AgriLIFE RESEARCH
Texas A&M System

UNDERSTANDING POSTPARTUM ANESTRUS AND PUBERTY

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Improving Life through Science and Technology.

PUBERTY IN THE HEIFER

- Puberty is the attainment of a developmental state that supports normal ovarian cyclicity and the ability to become pregnant
- Sexual maturation begins in the lower brain (hypothalamus); All other development changes related to reproductive maturity are dependent ultimately upon changes that occur first in the hypothalamus
- The timing of requisite changes in the hypothalamus are influenced by breed type, maternal nutrition, and the nutritional environment during the first year of life
- Age at puberty can be delayed markedly by undernutrition as well as accelerated by high-energy diets and rapid rates of gain.

DEVELOPING AND MANAGING THE BEEF HEIFER

FACTORS AFFECTING SEXUAL MATURATION

- Genetics (Breed Type/Mature Body Weight)
  - -- Larger, later-maturing breeds
  - -- *Bos indicus* influence
- Pre- and Post-Weaning Nutrition
  - -- Pre-weaning effect > post-weaning
  - -- Time of weaning and type of growing diet
- Critical Body Weight/Adiposity
  - -- Interaction of breed x nutrition
  - -- Sexual maturation of the brain
  - -- Reproductive tract and skeletal development

PUBERTY IN THE HEIFER

- Lifetime productivity of beef heifers heavily-dependent upon ability to reach sexual maturity, conceive early in the initial breeding season, and to calve the first time as 2 year-olds
- Early conception is positively influenced by the number of estrous cycles occurring before the onset of the first breeding season
- Many heifers do not reach puberty in time to conceive early in their first breeding season, particularly in later-maturing breeds

PUBERTY IN THE HEIFER

- Can develop heifers for reaching puberty using the concept of "targeted body weight"
- Cost associated with continuous, rapid rates of gain is one of the reasons that most cattlemen do not adopt this approach.
- Only a small percentage of cattlemen in the U.S. beef nutritionally pre-program developing heifers to become herd replacements

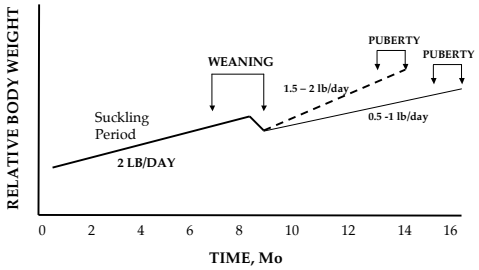
DEVELOPING AND MANAGING THE BEEF HEIFER

Table 1. Selected management procedures used on replacement beef heifers[a]

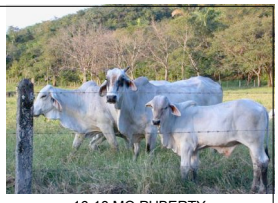
Management practice	Percent of operations
Feed separately	31.8
Pelvic measurements	3.0
Reproductive tract scores	1.2
Breed prior to the mature herd	12.7
Synchronize estrus	3.0
Artificial insemination	3.3
Body condition score	4.6
Weigh	17.9
Pregnancy diagnosis/palpation	15.9

[a]Adapted from NAHMS, 1994a.

TARGETED BW FOR MANAGEMENT OF PUBERTY (BREED/BREED-TYPE SENSITIVE)



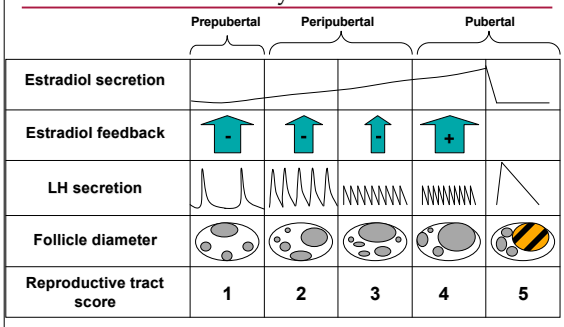
12-14 MO PUBERTY



16-18 MO PUBERTY

14-16 MO PUBERTY

Endocrine and Ovarian Changes Associated with Puberty Onset



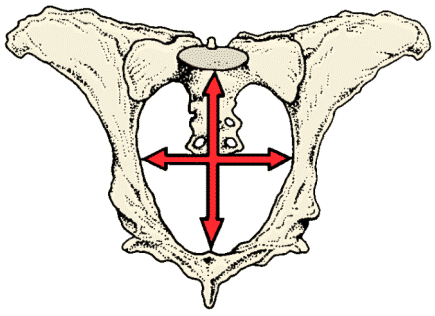
Adapted from Day and Anderson 1998; Anderson et al., 1991; Patterson et al., 2005

