Fertility in Beef Cattle

Tom Geary
Reproductive Physiologist

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Pregnancy Diagnosis

Cow Fertility
- Vibrio
- Trich
- Stress

Breeding Season
- Neospora
- EBA (Foothills)
- Nitrates
- IBR
- Lepto

Bull Fertility
- BVD

Plant / Water Toxins

When?

When does pregnancy diagnosis occur?
Factors affecting Individual Pregnancy

- Cow Fertility
  - Postpartum interval (PPI)
  - Age
  - Body Condition Score (BCS)
  - Genetics
  - Dystocia
  - Nutrition
- Bull Fertility
- Stress
- Disease
- Toxins
Day of Calving Season

Percentage of Calves Born

Shorter calving season improves ability to manage cattle in your environment & increase profitability of cowherd!
Nutrient Partitioning

1. Maintenance
2. Activity
3. Growth
4. Milk production
5. Body reserves (FAT)
6. Reproduction

Proper nutrition is obligatory to reproductive success, but not focus of presentation.
Improve Cowherd Reproduction with Genetics

Crossbreeding!!!
Animal Breeding 101

Crossbreeding

Reproduction

Production

Carcass

Additive genetic value

Non-additive genetic value

Selection

Hybrid Vigor
Cumulative hybrid vigor effects on weight of calf weaned per cow exposed

Combined Effects of:
- Reproduction
- Survival
- Maternal Ability

Age of Puberty

% Increase

23.1

Straightbred calves from straightbred cows

X-bred calves from straightbred cows

X-bred calves from x-bred cows

Cundiff et al., 1974; Hereford, Angus, & Shorthorn
AI Heifers to “Calving Ease”
Proven Sires

At today’s diesel prices, maybe I should consider AI.
Cost of Dystocia?

<table>
<thead>
<tr>
<th>Dystocia</th>
<th>Culled for Reproductive Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers</td>
<td>25%</td>
</tr>
<tr>
<td>Cows</td>
<td>58%</td>
</tr>
</tbody>
</table>

Rogers et al., 2004
Reproductive Measures that Result in Pregnancy
Single most important measure of fertility for cow/calf producer?

Each bull is expected to contribute to the production of 20 to 30 calves, so the fertility of each bull is at least 20x more important than a cow.

Limitations: Fertility measure on that given day Only about 1/3 of the “Fertility Picture”
Effect of Social Dominance on Percentage of Calves Sired

<table>
<thead>
<tr>
<th>Bull</th>
<th>Year 1</th>
<th>Year 2</th>
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<td>0</td>
<td>12</td>
<td>15</td>
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What if the dominant bull is sterile?
Bull Dominance or Bull Fertility?

Percent of calves sired by:

- Bull 4
- Bull 3
- Bull 2
- Bull 1

Bull Dominance or Bull Fertility?

USDA-MARC, Clay Center, NE
17 Pastures
Average of 42 cows/pasture (range of 31 to 66)
Average of 9 bulls/pasture (range of 7 to 12)
42 d breeding season
Each bull in the pasture sired at least 1 calf
Bull Dominance or Bull Fertility?

Percent of calves sired by:

Pasture:

A B C D E F G H I J K L M N O P Q

Bull 4
Bull 3
Bull 2
Bull 1
Bull Dominance or Bull Fertility?

In 47% of pastures >50% of the calves were sired by a single bull (Range: 31% to 67%).
Bull Dominance or Bull Fertility?

In 82% of pastures, >40% of the calves were sired by a single bull. In only 1 pasture, the second most fertile or dominant bull sired >16% of the calves.
Key Parameters of Sperm Fertility

MEMBRANE INTEGRITY (1)
• BROKEN, OPENS THE DOOR TO DNA

DNA CONTENT (2)
• CONTROL DNA FRAGMENTATION

ACROSOME (3)
KEY ROLE IN FERTILIZATION

MITOCHONDRIAL STATUS (4)
• INFLUENCE MOTILITY

CAPACITATION (5)
• PREPARE SPERM TO FERTILIZE

Bacterial count
• CONTAMINATION ALTERS FERTILITY

Measuring these key physiological functions provides insight into the fertilization potential of sperm.

