Building a Stronger Cow Team Through Genetics and Reproduction

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Pictures by Bonnie Mohr http://www.bonniemohr.com/

November 18 and 19, Mystic Lake, MN
I want to give you a conceptual snapshot on a multitude of factors that influence reproduction on a dairy farm

- Peripartum health
- Reproductive programs
- Decisions on cows – who and when to breed
- Genomics for genetic selection

(Hidden element → H-factor)

Finally, I will touch on heifer reproduction
Distribution of Gestation Length in Holstein Cows

Mean ± SD = 276 ± 6 d

9.4% (n = 762) 76.4% (n = 6,181) 14.2% (n = 1,152)
Timeline Management of Dairy Cows For Successful Transition

Provide Proper Comfort and Heat Abatement

1. Dry off
   - 230 days of gestation
   - Proper body condition
   - Control of mastitis
   - Routine hoof trimming
   - Vaccination program
   - Proper diet to avoid over and under consumption of nutrients

2. Close up
   - Move based on days pregnant - 255 days of gestation
   - Proper grouping
   - Vaccination program
   - Feed diets to minimize metabolic disorders in early lactation

3. Early Postpartum
   - Monitor health for early diagnosis of diseases and treatment
   - Feed diets that do not limit intake
   - Control ketosis

4. High group
   - Feed diets that maximize milk production and recovery of body condition

Day Relative to Calving

- 45 d
- 21 d
21 to 28 d
> 28 DIM

3. Parturition
   - Training of personnel
   - Minimize intervention
   - Reduce calving related disorders
Conceptual Timeline for Successful First Postpartum Insemination

1. Prepartum period
   Proper grouping
   Ration balancing
   Minimize metabolic disorders
   Minimize calving problems

2. Calving
   Proper training of maternity personnel
   Minimize unnecessary intervention

3. Early postpartum
   Monitoring cows
   Diagnosis and therapy of key diseases

4. Reproductive program
   PGF$_{2\alpha}$
   Presynchronization for 1$^{st}$ AI

5. End of the VWP
   Increase pregnancy rate ($IR \times P/AI$)

Day Relative to Calving

- 30 d  14 to 21 d
Dry Off Cows

- Dry off cows at 230 ± 3 d of gestation
  - 1st lactation cows need 45 d of dry period
  - Older cows need 28 d of dry period

- Short dry periods for 1st lactation compromise subsequent lactation

- No cow needs more than 45 days dry

- Assure 45 days dry for all cows
Move Cows to Prepartum

- Weekly moves
  - 255 ± 3 d of gestation

- Target 3 weeks in the prepartum pen and assure that all cows spend a minimum of 14 d

- A single group dry cow pen can be used, but consider the pros-and cons at this point
  
  **Pros**
  - Ease of managing cows
  - No group move
  - Single dry cow ration

  **Cons**
  - Longer feeding of acidogenic salts
  - Increase in metabolizable protein needs during late gestation
  - Benefit from some additives during late gestation
Mortality Based on Weeks in Prepartum Pen

- Death 30 d
  - > 2 wk: 2.0%
  - < 2 wk: 3.0%
  - None: 7.1%

- Death 60 d
  - > 2 wk: 2.4%
  - < 2 wk: 3.3%
  - None: 7.8%

- Death 120 d
  - > 2 wk: 3.1%
  - < 2 wk: 3.9%
  - None: 9.0%

- Overall
  - > 2 wk: 3.6%
  - < 2 wk: 4.7%
  - None: 10.1%

Santos et al. (2013)
Survival analysis of exposure to a transition diet: Controlling for farm, age, calving order (mating start date)

Adequate Calving Assistance

Patience, hygiene and lots of lubrication
Morbidity is a Problem of Early Lactation Cows

N = 753 cows with metritis in dairy farms in NY, OH, and CA

Metritis

Galvão et al. (2014)

N = 1,171 cows with non-uterine disease (NUTD) in dairy farms in FL

Non-uterine diseases

Morbidity is a Problem of Early Lactation Cows

N = 753 cows with metritis in dairy farms in NY, OH, and CA

Metritis

30 to 35% of cows are affected by disease in the first 3 weeks of lactation

78% the first disease diagnosis occur within 3 weeks postpartum

Ribeiro et al. (2016) J. Dairy Sci. 99: accepted *in press*
Disease and Nutrient Flux

