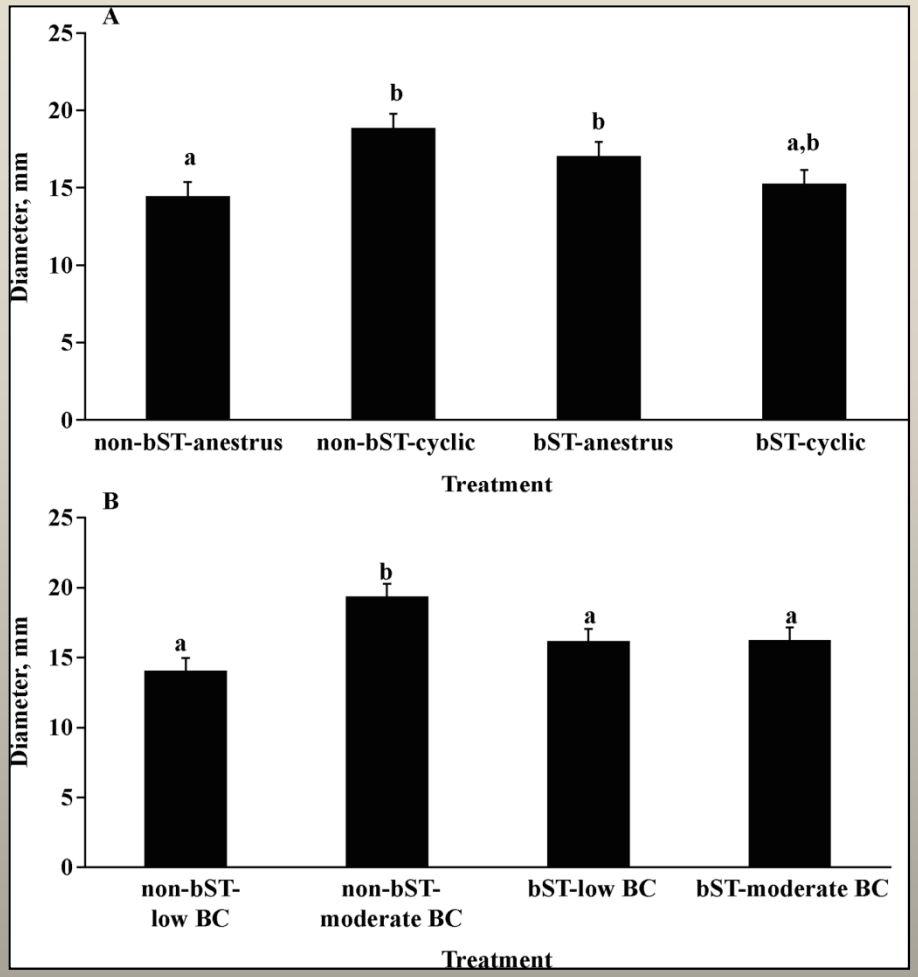
Flores et al., 2007

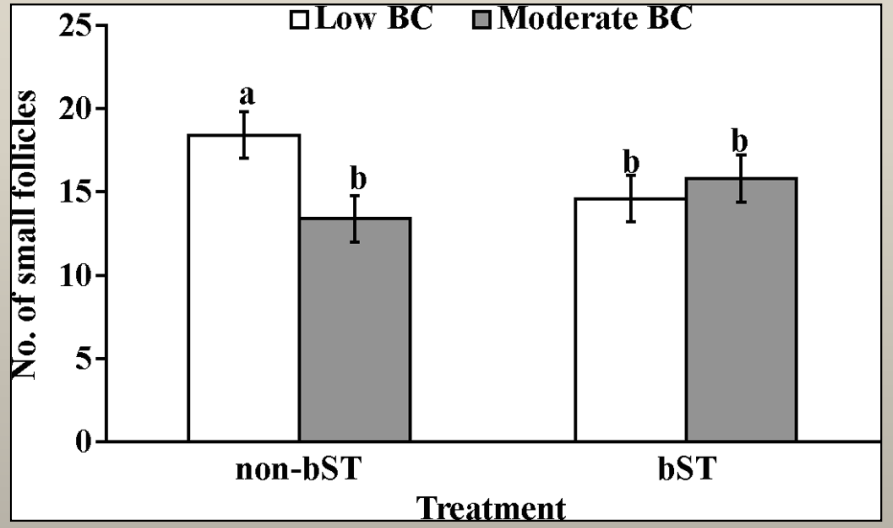
Somatotropin influenced number of cows pregnant during first 25 days