Table 1. Reproductive tract scores (RTS)[a]

RTS	Uterine horns	Ovarian length (mm)	Ovarian height (mm)	Ovarian width (mm)	Ovarian structures
1	Immature, < 20 mm diameter, no tone	15	10	8	No palpable follicles
2	20-25 mm diameter, no tone	18	12	10	8 mm follicles
3	20-25 mm diameter, slight tone	22	15	10	8-10 mm follicles
4	30 mm diameter, good tone	30	16	12	10 mm follicles, CL possible
5	> 30 mm diameter, coiled	> 32	20	15	CL present

[a]From Anderson et al., 1991.

MEASURING PELVIC AREA



RELATIONSHIP OF REPRODUCTIVE TRACT SCORES (RTS) TO BW, PELVIC HEIGHT, PELVIC WIDTH, PELVIC AREA AND EXPECTED PERCENT CYCLING

RTS	n	Weight (kg)	Pelvic height (cm)	Pelvic width (cm)	Pelvic area (cm^2)	Estrus response (%)
1	61	270^a	13.9^a	10.9^a	152^a	54^a
2	278	282^b	14.1^a	11.2^a	158^a	66^b
3	1103	317^c	14.5^b	11.4^b	166^b	76^c
4	494	333^d	14.7^c	11.7^c	172^c	83^d
5	728	343^d	14.7^c	11.7^c	172^c	86^d

Adapted from Patterson and Bullock, 1995

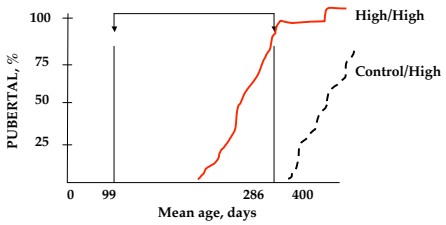
NUTRITIONAL PRE-PROGRAMMING OF SEXUAL MATURATION IN THE DEVELOPING HEIFER

QUESTIONS

- Does Early Weaning and Early-Life Exposure to a High Concentrate, High-Gain Diet Modify Developmental Gene Expression in the Brain Resulting in the Ability to Reach Sexual Maturity Early?
- Can a High-Gain, Forage Diet Promote Precocious Puberty Similarly to a High Concentrate Diet?
  ---Acetate vs Propionate

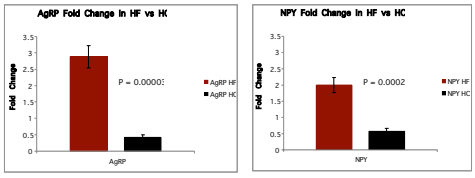
NUTRITIONAL PRE-PROGRAMMING OF SEXUAL MATURATION IN THE DEVELOPING HEIFER

PRECOCIOUS PUBERTY (300 d) 90% OF HH



Garcia et al., 2002
Gasser et al., 2006

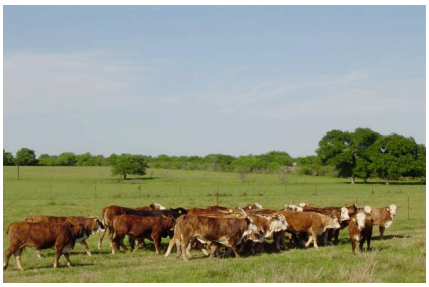
RELATIVE GENE EXPRESSION CHANGES IN THE HYPOTHALAMUS OF CONTROL HEIFERS AND HEIFERS FED A HIGH-CONCENTRATE, HIGH GAIN DIET FOR 90 DAYS