- **Fed/Control**
  - Fed *ad libitum* and not challenged

- **Fed/Challenge**
  - Fed *ad libitum* and challenged with 10 mL of $1 \times 10^9$ mL CFU of *M. haemolytica* via a tracheal tube on h 0

- **Fasted/Control**
  - Feed was removed 14 h before the challenged steers received *M. haemolytica* and steers Control steers remained without feed during the sampling period (total of 72 h)

- **Fasted/Challenge**
  - Feed was removed 14 h before the *M. haemolytica* challenge and steers remained without feed during the sampling period (total of 72 h)

Burciaga-Robles et al. (2009)
Arterial haptoglobin concentration in steers fed or fasted with or without a *M. haemolytica* intratracheal challenge

Diet effect, $P = 0.009$
Disease effect, $P < 0.0001$
Diet×Disease effect, $P < 0.0001$

Burciaga-Robles et al. (2009)
Amino Acid Hepatic Flux in Steers Fed or Fasted with or without an Intratracheal Challenge with *M. haemolytica*

At 0.67 efficiency, this is equivalent to the true protein in 8 kg of milk (18 lbs)

Differential of 2.6 moles/day $\rightarrow$ $\sim$ 380 g of AA for a 400 kg steer

Disease effect, $P = 0.11$
SEM = 19.6

Disease effect, $P = 0.03$
SEM = 28.5

Disease effect, $P = 0.02$
SEM = 45.4

Essential amino acids
Non essential amino acids
Total amino acids

Burciaga-Robles et al. (2009)
Disease Influences Early Embryo Development

• Data from 419 embryo-oocytes from single ovulating lactating dairy cows flushed on days 5-6 after AI were evaluated for:
  ✓ Fertilization
  ✓ Embryo quality
  ✓ Cell number

• Data from 148 lactating dairy cows flushed on days 15-16 after AI were evaluated for:
  ✓ Pregnancy
  ✓ Embryo shape and length
  ✓ Interferon-tau concentration
  ✓ Transcriptome

Disease Influences Development to Morula

Disease Influences Conceptus Quality

B

\[\begin{align*}
&\text{No disease} & \text{Disease} \\
&\text{\ } & \text{\ }
\end{align*}\]

\[P < 0.01\]

C

\[\begin{align*}
&\text{No disease} & \text{Disease} \\
&\text{\ } & \text{\ }
\end{align*}\]

\[P = 0.02\]

Disease Influences Blood Leucocytes Response to Pregnancy

A  □ Nonpregnant on d 64  □ Pregnant on d 64

\[ P < 0.01 \quad P = 0.31 \]

\[
\begin{align*}
\text{ISG15 relative mRNA expression} & \\
\text{Nonpregnant on d 64} & \text{Pregnant on d 64} & \text{PREG} < 0.01 & \text{DIS} = 0.55 & \text{INT} = 0.04
\end{align*}
\]

Diseases Have Additive Negative Effects on Fertility

Uterine disease (UTD)

Non-uterine disease (NUTD)

Additive Impacts of Diseases on Fertility

Negative Impacts of Disease on Fertility Are Not Bypassed by ET

BRDT = 0.12
DIS < 0.01
INT = 0.37
AOR1 = 0.71
AOR2 = 0.82

BRDT = 0.03
DIS < 0.01
INT = 0.27
AOR1 = 0.58
AOR2 = 0.70

BRDT = 0.87
DIS < 0.01
INT = 0.59
AOR1 = 1.92
AOR2 = 2.30

Breeding Programs in US Dairy Farms

Most dairy producers in the US inseminate cows using a combination of AI on estrus and timed AI

Multitude of programs available for producers to bred cows on estrus or implement synchronization of estrus and ovulation

In most farms, the goal is to achieve:

- 100% AI within 3 weeks after the end of the voluntary waiting period
- Reinseminate nonpregnant cows at an average of 28-30 d intervals:
  - ~50 to 70% of the nonpregnant return to estrus before pregnancy diagnosis
  - ~30 to 50% resynchronized and reinseminated within 10 d of the nonpregnancy diagnosis
- Begin insemination between 60 and 80 DIM and have 50-60% of the herd pregnant by 110-120 DIM