EasyCyte Flow Cytometer

Evaluates 5000 sperm/min
Fertility of a Single Service: Beef Cattle

- Fertilization: 95%
- Pregnancy d 27: 70%
- Pregnancy d 42: 62%
- Calving: 60%

~ 25% Loss
Estrous Cycle

Hormone Level

Progesterone

Estrogen

Day of Estrous Cycle

0 2 4 6 8 10 12 14 16 18 20 1

Estrus

Ovulation

Prostaglandin (PGF$_{2\alpha}$)

COX, PGFS

CL
Maternal Recognition of Pregnancy

- Estrus
- Progesterone
- Estrogen
- Uterus
- Prostaglandin (PGF$_{2\alpha}$)
- IFN-τ
- Embryo

Day of Estrous Cycle

Hormone Level
Maternal Recognition of Pregnancy

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<tr>
<td></td>
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- Estrus
- Progesterone
- Estrogen
- Prostaglandin (PGF$_{2\alpha}$)
- IFN-τ
- Embryo
Maternal Recognition of Pregnancy Failure

Hormone Level

Progesterone

Estrogen

Estrus

Day of Estrous Cycle

0 2 4 6 8 10 12 14 16 18 20 22

Uterus → Prostaglandin (PGF$_{2\alpha}$)

IFN-τ

Embryo

Exestrus
Maternal Recognition of Pregnancy Failure

Management can cause this scenario: ANYTHING that delays embryo growth can affect pregnancy establishment!
Why / Where is pregnancy failing?

Day 1
95%

Oocyte Competence

Progress difficult without earlier pregnancy diagnosis

Day 27
70%

Oviductal support
D 1 - 4

Embryo Elongation
D 5 - 14

MRP (IFN-τ)
D 15 - 17

Uterine dependent period
D 18 - 27

Spencer et al. 2004
Post AI Management

- Anecdotal evidence

- Heifers developed in feedlots (high energy diet) to facilitate AI
  - Conception rates vary tremendously (40-70%)

- Does Post-AI nutritional management play a role?
  - Green grass???
Feedlot AI, then to Grass (~30 d)

Data from George Perry (SDSU)
All heifers gaining 1.5 lbs/d from mid-winter to breeding

- 21 d after breeding:
  - Control (continue 1.5 lbs/d) = Gaining
  - Drop to maintenance = Maintaining
  - 80% of maintenance = Losing

- Scott Lake (UW) & Ron Lemanger (Purdue), 2012
21 d Post-AI Nutrition

![Graph showing pregnancy rates for heifers gaining, maintaining, and losing weight during the first 21 days post-AI.](image)

- **Gaining**: AI - 77%, 2nd Service - 58%, Breeding Season - 96%
- **Maintaining**: AI - 56%, 2nd Service - 24%, Breeding Season - 86%
- **Losing**: AI - 61%, 2nd Service - 35%, Breeding Season - 84%

P < 0.05
Recent Reciprocal ET Study Identified Key Elements of Fertility

GnRH-induced Ovulatory Follicle Size

Embryo Donor Cow
- Large
- Small

Embryo Recipient Cow
- Large
- Small

Day 7 after AI
Reciprocal ET Study - Summary

- 3 Primary Measures of Fertility:
  - Fertilization Success
  - Embryo Survival to day 27
  - Embryo Survival to day 72
Recent Reciprocal ET Study Identified Key Elements of Fertility

- High Progesterone after breeding
- What decreases Progesterone?
  - Negative energy balance
  - Increased milk
  - Excess protein
  - Stress
  - ???
Vaccination Program

• Cow Herd
• Calves
• Bull
• Feeder Cattle

Effects on fertility?
Timing of Vaccination

Immune Response

Synch  Breeding  Fertilization

6/10/06  6/24/06  7/8/06  7/22/06  8/5/06  8/19/06  9/2/06  9/16/06  9/30/06  10/14/06  10/28/06  11/11/06  11/25/06  12/9/06  12/23/06  1/6/07  1/20/07  2/3/07  2/17/07  3/3/07  3/17/07  3/31/07

Calving

Dr. Russ Daly
SOUTH DAKOTA STATE UNIVERSITY
Cooperative Extension Service

SDSU
Conclusions

- Pre-breeding vaccination starts before weaning
- Best time for repro vaccines = 30 days pre-breeding
  - Avoid using MLV vaccines in naïve animals < 30 d before breeding
Heifer Fertility: Genetic Markers?