Flores et al., 2007

Influence of somatrotopin on follicular dynamics of cattle





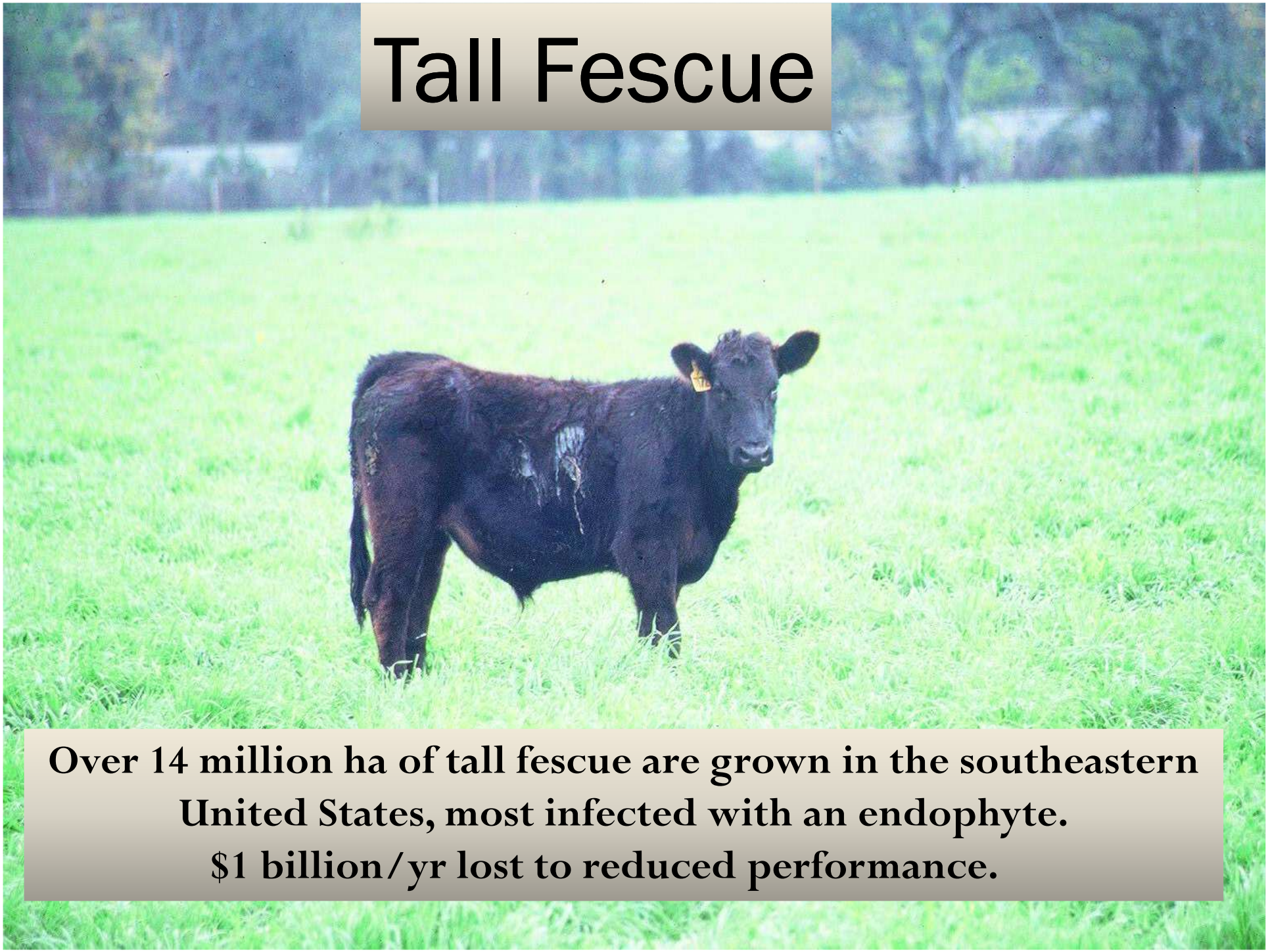
Flores et al., 2008

Implications

- **Decreased estrous behavior in thin cows may be associated with increased concentrations of growth hormone.**

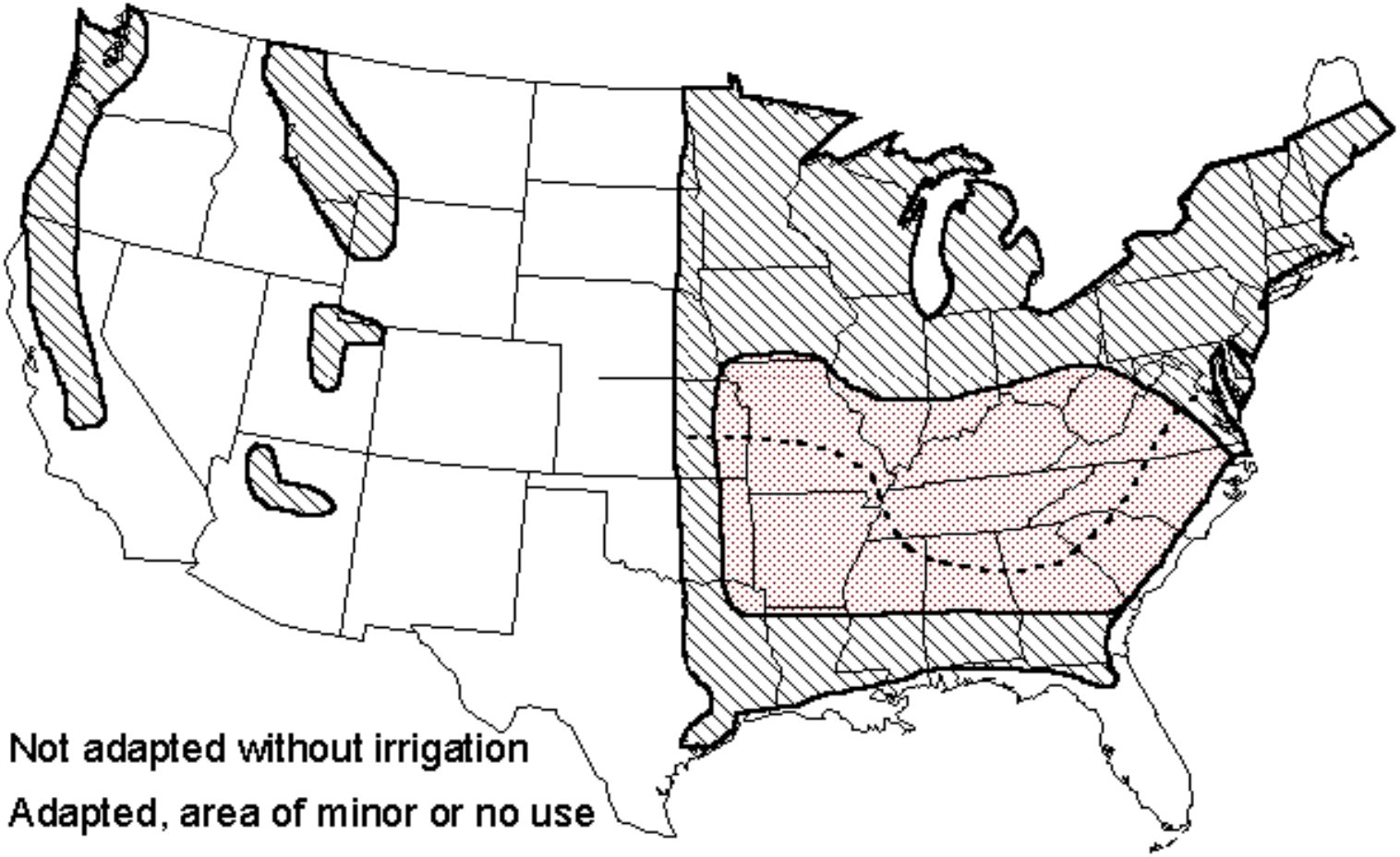
- **Undernutrition of cattle may be communicated to the hypothalamic-pituitary-ovarian axis via metabolic hormones including GH, IGF-I and prolactin.**

Tall Fescue



Over 14 million ha of tall fescue are grown in the southeastern United States, most infected with an endophyte.
$1 billion/yr lost to reduced performance.

