STRESSORS

Temperature
Nutrition
Temperament
Transportation / relocation
Disease and inflammation
Effect of temperature for 72 h post insemination

<table>
<thead>
<tr>
<th>Chamber Temperature</th>
<th>No. Hfrs</th>
<th>No. conceiving</th>
<th>Avg rectal Temp</th>
<th>Avg breaths/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>23</td>
<td>0</td>
<td>104</td>
<td>105.3</td>
</tr>
<tr>
<td>70</td>
<td>25</td>
<td>12</td>
<td>101.3</td>
<td>47.3</td>
</tr>
</tbody>
</table>

Dunlap and Vincent, 1971
Effect of heat shock on d 4 or 5 embryos

Development to the blastocyst stage (%)

Angus  Holstein  Brahman  Angus  Brahman  Romo.  Ang. x Hol.  Nelore

38.5 °C = 101.3 °F  41 °C = 105.8 °F
Commercial Dairy in Brazil

B

Pregnancy rate (%)

ET

AI

Summer

Winter
### Mean environmental conditions relative to beginning of breeding season

<table>
<thead>
<tr>
<th></th>
<th>Day -30</th>
<th>Day 21</th>
<th>Day 42</th>
<th>Day 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Temp</td>
<td>58.6</td>
<td>66.4</td>
<td>70.2</td>
<td>72</td>
</tr>
<tr>
<td>Min. Temp</td>
<td>47.5</td>
<td>55.6</td>
<td>59</td>
<td>60.8</td>
</tr>
<tr>
<td>Max. Temp</td>
<td>70</td>
<td>77.2</td>
<td>81.3</td>
<td>82.9</td>
</tr>
<tr>
<td>RH, %</td>
<td>68.9</td>
<td>72.1</td>
<td>71.6</td>
<td>72.7</td>
</tr>
<tr>
<td>THI</td>
<td>58.4</td>
<td>64.9</td>
<td>68.1</td>
<td>69.7</td>
</tr>
<tr>
<td>Solar Radiation</td>
<td>494.7</td>
<td>531.5</td>
<td>578.0</td>
<td>590.7</td>
</tr>
<tr>
<td>Accum. precipitation</td>
<td>4.1</td>
<td>3.4</td>
<td>6.9</td>
<td>9.7</td>
</tr>
<tr>
<td>Wind speed</td>
<td>4.5</td>
<td>3.9</td>
<td>3.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Pregnancy rate</td>
<td>54.2</td>
<td>75.8</td>
<td>83.0</td>
<td></td>
</tr>
</tbody>
</table>

Amundson et al., 2006
Summary Points

• Lower night time temperatures – greater coping ability for hot days

• THI threshold above which PR is negative was 73, close to the avg temp on days on days 42 and 60

• Optimum conditions change with changing environment

Amundson et al., 2006
FIG. 1. Effects of characteristics.
FIG. 1. Effects of exposure to 40°C upon various spermatozoal characteristics.
M.B. Rahman et al. / Theriogenology 113 (2018) 102–112

Heat stress

Spermatogonia → Spermatocytes → Round spermatids → Early spermatids → Elongated spermatids → Spermatozoa

Spermatocytogenesis (~21 days) → Meiosis (~23 days) → Spermiogenesis (~17 days) → Epididymal maturation (~7 days)

Spermatogenesis (~61 days)
• THI > 80 for 11 hr and > 85 for 6 hr
  ○ THI > 80 for 7 hr and non over 85

Vaginal temperature peak lags the peak in THI

Hamblen et al., 2018
Dealing with heat stress

If peak environmental temperature is at 4:00 pm 6:00 pm – Peak animal core temperature 12:00 am – recovery from heat load

Heat production from feed intake peaks 4-6 hr post feeding

Biting flies cause animals to bunch up, decreasing cooling
http://mesonet.k-state.edu/

Comfort Index includes temperature, relative humidity, wind speed, and solar radiation.
STRESSORS

Temperature
Nutrition
Transportation / relocation
Temperament
Disease and inflammation
Effect of pre-breeding and post-breeding nutrition