TAMU Heifers to Fort Keogh

1. Embryo donors – oocyte problem
2. Embryo recipients – uterine problem
TAMU Heifers as Embryo Donors

Pregnancy Rate of Fort Keogh Recipient Cows

<table>
<thead>
<tr>
<th>TAMU Embryo Donor Classification</th>
<th>High Fertile</th>
<th>Subfertile</th>
<th>Infertile</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.6%</td>
<td>37.5%</td>
<td>61.5%</td>
<td></td>
</tr>
</tbody>
</table>
TAMU Heifers as Embryo Recipients

- High Fertile: 69.2%
- Subfertile: 38.5%
- Infertile: 27.3%

Infertile heifers had compromised maternal environment.
Sent to WSU
1. Uterine Biopsies – expression profiles
2. Genetic Markers?

7 genes identified related to fertility
Why / Where is pregnancy failing?

What role does the bull have in pregnancy success?

Day 1
95%

Oocyte Competence

Oviductal support
d 1 - 4

Embryo Elongation
d 5 - 14

MRP (IFN-τ)
d 15 - 17

Uterine dependent period
d 18 - 27

Day 27
70%

Spencer et al. 2004
Biological Markers Associated with Fertility

Ubiquitin

Cellular damage

PNA

Acrosome reacted sperm

Peter Sutovsky
University of Missouri
Head of defective sperm

Ubiquitin-binding antibody

Ubiquitin (defective sperm only)

Magnetic Nanoparticle
IVF Using Magnetic Sperm Depletion

Sperm sorted with Ubiquitin or PNA antibody resulted in greater fertilization & cleavage rate.

Peter Sutovsky
University of Missouri
Ubiquitin / PNA Nano-Particle Field Trial – Fort Keogh

- 390 Cows + 110 Heifers
- 3 Sires
- 4 Treatments
  - Control 20 x 10^6 Sperm
  - Control 10 x 10^6 Sperm
  - Ubiquitin Sorted 10 x 10^6 Sperm
  - PNA Sorted 10 x 10^6 Sperm
Male fertility may account for more than 10% of pregnancy failures. 10% of the time, fertilization achieved by less optimal sperm.
Early pregnancy diagnosis to identify causes of pregnancy failure at Fort Keogh.

- **Day 1**
  - 95%
  - Oocyte Competence
  - Oviductal support (d 1 - 4)

- **Day 30**
  - 70%
  - Embryo Elongation (d 5 - 14)
  - MRP (IFN-τ) (d 15 - 17)
  - Uterine dependent period (d 18 - 28)

**Current Technology (d 27)**
- Ultrasound
- Blood – Pregnancy specific proteins
  - d 19 with very good accuracy
    - Endometrial echotexture
    - CL blood flow

Spencer et al. 2004
Fertile Mating?

Questions?

Tom Geary
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Tom.Geary@ars.usda.gov
Path Diagram: Embryo Donor Cow

- **Condition score**
  - 0.068 ± 0.034
  - 0.094 ± 0.035
- **Cyclicity**
  - -0.196 ± 0.030
  - 0.132 ± 0.034
- **Ovulation, d -9**
  - 0.054 ± 0.030
  - 0.066 ± 0.030
- **Follicle growth rate**
  - 0.066 ± 0.030
- **E2, d 0**
  - 0.128 ± 0.032
  - -0.072 ± 0.033
- **Follicle Size, d 0**
  - 0.048 ± 0.029
  - 0.097 ± 0.057
- **Fertilized, d7**
  - 0.207 ± 0.039
  - 0.184 ± 0.055

- **Days post-partum**
  - 0.162 ± 0.032
  - 0.168 ± 0.034
- **Body weight**
  - 0.094 ± 0.035
  - 0.068 ± 0.034
  - 0.057 ± 0.031
- **Age**
  - -0.38
  - -0.43
  - 0.49

- **Recovered structures**
  - 0.007 ± 0.025
  - 0.316 ± 0.024
Path Diagram: Additional Fertility Measures – Embryo Donor Cow
Path Diagram: Embryo Recipient Cow

All the preceding stuff back here

Embryo Quality

Temp

Age

Follicle size

P4 @ RET

E2, d0

Pregnant, d 27

Pregnant, d 72

Recipient Age

Embryo Quality

All the preceding stuff back here
Some Summary Effects: Fertilization

- Days post-partum
- Body weight
- Age
- Condition score
- E2, d 0
- Follicle Size, d 0
- Fertilized, d7

Correlations:
- Days post-partum: 0.44
- Body weight: -0.38
- Age: 0.49
- Condition score: 0.11
- E2, d 0: 0.46
- Follicle Size, d 0: 0.097 ± 0.057
- Fertilized, d7: 0.207 ± 0.049