Santos (2008) Cattle Practice 16:5-14
Milk, kg/day

Days in milk at pregnancy

Daily milk yield

Daily milk yield per day of CI

Additional 1.51 kg milk/day

Additional ~498 kg milk/year

Reduction of 63 days of CI

305-d milk production = 12,500 kg
(27,500 lbs/305 d or equivalent to 29,000 lbs of RHA)

CI (months): 12.4 13.5 14.5 15.6 16.5 17.7 18.6 19.8 20.9 21.8

## Use of reproductive hormone and costs associated with that in 3 dairy herds that inseminate cows on estrus and timed AI (year of 2013)

<table>
<thead>
<tr>
<th>Item</th>
<th>Herd 1</th>
<th>Herd 2</th>
<th>Herd 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milking cows, n</td>
<td>1,852</td>
<td>1,471</td>
<td>5,486</td>
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<tr>
<td>Calvings, n</td>
<td>2,281</td>
<td>1,825</td>
<td>6,755</td>
</tr>
<tr>
<td>RHA 3.5% FCM, kg/year</td>
<td>12,300</td>
<td>12,750</td>
<td>13,350</td>
</tr>
<tr>
<td>Total AI performed</td>
<td>5,953</td>
<td>4,152</td>
<td>16,158</td>
</tr>
<tr>
<td><strong>Timed AI performed, n (% AI)</strong></td>
<td>1,681 (28.2%)</td>
<td>845 (20.4%)</td>
<td>3,878 (24.0%)</td>
</tr>
<tr>
<td>P/Al, % all AI</td>
<td>34.9%</td>
<td>43.9%</td>
<td>38.9%</td>
</tr>
<tr>
<td>Value of pregnancy ($280/unit)</td>
<td>582,400</td>
<td>510,160</td>
<td>1,758,400</td>
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<tr>
<td>Reproductive hormones, units</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PGF</td>
<td>5,926</td>
<td>4,205</td>
<td>16,317</td>
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<tr>
<td>GnRH</td>
<td>3,311</td>
<td>1,622</td>
<td>7,523</td>
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<td>P4 inserts</td>
<td>75</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Cost of reproductive hormones</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cost with hormone therapy, $/AI</td>
<td>$3.1</td>
<td>$2.8</td>
<td>$2.9</td>
</tr>
<tr>
<td>Cost, % of value of pregnancy</td>
<td>3.2%</td>
<td>2.3%</td>
<td>2.7%</td>
</tr>
</tbody>
</table>
Recent Evolution of Reproductive Parameters in Holstein Herds in the US

Bisinotto et al. (2014) Animal 8:s1, pp 151–159
# Measures of Reliability of Diagnostic Tests as Indicators of Estrus for Dairy Cows

<table>
<thead>
<tr>
<th>Measure</th>
<th>CL regression only</th>
<th>CL Reg. and Ovulation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>Pedometry</strong> Positive</td>
<td>93</td>
<td>0</td>
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<tr>
<td><strong>Pedometry</strong> Negative</td>
<td>43</td>
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<tr>
<td>Se</td>
<td>68.4</td>
<td></td>
</tr>
<tr>
<td>Sp</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>PPV</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>NPV</td>
<td>40.3</td>
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<tr>
<td>Accuracy</td>
<td>73.9</td>
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</tr>
</tbody>
</table>

Vilar et al. (University of Florida unpublished results)
# Measures of Reliability of Diagnostic Tests as Indicators of Estrus for Dairy Cows

## Measures of Reliability

<table>
<thead>
<tr>
<th>Measure</th>
<th>CL regression only</th>
<th>CL Reg. and Ovulation</th>
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</thead>
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<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>Positive</td>
<td>93</td>
<td>0</td>
</tr>
<tr>
<td>Negative</td>
<td>43</td>
<td>29</td>
</tr>
</tbody>
</table>

**Se** (Sensitivity): 82.9%
**Sp** (Specificity): 98.1%
**PPV** (Positive Predictive Value): 98.9%
**NPV** (Negative Predictive Value): 73.6%
**Accuracy**: 73.9%

**Accuracy**: 87.9%

However, only 93 of the 165 eligible cows would be inseminated (56.4%).

Vilar et al. (University of Florida unpublished results)
What is the Percentage of Cows in Ovsynch that Regress the CL and Ovulate to the Final GnRH?