<table>
<thead>
<tr>
<th></th>
<th>L-L</th>
<th>L-H</th>
<th>H-H</th>
<th>H-L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total heifers</td>
<td>66</td>
<td>65</td>
<td>60</td>
<td>56</td>
</tr>
<tr>
<td>Total Pregnant</td>
<td>46</td>
<td>46</td>
<td>39</td>
<td>21</td>
</tr>
<tr>
<td>Embryo Survival rate</td>
<td>0.70</td>
<td>0.71</td>
<td>0.65</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Pasture allowance:
L=.8 maintenance energy requirements
H= 2x maintenance energy requirements

10 days prebreeding
14 days post insemination – Embryo recovery
30 days post insemination - US

Dunne et al., 1999
Effect of Acute Nutritional Restriction on Incidence of Anovulation and Periovulatory Estradiol and Gonadotropin Concentrations in Beef Heifers


Mackey et al., 1999
Effect of Acute Nutritional Restriction on Incidence of Anovulation and Periovulatory Estradiol and Gonadotropin Concentrations in Beef Heifers


Mackey et al., 1999

Maximum diameter attained
1.2 Mn 12.6 mm
0.4 Mn 11.7 mm
Maximum diameter attained
1.2 Mn 13.8 mm
0.4 Mn 10.6 mm

Number of anovulatory hfrs
1.2 Mn 0 / 21
0.4 Mn 10 / 21

Effect of Acute Nutritional Restriction on Incidence of Anovulation and Periovulatory Estradiol and Gonadotropin Concentrations in Beef Heifers
Mackey et al., 1999
Forage vs Drylot (normal) Development

Average daily gain: kg/day

- * P=0.06; ** P<0.05

Perry et al., 2013
INFLUENCE OF PRIOR GRAZING EXPERIENCE ON PERFORMANCE ON SUMMER PASTURE

Average Daily Gain, lb/d

<table>
<thead>
<tr>
<th>Replicate</th>
<th>Experienced</th>
<th>Naïve</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.0</td>
<td>1.45</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>0.8</td>
</tr>
<tr>
<td>4</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>1.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

AI Preg Rate

- Experienced: 59.4%
- Naïve: 49.1%

Perry et al., 2013
Grazing Behavior Prior to Movement

Steps per day

Days of treatment

DRLT
GRS

P < 0.01

Perry et al., 2015 Prof Anim Sci 31:264-269
Grazing Behavior after Movement

Steps per day vs. Days after treatment

DRLT
GRS

P < 0.01

Perry et al., 2015 Prof Anim Sci 31:264-269
Note scale difference
## Transportation stress

<table>
<thead>
<tr>
<th></th>
<th>1-4</th>
<th>8 to 12</th>
<th>29 - 33</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>143</td>
<td>143</td>
<td>144</td>
</tr>
<tr>
<td>Synchronized pregnancy rate</td>
<td>74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Breeding season pregnancy rate</td>
<td>95</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Mean day of conception</td>
<td>9.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.6&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
If heifers must be moved after AI, then transportation should be within 3-4 days of breeding or after 42 days.

<table>
<thead>
<tr>
<th></th>
<th>1-4</th>
<th>8 to 12</th>
<th>29 - 33</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>143</td>
<td>143</td>
<td>144</td>
</tr>
<tr>
<td>Synchronized pregnancy rate</td>
<td>74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Breeding season pregnancy rate</td>
<td>95</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Mean day of conception</td>
<td>9.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.6&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event</th>
<th>Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estrus</td>
<td>0</td>
</tr>
<tr>
<td>Fertilization</td>
<td>1</td>
</tr>
<tr>
<td>Migration to uterus</td>
<td>5 - 6</td>
</tr>
<tr>
<td>Maternal recognition of pregnancy</td>
<td>15-17</td>
</tr>
<tr>
<td>Adhesion to uterus</td>
<td>21-22</td>
</tr>
<tr>
<td>Placentation</td>
<td>25</td>
</tr>
<tr>
<td>Definitive attachment of embryo to uterus</td>
<td>42</td>
</tr>
</tbody>
</table>
STRESSORS