Adaptation and use of tall fescue in the U.S.



Not adapted without irrigation

Adapted, area of minor or no use

Adapted, area of major use

----- Endophyte presence may be important for persistence south of dashed line depending on grazing management, cultivar and soil.

Tall fescue in South America

- **Mostly widely grown cool season perennial grass in Uruguay and Argentina.**

- **In Argentina, 30% of total cultivated pasture area (3,500,000 ha).**

Jose De Battista, INTA EEA Concepción del Uruguay Entre Ríos, Argentina

5th International Symposium on *Neotyphodium*/Grass Interactions, Fayetteville AR, USA

Endophyte-Plant-Animal Relationship

- **Advantages to plant**
  - **Stress (drought and grazing) tolerance**
  - **Low input**

- **Disadvantages to cattle**
  - **Poor production**
  - **Health maladies**
  - **Fescue foot**
  - **Fat necrosis**
  - **Fescue toxicosis**

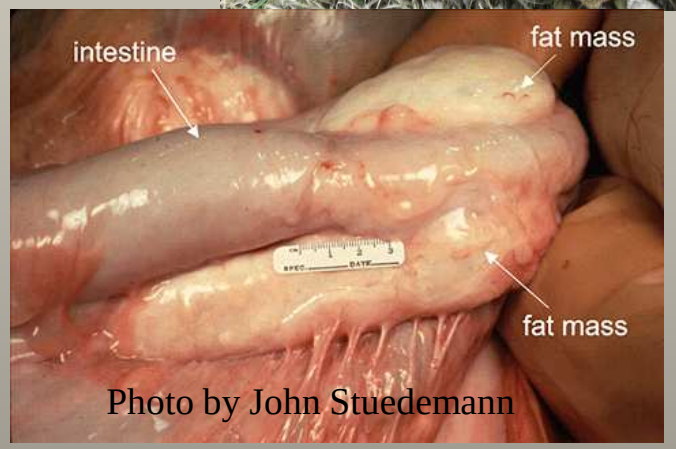
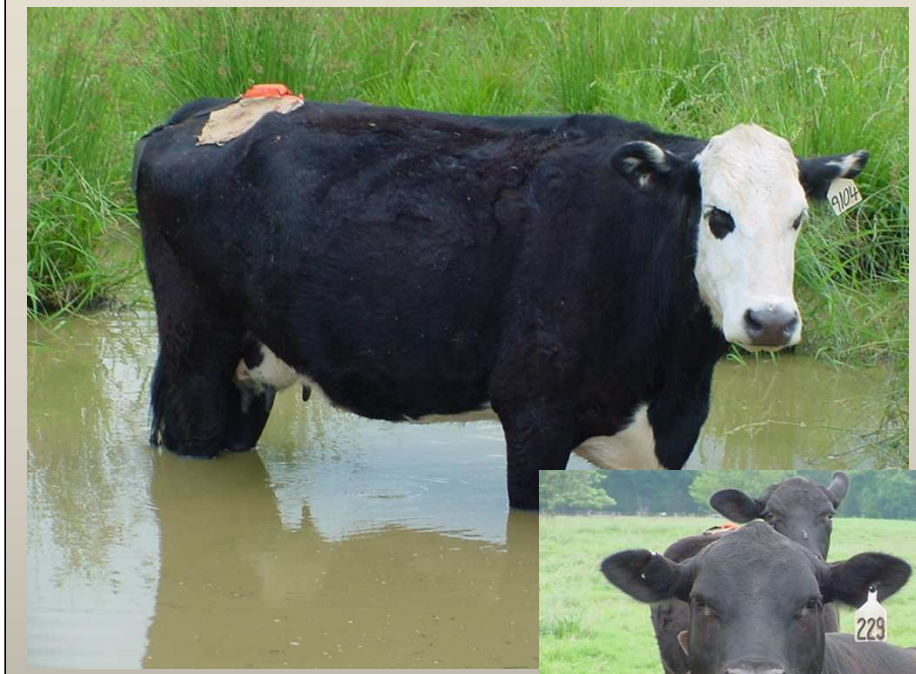


Photo by John Stuedemann

Influence of toxic fescue and body condition on reproduction



Methods

- **Spring-calving, multiparous Brahman-influenced cows**
  - **Thin body condition (BCS = 4.7 ± 0.1; n = 106)**
  - **Good body condition (BCS = 6.6 ± 0.1; n = 121)**

- **During the 60-d breeding season (2 years), cows within each BCS were assigned to:**
  - **common bermudagrass (CB; n = 3 pastures)**
  - **toxic tall fescue (EI; n = 3 pastures)**

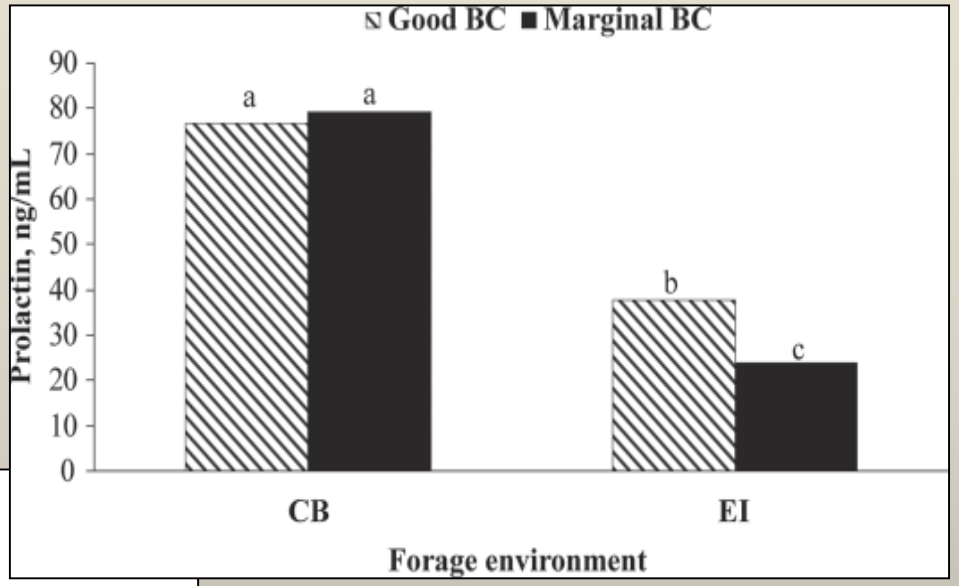
- **Estrous behavior was monitored using a radiotelemetry system (Heatwatch) during the first 30-d of the breeding period.**
  - **Cows exposed to bulls (1 bull/20 cows) from 11 May to 11 July.**