Allen et al., 2009

FACTORS CONTRIBUTING TO REPRODUCTIVE EFFICIENCY IN THE POSTPARTUM BEEF COW

- GENETICS/ENVIRONMENT
- GESTATIONAL ENDOCRINOLOGY
- SUCKLING/MATERNAL BEHAVIOR
- NUTRITION
- MANAGEMENT



GESTATIONAL ENDOCRINOLOGY

DEPLETION OF PITUITARY LH DURING LATE GESTATION IN THE COW

PLACENTAL ESTRADIOL

↓

ANTERIOR PITUITARY

↓

INHIBITED SYNTHESIS OF LH

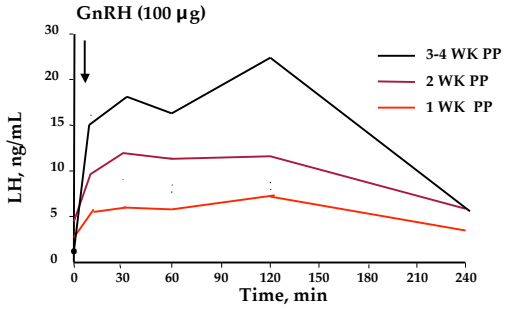
↓

DEPLETION OF RELEASABLE LH

↓

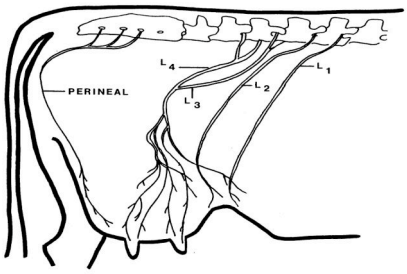
2 TO 4-WEEK RECOVERY

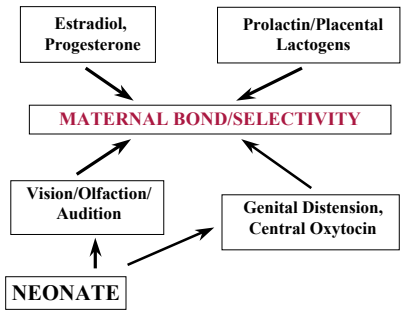
RELEASABLE POOLS OF LH DURING THE FIRST 30 DAYS POSTAPARTUM



SUCKLING, THE MAMMARY GLAND AND MATERNAL BEHAVIOR

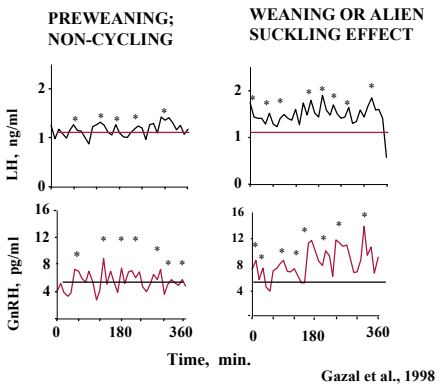
INNERVATION TO THE BOVINE MAMMARY GLAND





ALIEN SUCKLING AND ALIEN COHABITATION

- CONTROLLED SUCKLING BY AN ALIEN CALF CREATES THE SAME EFFECT AS TEMPORARY WEANING (Silveira et al. 1993)
- "ALIEN COHABITATION" CAN BE USED INTERCHANGEABLY WITH 48-HOUR CALF REMOVAL TO OPTIMIZE SYNCHRONIZATION OF OVULATION



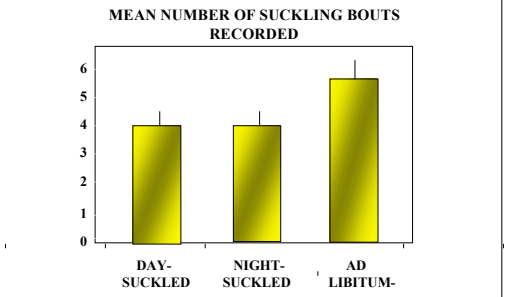
Gazal et al., 1998

CUMULATIVE PREGNANCY RATES IN MATURE BRAHMAN X HEREFORD COWS SYNCHRONIZED WITH SYNCRO-MATE-B IN CONJUNCTION WITH 48-HOUR CALF REMOVAL OR ALIEN COHABITATION

Group	No.	Percent Pregnant		
		Timed AI	15 Days	60 Days
SMB-W	21	57.1*	81.0	95.2
SMB-A	21	52.3*	76.2	85.7
SMB-S	21	19.0	52.3	90.4