Values:
- Days post-partum: 0.46
- Follicle Size, d 0: 0.097 ± 0.057
- Fertilized, d7: 0.207 ± 0.049
Some Summary Effects: Pregnant d 27

- **Days post-partum**
  - Condition score
  - Body weight
  - Age

- **Follicle Size, d 0**
  - Condition score
  - Body weight

- **Fertilized, d7**
  - Condition score
  - Body weight

- **P4, d7**
  - Condition score
  - Body weight

- **E2, d 0**
  - Condition score
  - Body weight

- **Pregnant, d27**
  - Condition score
  - Body weight

**Summary Effects:**
- Pregnant d 27
- Condition score
- Body weight
- Age
- Follicle Size, d 0
- Fertilized, d7
- P4, d7
- E2, d 0
- Pregnant, d27
Some Summary Effects: Pregnant d 72

- Days post-partum: Condition score
- Body weight
- Age
- E2, d 0
- Follicle Size, d 0
- Fertilized, d7
- P4, d7
- Embryo Quality, d7
- Pregnant, d27
- Pregnant, d72
Heifer Protocols

**BEEF HEIFER PROTOCOLS - 2012**

### HEAT DETECTION

**1 Shot PG**
- Heat detect & AI

**7-day CIDR®-PG**
- Heat detect & AI

**MGA®-PG**
- Heat detect & AI

### HEAT DETECT & TIME AI (TAI)

**Select Synch + CIDR® & TAI**
- Heat detect and AI day 7 to 10 and TAI all non-responders 72 - 84 hr after PG with GnRH at TAI.

**MGA®-PG & TAI**
- Heat detect and AI day 33 to 36 and TAI all non-responders 72 - 84 hr after PG with GnRH at TAI.

**14-day CIDR®-PG & TAI**
- Heat detect and AI day 30 to 33 and TAI all non-responders 72 hrs after PG with GnRH at TAI.

### FIXED-TIME AI (TAI)*

**7-day CO-Synch + CIDR®**
- Perform TAI at 54 ± 2 hr after PG with GnRH at TAI.

**MGA®-PG**
- Perform TAI at 72 ± 2 hr after PG with GnRH at TAI.

**14-day CIDR®-PG**
- Perform TAI at 66 ± 2 hr after PG with GnRH at TAI.

### COMPARISON OF PROTOCOLS FOR BEEF HEIFERS

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<thead>
<tr>
<th>Protocol</th>
<th>Cost</th>
<th>Labor</th>
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<td>1 Shot PG</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>7-day CIDR®-PG</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>MGA®-PG</td>
<td>Low</td>
<td>Low/Medium</td>
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<td>Select Synch + CIDR®</td>
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<td>(TAI non-responders 72-84 hr after PG)</td>
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Synchronization Products

GnRH = Gonadotropin Releasing Hormone

PG = PGF = Prostaglandin F$_{2\alpha}$

Cystorelin®, Factrel®, Fertagyl®, OvaCyst®
estroPLAN®, Estrumate®, In-Synch®, Lutalyse®, ProstaMate®

Identical $2.00

Equal $2.00

2 cc

5 cc
Synchronization Products

MGA = Melengestrol Acetate
Feed Additive
Progestin = “Progesterone Like”

CIDR = Controlled Internal Drug Releaser
Intra-vaginal Device
Progesterone

CIDR = Much better job of inducing estrous cycles
Not Equal
THE ESTROUS CYCLE

Hormone concentration

CL → Progesteron

FSH

GnRH

LH

PGF2α

Ovulation

Estrus

5 10 15

Estrus
Follicular Waves during Anestrus

Before puberty
After calving
In Utero Influence on Development of Replacement Heifers

- Uterine environment: Dam’s nutrition during embryo & fetal development = lifelong effects.
IVOMD and CP Availability: Montana

Grings et al., 2005
Cow Energy & Protein Requirements

Energy (TDN), kg

Protein, g/d

Month

January, February, March, April, May, June, July, August, September, October, November, December

NRC, 2000

Calving

Breeding

IVOMD and CP
Grings et al., 2005
Possible Mechanism(s)?

Stress →
- Temperature
- Epinephrine
- CRH → ACTH → Cortisol

Corpus Luteum
- Sensitivity to PGF$_{2\alpha}$

Adrenal
- PGF$_{2\alpha}$

Gonadotrope
- LH

Liver
- Steroid Metabolism?
- Cortisol → P4-R

Endometrial?