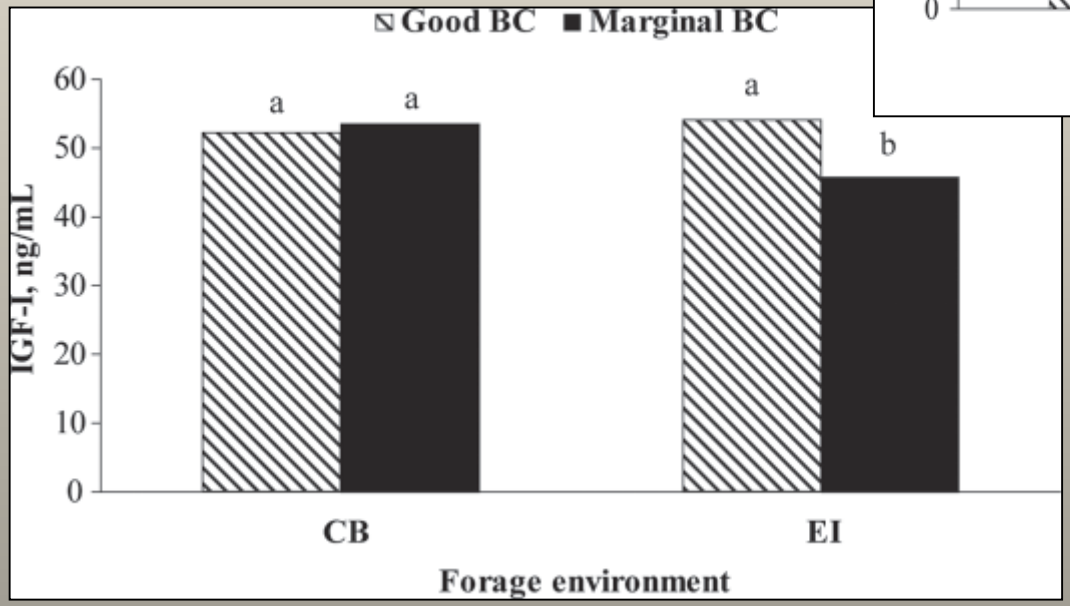
Body condition (BC) score and BC change of cows grazing either common bermudagrass or endophyte-infected tall fescue during the breeding period

	Forage				P value		
	Bermuda		Fescue				
Item	Marginal BC	Moderate BC	Marginal BC	Moderate BC	F[1]	BC	F x BC
No. of cows	30	30	25	25	--	--	--
BCS							
d 0	4.9 ± 0.1	6.5 ± 0.1	4.9 ± 0.1	6.6 ± 0.1	0.83	0.01	0.98
d 30	5.3 ± 0.2	6.4 ± 0.2	5.2 ± 0.2	6.2 ± 0.2	0.68	0.01	0.99
d 60	5.4 ± 0.2	6.3 ± 0.2	4.9 ± 0.2	5.9 ± 0.2	0.14	0.01	0.63
BCS change	0.5 ± 0.2	-0.2 ± 0.2	-0.1 ± 0.2	-0.6 ± 0.2	0.07	0.01	0.61

[1]Forage

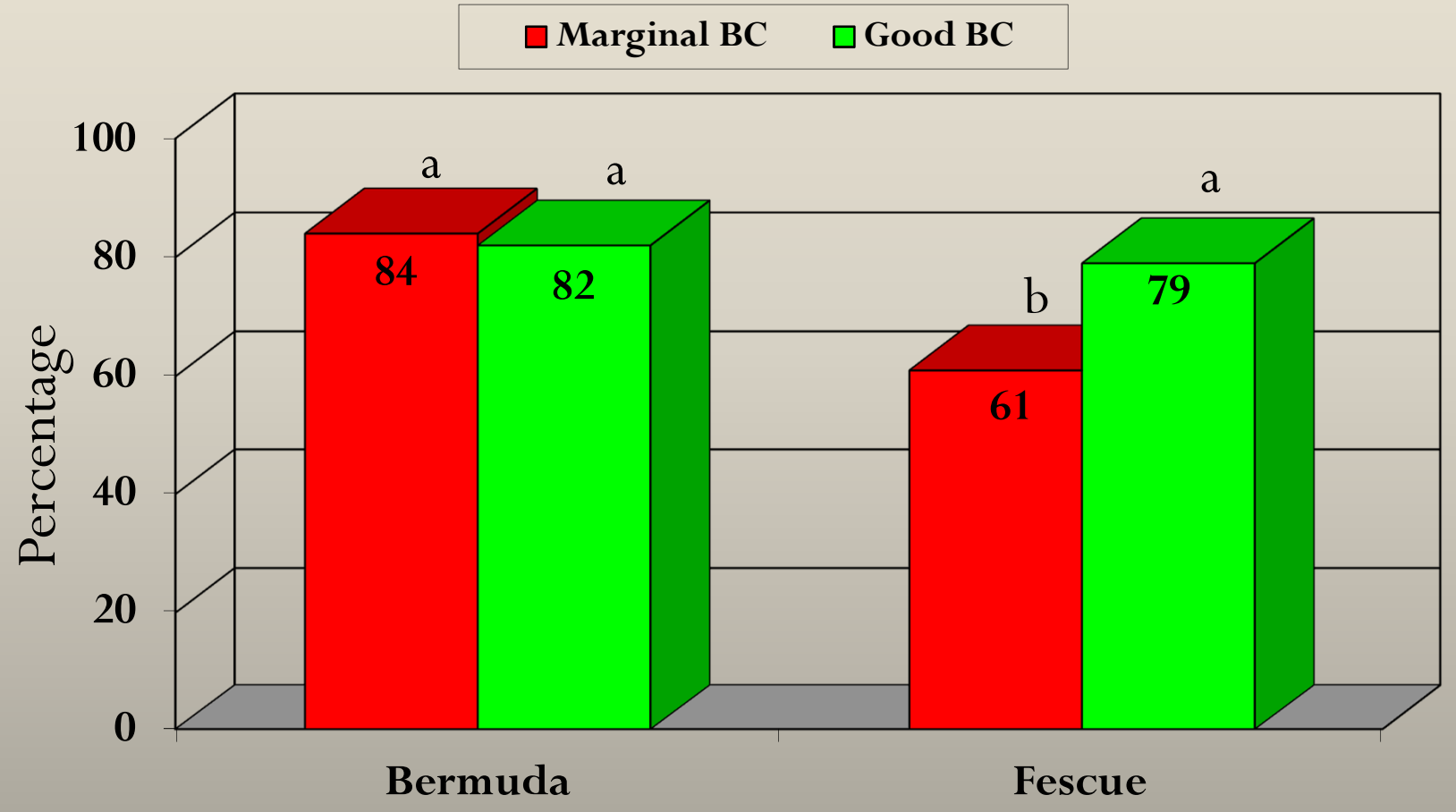
Influence of body condition on endocrine function in cattle