* P < 0.05

DAY VS NIGHT TIME SUCKLING

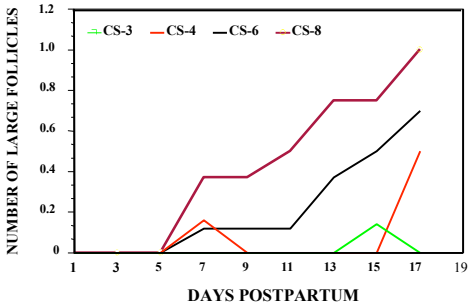


POSTPARTUM REPRODUCTIVE INTERVALS AND PREGNANCY RATES IN DAY-, NIGHT-, AND AD LIBITUM-SUCKLED COWS

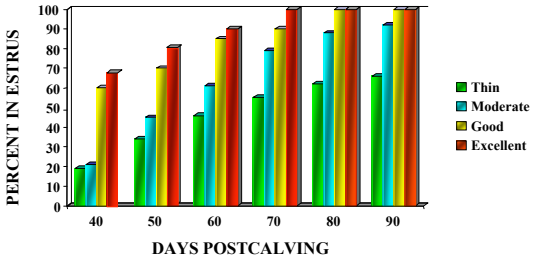
ITEM	DAY-SUCKLED	NIGHT-SUCKLED	AD-LIBITUM
NO. COWS	15	15	15
FIRST LUTEAL ACTIVITY, days	32 ± 2.5	32 ± 4.5	31 ± 1.7
FIRST NORMAL LUTEAL PHASE, days	38 ± 3.1	38 ± 3.8	37 ± 2.5
FIRST ESTRUS, days	40 ± 3.9	43 ± 3.5	36 ± 1.1
PREGNANT, %	93	93	100

NUTRITION

EFFECTS OF BODY CONDITION AT CALVING ON FOLLICULAR DEVELOPMENT



EFFECTS OF BODY CONDITION AT CALVING ON CUMULATIVE OCCURRENCE OF ESTRUS



INTERACTION OF BODY CONDITION AND SUCKLING ON POSTPARTUM REPRODUCTION

PHYSIOLOGICAL STATUS	POSTPARTUM ANOVULATORY INTERVAL
WEANED AT BIRTH/ FAT CONDITION	7-14 DAYS
WEANED AT BIRTH/GOOD CONDITION	7-21 DAYS
SUCKLED/FAT CONDITION	30-45 DAYS
SUCKLED/ GOOD CONDITION	45-70 DAYS
SUCKLED/THIN CONDITION	80-120 DAYS

GOALS FOR SUPPLEMENTATION OF GRAZING CATTLE

- MAJORITY OF NUTRIENTS FROM GRASS OR FORAGE
- PROTEIN AND MINERAL SUPPLEMENTATION TO MAXIMIZE FORAGE UTILIZATION
- USE OF NOVEL NUTRITIONAL STRATEGIES DURING WINDOWS OF OPPORTUNITY TO ENHANCE REPRODUCTIVE PERFORMANCE:

DIETARY FAT SUPPLEMENTATION

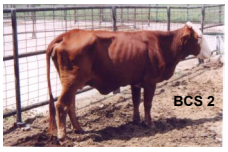
FAT SUPPLEMENTATION IN GRAZING SYSTEMS

BASES FOR USING FAT SUPPLEMENTS

- LOW TO MODERATE LEVELS OF FAT AS AN ENERGY SOURCE
- HIGHER LEVELS OF SPECIFIC TYPES OF FATS TO CONTROL INTAKE OF LIQUID SUPPLEMENTS (FISH OIL)
- HIGH LEVELS OF PLANT OILS, MEGALAC, OR ANIMAL TALLOW AS REPRODUCTIVE NUTRICEUTICALS

OUR OBJECTIVES FOR FEEDING FAT

"Determine whether the metabolic changes created by dietary fat supplementation will result in endocrine and ovarian changes that can enhance reproductive efficiency in the suckled beef cow in thin to moderate body condition beyond that which would be expected in response to traditional supplementation strategies"