All cows are inseminated and 82.6% (346/419) regressed the CL and ovulated within 48 h

82.6 vs. 56.4%

89.5% progesterone < 1 ng/mL (375/419)

91.2% ovulated within 48 h (382/419)
Use of Synchronized AI in Dairy Herds in the US and Pregnancy per AI

1.14 million breeding records from US dairy herd

* States in USA reporting < 1,000 AI records not used in the analysis and colored in grey (unknown frequency of SAI)

All postpartum AIs for entire US

- P/Al for SAI
- P/Al for EAI

10% to 30% SAI

Unknown*

Voluntary Waiting Period

- Depends on:
  - Ideal interval to pregnancy
    - Milk production
    - Persistence of lactation
  - Pregnancy rate
  - Reproductive program for first AI
  - Fertility of first AI

- In general > 50 DIM

<table>
<thead>
<tr>
<th>Voluntary waiting period</th>
<th>Anticipate</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Milk persistency</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>First AI</td>
<td>Estrous detection</td>
<td>Timed-AI</td>
</tr>
<tr>
<td>21-d pregnancy rate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Pregnancy at first AI</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

Choosing the Voluntary Waiting Period

## Can You Afford DNB?

<table>
<thead>
<tr>
<th></th>
<th>100</th>
<th>100</th>
<th>100</th>
<th>100</th>
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<tbody>
<tr>
<td>Cows, n</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Heifers, n</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>PR 1&lt;sup&gt;st&lt;/sup&gt; 21 DIM, %</td>
<td>45.0</td>
<td>45.0</td>
<td>35.0</td>
<td>35.0</td>
<td>45.0</td>
</tr>
<tr>
<td>PR after 1&lt;sup&gt;st&lt;/sup&gt; 21 DIM, %</td>
<td>20.0</td>
<td>20.0</td>
<td>15.0</td>
<td>15.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Overall PR cows, %</td>
<td>26.7</td>
<td>26.7</td>
<td>18.8</td>
<td>18.8</td>
<td>26.7</td>
</tr>
<tr>
<td>Culling/death cows/year, %</td>
<td>25.0</td>
<td>35.0</td>
<td>25.0</td>
<td>35.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Pregnancy loss</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Heifer mortality, %</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Heifer culling, %</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Heifer pregnant by 16 mo, %</td>
<td>90.0</td>
<td>90.0</td>
<td>90.0</td>
<td>90.0</td>
<td>90.0</td>
</tr>
<tr>
<td>Female, %</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
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<tr>
<td>Female calves from cows</td>
<td>30</td>
<td>26</td>
<td>28</td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>Female calves from heifers</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Total females born/year</td>
<td>47</td>
<td>43</td>
<td>45</td>
<td>42</td>
<td>40</td>
</tr>
<tr>
<td>Heifers entering herd in 2 years</td>
<td>36</td>
<td>33</td>
<td>35</td>
<td>32</td>
<td>26</td>
</tr>
</tbody>
</table>
21-d Pregnancy Rate and Milk Production of USA Herds

Source: DRMS, DairyMetrics, April 26th, 2011
Average Production 1940
(2,000 Kg/cow)

- Milk
- Dry Matter
Average Production 2015
(10,400 Kg/cow)
Current World Records

Hartje Meyer Beacon 9792 **33,665 kg** (74,064 pounds) in 365 d

Smurf - **216,891 kg** (478,163 pounds) over 15 years
Glycogen

Essential processes: cell maintenance, circulation, neural activity

Diet

Oxidizable metabolic fuels

Reducible processes: Thermoregulation, locomotion, growth, and LACTATION

Fatty acids

Expendable processes: REPRODUCTION, fat storage

Partitioning of metabolic substrates according to priority

If Energy Balance is a Major Drive of Reproductive Success in the Dairy Cow, then the Focus Should be on Intake and not Milk Yield

Heritability of Reproductive Traits

AFS/O = age first service/ovulation
AFC = age first calving
CFH = calving to first heat interval
CFS = calving to first service interval
NS = Number of services
PRFS = pregnant to first service
PR Period = pregnant in a given period of breeding
CIV = calving interval
CCI/DO = calving to conception interval / days open
First to last = interval from first to last AI
NR = nonreturn rate
SR = submission rate