Looper et al., 2010

Influence of body condition (BC) and forage type on calving rate of cows



$^{a,b}p = 0.04$

Looper et al., 2010

Conclusions

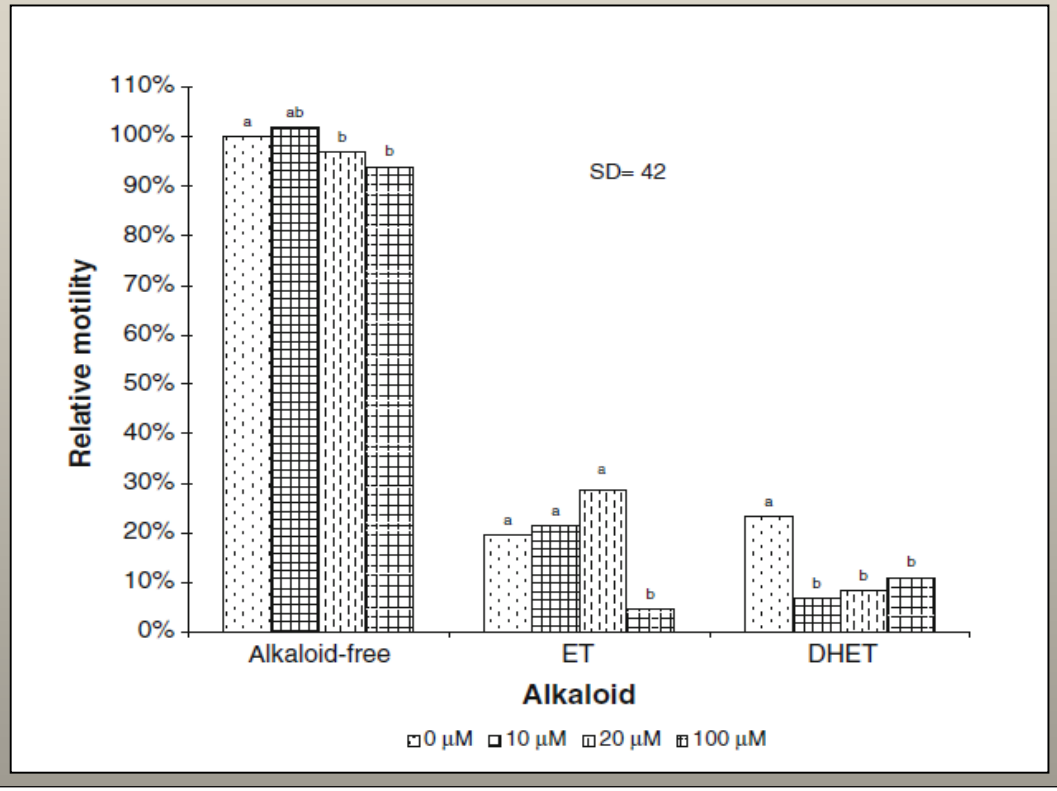
- Cows grazing toxic tall fescue had lower body weight at day 30 and 60 of breeding.
  - Cows grazing fescue gained less during the breeding period than cows grazing bermudagrass.
- Cows grazing fescue pastures during the breeding season tended to have a decrease in body condition.
- Cows grazing fescue had decreased rump fat at the end of the breeding season compared with cows grazing bermudagrass.

Conclusions

- Estrous characteristics of cows did not differ between forage type, body condition, or the interaction.
- Percentage (73%) of cows exhibiting estrus during the first 30 d of the breeding period was similar among all treatment groups.

Effect of toxic fescue on male reproductive fitness

- Majority of research has focused on the female.
- Fertility of 1 bull will impact the ability of 20 to 25 cows to produce offspring.