TYPE AND LEVEL OF FAT FEEDING

TYPE OF FAT

- PU (PLANT OIL) > SAT (TALLOW) > HPU (FISH OIL) POSITIVE METABOLIC EFFECTS AND FOLLICULAR GROWTH

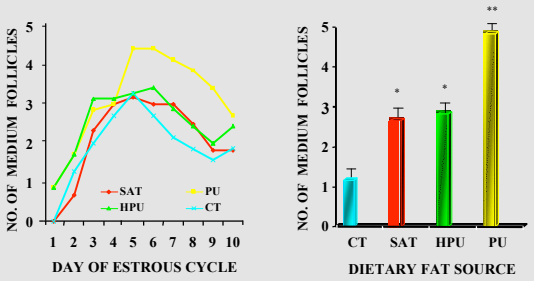
LEVEL OF FAT

- EFFECTS SEEN WITH AS LITTLE AS 2% ADDED FAT (DAIRY CATTLE)
- MAXIMAL FOLLICULAR GROWTH AT 4% ADDED FAT (POLYUNSATURATED FATTY ACIDS; PUF)

POLYUNSATURATED FATTY ACIDS

- HYDROGENATION OF PUF; 50-55% LINOLEIC ACID; 10 -25% ESCAPE TO SMALL INTESTINE
- INCREASED RUMEN PROPIONATE PRODUCTION; GLUCONEOGENESIS

EFFECTS OF HIGH FAT DIETS ON FOLLICULAR GROWTH



REPRODUCTIVE PERFORMANCE OF CATTLE FED HIGH FAT DIETS*

Reference	Class of Cattle	Type of Fat	Response
Wehrman et al	Postpartum	Polyunsaturated	Reduced PPI
Hightshoe et al	Postpartum	Saturated	Reduced PPI
De Fries et al	Postpartum	Polyunsaturated	Earlier Pregnancy
Espinoza et al	Postpartum	Saturated	Reduced PPI
Whitney et al	Heifers	Polyunsaturated	Earlier Pregnancy

* All experiments included isocaloric/isonitrogenous controls

LACK OF EFFECTS OF FAT SUPPLEMENTATION ON TAI CONCEPTION AND CUMULATIVE 45-DAY PREGNANCY RATES IN SMB-SYNCRHONIZED FEMALES

Group	Age	No.	Pregnancy, % TAI	Pregnancy, % 45-Day
SMB-Control	Pluriparous	22	54.5	82.0
	Primiparous	13	46.1	78.6
	Nulliparous	15	47.0	100.0
	Total	50	50.0	86.3
SMB-High Fat	Pluriparous	22	50.0	81.8
	Primiparous	14	42.8	92.8
	Nulliparous	15	53.3	80.0
	Total	51	49.0	84.3

SUMMARY I - PUBERTY

- Developmental changes leading to puberty are initiated first within the lower brain (hypothalamus), the central regulator of reproduction
- Factors influencing the rate of sexual maturation include genetic background, and maternal and juvenile nutrition
- Reproductive tract scoring can be used as a marker to estimate stage of sexual maturity; pelvic measurements can identify heifers with abnormally small pelvic areas and help reduce the incidence of dystocia
- High-energy diets fed during the early postnatal period can have dramatic effects on age at puberty (e.g., precocious puberty)
- Need a better understanding of the latter processes to devise practical strategies for nutritional management

SUMMARY II – SUCKLING EFFECTS

- Suckling suppresses the central reproductive axis for variable periods after calving and this effect is exacerbated by low body condition
- Therefore, suckling and body condition at calving have the greatest overall influence on postpartum reproductive performance
- 1X – daily suckling for early weaning will markedly enhance reproductive performance under adverse environmental conditions (drought)
- Use of either temporary weaning (48-hr) or alien cohabitation (48-h) of cows during estrus synchronization may enhance synchronization efficiency and fixed-time AI conception rates
- Time of suckling during the 24-Hr day has no effect on postcalving reproductive efficiency

SUMMARY III –FAT SUPPLEMENTATION

- Dietary fat supplementation can have beneficial effects on metabolic physiology of cows in low body condition
- Include the fat supplement (preferably plan-derived) at 4% of total diet dry matter (0.6-0.8 lb/day) if adding fat directly; up to 7% if supplied by an oilseed
- Feed to cows in thin to moderately thin body condition for at least 30 days before onset of breeding and continue during the breeding season only as long as a supplement is needed
- Fat supplementation is **not a silver bullet** and will not enhance reproductive performance in cows in good body condition