Selection for Milk Yield and Daughter Fertility

626 active Holstein sires with proof in the US (August 2010)

Many Sires Have Improved Daughter Fertility and Increased PTA Milk

Fig. 2. Milk PTA (kg) and DPR of genomic and proven sires released in December 2011 (AIPL-USDA)
We Can Select for High Net Merit, Bull Fertility, and Daughter Fertility

- 5.0 - 4.0 - 3.0 - 2.0 - 1.0 0.0 1.0 2.0 3.0 4.0

-500 0 500 1000

Daughter pregnancy rate (DPR, %)
Net Merit ($)

- Low sire conception rate bulls
- High sire conception rate bulls


382 active Holstein sires with all 3 proofs in the US (August 2010)
Traditional Genetic Selection Progeny Testing

Don’t know the genes responsible for the trait (milk yield)

We know that bulls with daughters that produce more milk are more likely to have the genes that confer higher milk production

Estimated genetic value - - - - - - - True genetic value
Gene – a blueprint that tells the cell how to make a protein (~22,000 in cow)

Protein – the main work horses in a cell or animal

Most SNP are not on the chip
Bovine HD chip - 777,000 SNP

SNP far from gene
Not related to trait

SNP near gene
related to trait

SNP in gene
strongly related to trait

3,000,000,000 bases

777,000 SNP
Basis of SNP Chip
Relates inheritance at each SNP on chip to trait of interest

SNPs in a gene or close to a gene will explain some of the genetic variability in a trait
Challenges

- Limited population for a given breed
- Best sires used more intensively
  - A single sire can disseminate desirable \textit{(an bad)} genes to a very large population
- Inbreeding and loss of health/fertility fitness

How many of you have used this sire? How many of you are using this sire?
Evaluate the Effect of Inseminating All Heifers on the First Day of Breeding

- 612 Holstein heifers in 3 herds with excellent insemination rate

- Evaluate reproductive performance

- Evaluate the cost per pregnancy with the two reproductive programs used

Control

PGF$_{2\alpha}$, detection of estrus & AI

5-d TAI

GnRH

PGF$_{2\alpha}$ PGF$_{2\alpha}$ GnRH+AI

CIDR

5 d 1 d 2 d

-6 -1 0 2 ................................................................. 84

Day of study
## Effect of Treatment on Reproductive Responses of Dairy Heifers at 1<sup>st</sup> AI

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control</th>
<th>TAI</th>
<th>Adjusted OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day to 1&lt;sup&gt;st&lt;/sup&gt; AI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (95% CI)</td>
<td>10.0 (9.0-11.0)</td>
<td>2.0 (1.0-2.0)</td>
<td>--------</td>
<td>0.001</td>
</tr>
<tr>
<td>Mean ± SEM</td>
<td>10.4 ± 0.4</td>
<td>1.7 ± 0.1</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Inseminated heifers, %</td>
<td>97.1 (297/306)</td>
<td>100 (305/305)</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td><strong>Pregnant 1&lt;sup&gt;st&lt;/sup&gt; AI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 32, % (n/n)</td>
<td>62.3 (185/297)</td>
<td>65.5 (199/304)</td>
<td>1.18 (0.82-1.69)</td>
<td>0.36</td>
</tr>
<tr>
<td>Day 60, % (n/n)</td>
<td>58.3 (173/297)</td>
<td>62.8 (191/304)</td>
<td>1.28 (0.90-1.85)</td>
<td>0.17</td>
</tr>
<tr>
<td>Pregnancy loss, % (n/n)</td>
<td>6.5 (12/185)</td>
<td>4.0 (8/199)</td>
<td>0.60 (0.24-1.52)</td>
<td>0.28</td>
</tr>
<tr>
<td><strong>Pregnant according to semen type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional, % (n/n)</td>
<td>64.6 (155/240)</td>
<td>65.4 (151/231)</td>
<td>1.04 (0.71-1.51)</td>
<td>0.86</td>
</tr>
<tr>
<td>Sex-sorted, % (n/n)</td>
<td>31.6 (18/57)</td>
<td>54.8 (40/73)</td>
<td>2.63 (1.26-5.46)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Days in the Study at 2\textsuperscript{nd} AI