Wang et al., 2009

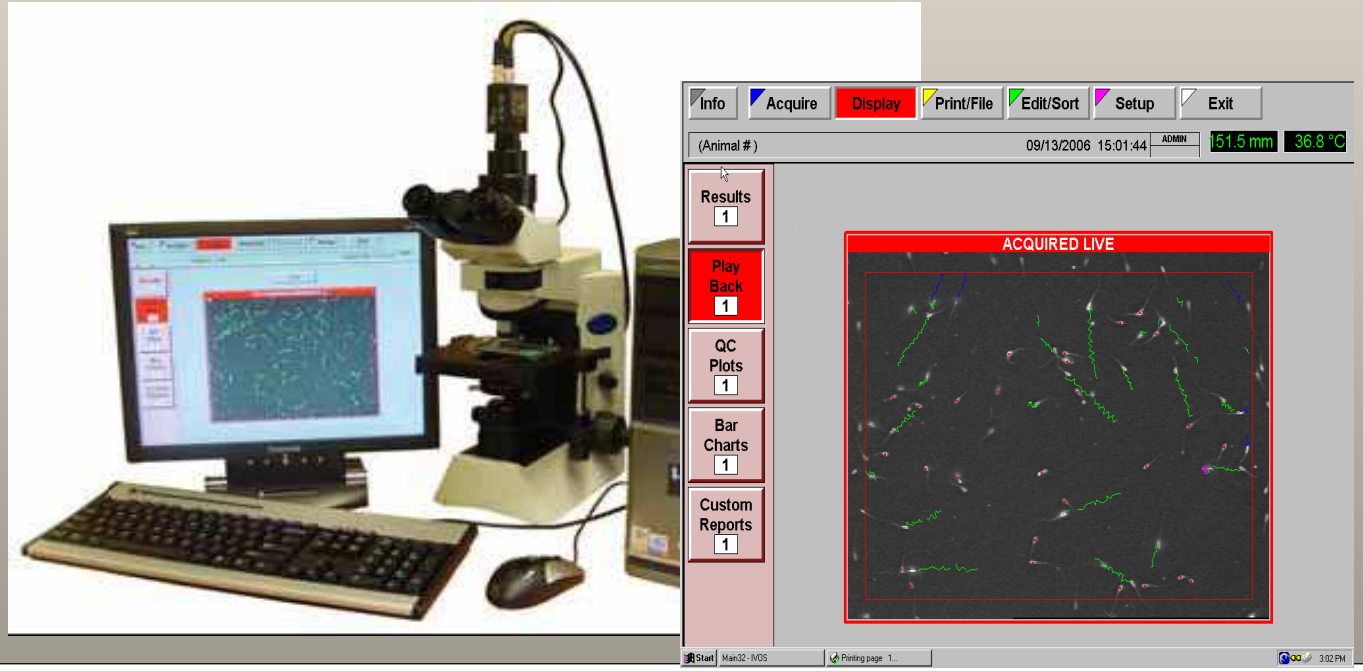
Methods

- **Sixteen (mean age = 1.1 ± 0.1 yr; mean BW = 478 ± 34 kg) Brahman-influenced bulls**
  - **1/8 to 3/16 Brahman-influence**
- **Bulls were randomly assigned to graze:**
  - **Toxic (4 bulls/pasture; 2 pastures)**
  - **Novel endophyte-infected (4 bulls/pasture; 2 pastures)**
- **Bulls grazed pastures from 19 April to 16 August**

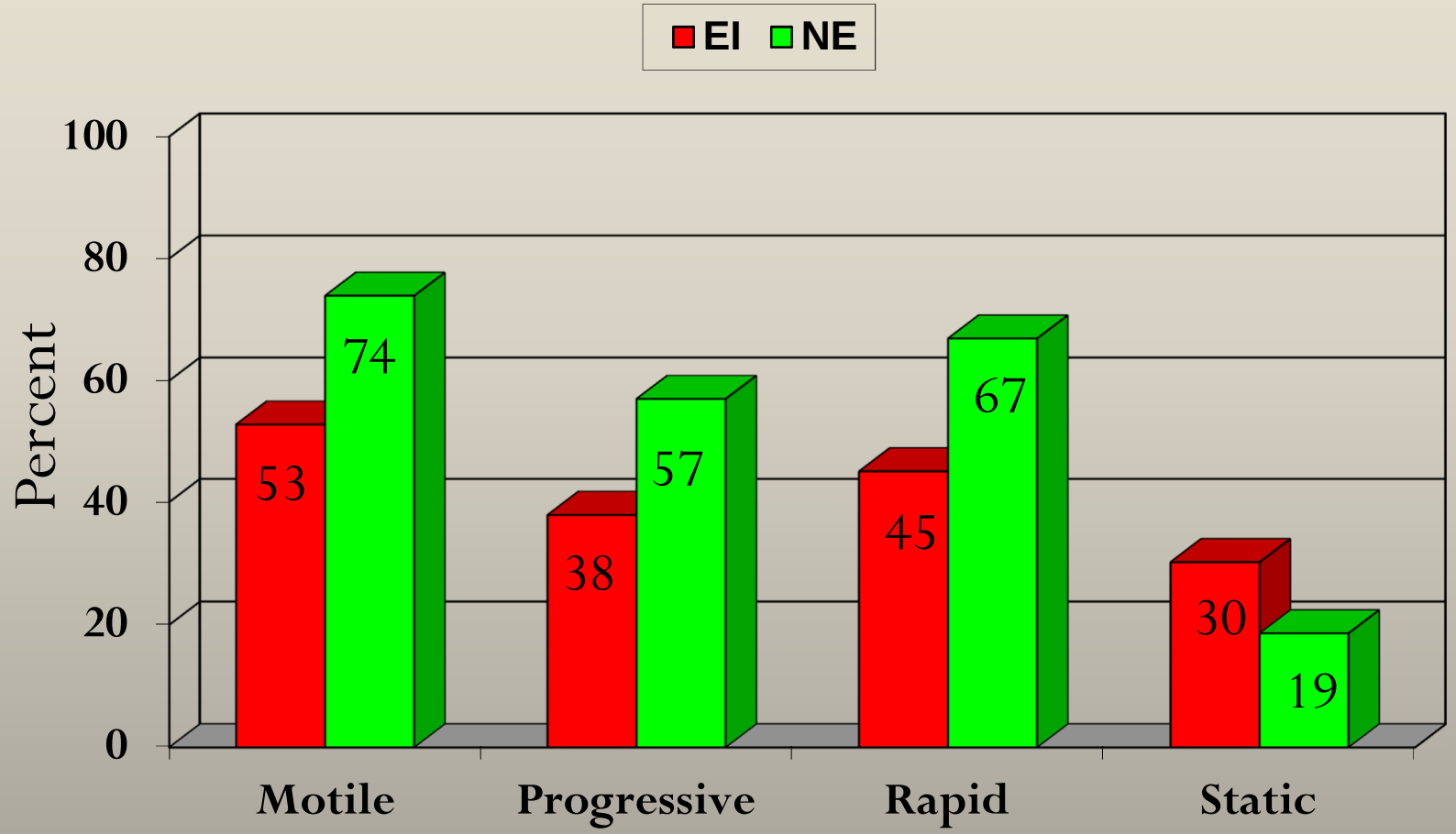
Methods

- **Semen was collected by electroejaculation.**
  - **Percent of live/dead semen was recorded.**
  - **Percent with minor and major defects recorded.**

- **Semen was evaluated using a computer-assisted sperm analysis system (CASA).**



Influence of toxic (EI) or novel endophyte-infected (NE) tall fescue on semen characteristics of Brahman-influenced bulls



$P \leq 0.07$

July and August

Looper et al., 2009

Implications

Semen from bulls grazing toxic tall fescue may have reduced sperm motility.

Decreased semen quality may be further reduced by increased temperature.

Exposure to toxic fescue 60 days prior to breeding may affect bull fertility.

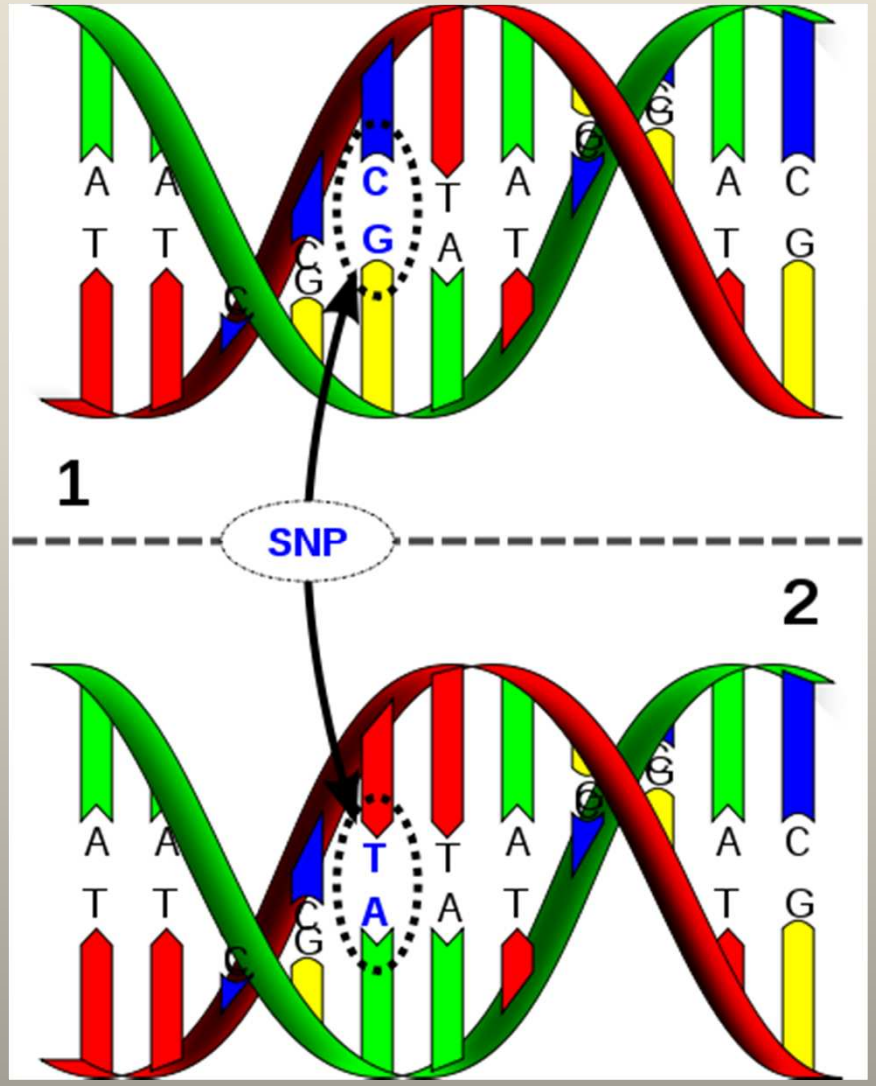
Specific candidate genes

- Primary role of prolactin (PRL) is development of the mammary gland and lactation.
  - May be involved with more than 300 different functions.
  - Enhancer element serves as an attachment region for transcription factors that augment or repress transcription.

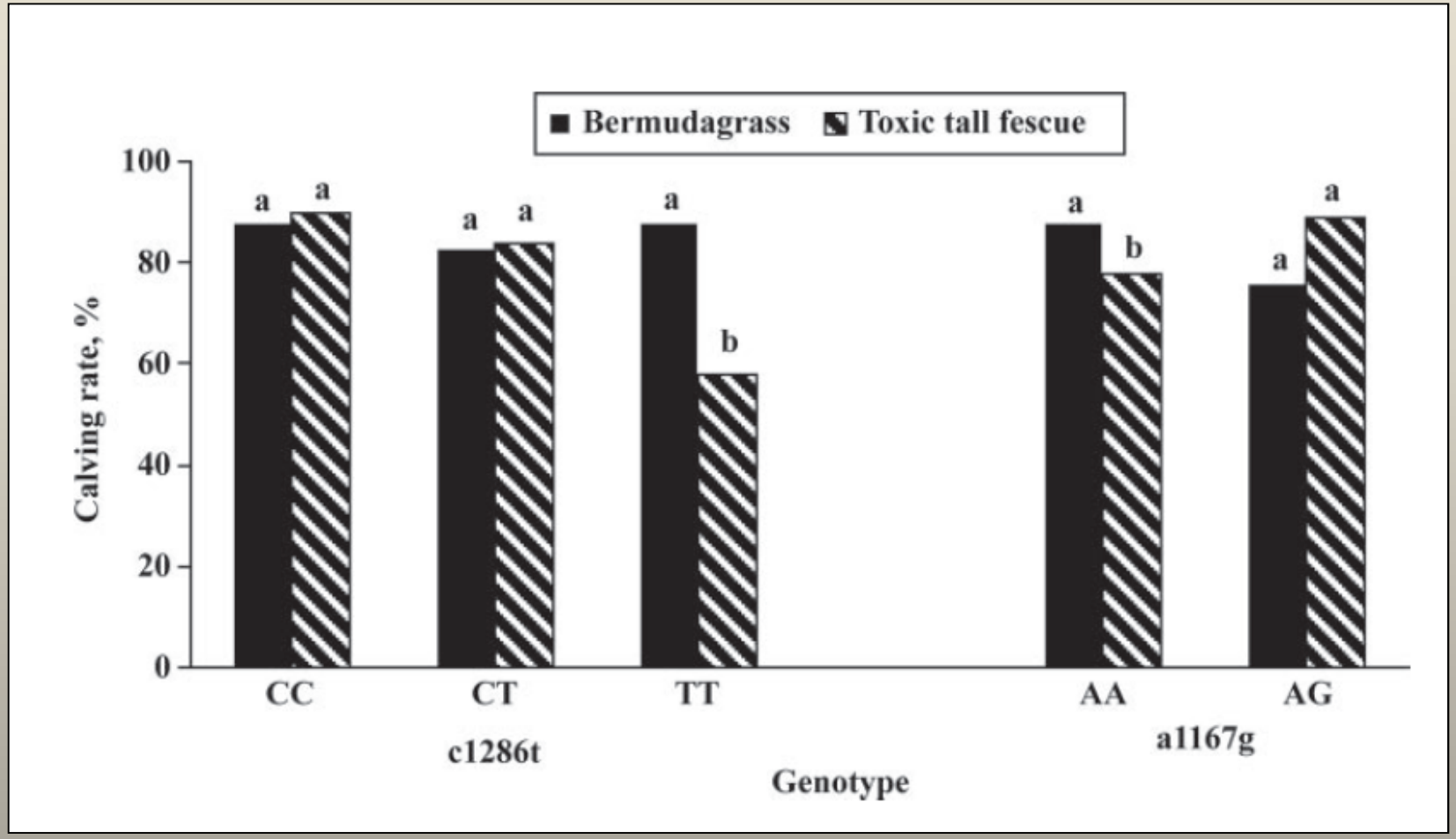
- Heat shock protein 70 (Hsp70) functions as a molecular chaperone after an organism is exposed to stress (pathological, environmental conditions, fever, ischemia, heat shock).
  - Expression of the Hsp70 gene is, in part, under the control ofupstream elements in the promoter region.