Heifers, n

Day in the study at 2\textsuperscript{nd} AI

# Effect of Treatment on Reproductive Responses of Heifers Throughout the 84-d Experiment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control</th>
<th>TAI</th>
<th>Adjusted OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insemination rate, 21-d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cycles, %</td>
<td>82.4 (449/5445)</td>
<td>91.4 (446/488)</td>
<td>3.51 (1.93-6.41)</td>
<td>0.001</td>
</tr>
<tr>
<td>After 1&lt;sup&gt;st&lt;/sup&gt; cycle, %</td>
<td>68.2 (163/239)</td>
<td>77.1 (141/183)</td>
<td>2.67 (1.35-5.26)</td>
<td>0.005</td>
</tr>
<tr>
<td>Pregnancy/AI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All AI, %</td>
<td>56.0 (261/466)</td>
<td>57.4 (279/486)</td>
<td>1.14 (0.86-1.50)</td>
<td>0.37</td>
</tr>
<tr>
<td>After 1&lt;sup&gt;st&lt;/sup&gt; AI, %</td>
<td>52.1 (88/169)</td>
<td>48.4 (88/182)</td>
<td>0.90 (0.58-1.39)</td>
<td>0.63</td>
</tr>
<tr>
<td>Pregnancy rate, 21-d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cycles, %</td>
<td>47.9 (261/545)</td>
<td>57.2 (279/488)</td>
<td>1.47 (1.11-1.94)</td>
<td>0.008</td>
</tr>
<tr>
<td>After 1&lt;sup&gt;st&lt;/sup&gt; cycle, %</td>
<td>34.7 (83/239)</td>
<td>38.8 (71/183)</td>
<td>1.37 (0.88-2.13)</td>
<td>0.17</td>
</tr>
</tbody>
</table>

## Effect of Reproductive Program on Cost per Heifer or per Pregnancy

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>TAI</th>
<th>SEM</th>
<th>Difference</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost per heifer, US $</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hormones</td>
<td>1.31</td>
<td>12.75</td>
<td>0.06</td>
<td>-11.44</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Detection of estrus</td>
<td>4.57</td>
<td>3.92</td>
<td>0.10</td>
<td>0.65</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Semen and AI</td>
<td>13.28</td>
<td>14.50</td>
<td>0.40</td>
<td>-1.22</td>
<td>0.03</td>
</tr>
<tr>
<td>Pregnancy diagnosis</td>
<td>3.68</td>
<td>3.86</td>
<td>0.05</td>
<td>-0.18</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Extra feed</td>
<td>62.11</td>
<td>40.43</td>
<td>3.46</td>
<td>21.68</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td><strong>Cost per heifer</strong></td>
<td>85.00</td>
<td>75.45</td>
<td>3.87</td>
<td>9.55</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Cost per pregnancy, US $</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hormones</td>
<td>1.54</td>
<td>13.88</td>
<td>0.08</td>
<td>-12.34</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Detection of estrus</td>
<td>5.37</td>
<td>4.28</td>
<td>0.11</td>
<td>1.09</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Semen and AI</td>
<td>15.56</td>
<td>15.83</td>
<td>0.45</td>
<td>-0.27</td>
<td>0.68</td>
</tr>
<tr>
<td>Pregnancy diagnosis</td>
<td>4.31</td>
<td>4.22</td>
<td>0.05</td>
<td>0.09</td>
<td>0.22</td>
</tr>
<tr>
<td>Extra feed</td>
<td>72.82</td>
<td>44.17</td>
<td>3.91</td>
<td>28.65</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td><strong>Cost per pregnancy</strong></td>
<td>99.59</td>
<td>82.43</td>
<td>4.36</td>
<td>17.16</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

SUMMARY

✓ Sound reproduction requires integrated management
  ✓ Cow health and nutrition to minimize diseases and excess weight loss
    ✓ Unquestionable that high prevalence of diseases in early lactation is disastrous for reproduction
  ✓ Reproductive programs
    ✓ Combine methods for detection of estrus and timed AI
  ✓ Genetic selection
    ✓ Take advantage of multi-trait selection and emphasize health and fertility traits without sacrificing yield of milk components

✓ Genomic methods for genetic selection reduce the generation interval and, for the first time, we can now identify some of the genes or genetic markers close to the genes that influence traits of interest

✓ Remember, there are opportunities in heifer reproductive management that influence profitability of the dairy, even in well-managed farms
Thank you

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