Single nucleotide polymorphism (SNP) selection of cattle

- Evaluate candidate gene segments for polymorphisms.
  - Specific segments are amplified using PCR
  - Amplified products are sequenced and compared between animals either by sequencing or RFLP
  - If polymorphisms are detected, then associations with economically important traits are evaluated

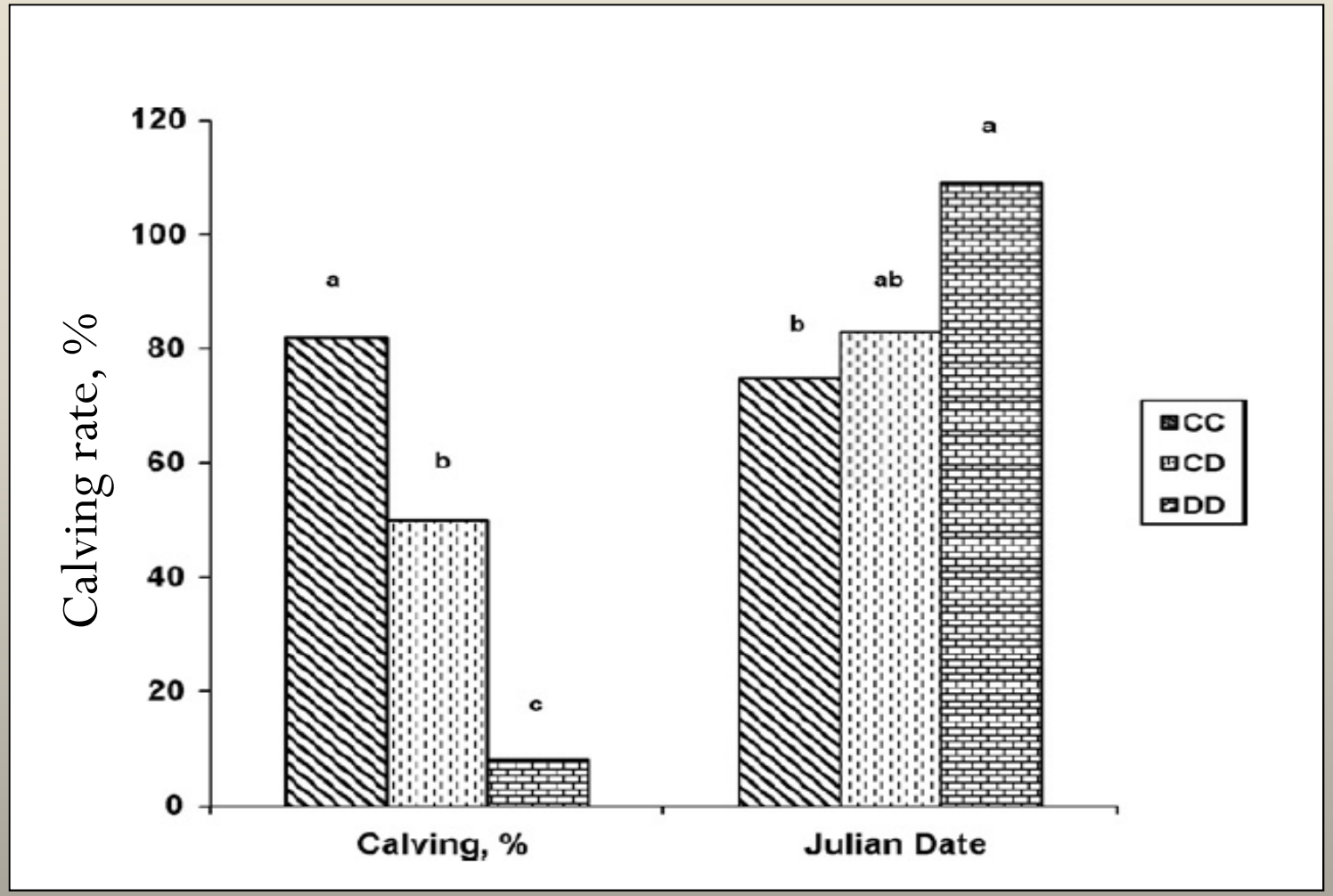


Relationship of transversions in the enhancer region of the prolactin gene with calving rate



Looper et al., 2010

Relationship of a deletion in the promoter region of the heat shock protein-70 gene with calving rate



Rosenkrans et al., 2010

Implications

Identification of cows with specific genotypes within candidate genes may serve as a marker for reproductive fitness in cattle.

Promoter region SNP of prolactin and HSP-70 genes are related to reproductive fitness.

Summary

- **Profitability of beef cow-calf operations is dependent on minimizing expenses and enhancing reproductive fitness of the herd.**

- **An increased understanding of the mechanisms that influence reproductive fitness in cattle can be the basis of new and (or) improved best management practices for more cost-effective beef production.**