Temperature
Nutrition
Transportation / relocation

Temperament
Disease and inflammation
Effect of temperament

<table>
<thead>
<tr>
<th>Item</th>
<th>Adequate</th>
<th>Excitable</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>324</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>Plasma Cortisol, ng/ml</td>
<td>17.8</td>
<td>22.7</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pregnancy rate, %</td>
<td>94.6</td>
<td>88.7</td>
<td>0.03</td>
</tr>
<tr>
<td>Calving rate, %</td>
<td>91.8</td>
<td>85</td>
<td>0.04</td>
</tr>
<tr>
<td>Weaning rate, %</td>
<td>89.9</td>
<td>83.9</td>
<td>0.09</td>
</tr>
<tr>
<td>Calf weaning BW, lbs</td>
<td>545</td>
<td>543</td>
<td>0.71</td>
</tr>
<tr>
<td>Lbs calf weaned/cow exposed</td>
<td>490</td>
<td>455</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Cooke et al., 2012
## Effect of acclimatization

<table>
<thead>
<tr>
<th>Item</th>
<th>Acclimated</th>
<th>Non-Acclimated</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>44</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Plasma Cortisol, ng/ml</td>
<td>26.1</td>
<td>32.8</td>
<td>0.01</td>
</tr>
<tr>
<td>Pubertal by 12 months</td>
<td>59.6</td>
<td>37.8</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Cooke et al., 2012
TEMPERAMENT

Acclimated to handling

– Lower cortisol, higher [LH] and LH pulse frequency
– Earlier puberty, earlier pregnant heifers

Probability of pregnancy is higher when cortisol is lower

Adequate temperament score (≤ 3) higher AI preg rate than Excitable Nelore cows
STRESSORS

Temperature
Nutrition
Transportation / relocation
Temperament
Disease and inflammation
Disease Issues

Presence of BVD PI will cause embryonic loss

BVD exposure to naïve animal causes ovarian response
As production levels (e.g., rate of gain, milk production per day, eggs per day) increase, the sensitivity and tolerance to stress increases and, when coupled with an adverse environment, the animal is at greater risk. Collier et al., 2019
How to assess temperament

Chute Score
behavior while restrained in chute

Scale
1. Calm, no movement
2. Restless movement
3. Frequent movement with vocalization
4. Constant movement, vocalization, shaking of chute
5. Violent and continuous struggling
HOW TO ASSESS TEMPERAMENT

Exit Velocity or Score

Speed of animal after it leaves chute

Measurement

Electronic – Classify on feet/second

Visual

1 = walks away from chute
2 = trots away from chute
3 = runs away from chute
Stress and reproduction

- Elevated Cortisol
- Decreased GnRH & LH secretion
- Decreased oestradiol
- Poor oestrus expression
- Prolonged follicular dominance
- Low fertilisation rate
- Poor embryo quality
- Compromised uterine environment
- Embryonic loss
- Negative energy balance
- Decreased feed intake
- Ovulation success
- Luteal development
- Pregnancy maintenance
- Reproductive failure
Less heat stress (vaginal temp & sweating rate)

- heifers that were calm in the chute
- Shorter, smoother hair coats

Hamblen et al., 2018
• Night-time cooling
• THI
• Acclimitization
Percentage of Calves born by month, NAHMS 2007-2008
# Temperament x Reproduction

**Angus x Hereford cows**

<table>
<thead>
<tr>
<th>Item</th>
<th>EXC</th>
<th>ADQ</th>
<th>SEM</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding season</td>
<td>n = 109</td>
<td>n = 324</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plasma cortisol at AI, ng/mL</td>
<td>22.7</td>
<td>17.8</td>
<td>0.8</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Pregnancy rates, %</td>
<td>88.7</td>
<td>94.6</td>
<td>1.9</td>
<td>0.03</td>
</tr>
<tr>
<td>Pregnancy loss, %</td>
<td>3.8</td>
<td>2.8</td>
<td>1.3</td>
<td>0.63</td>
</tr>
<tr>
<td>Calving rate, %</td>
<td>85.0</td>
<td>91.8</td>
<td>2.2</td>
<td>0.04</td>
</tr>
<tr>
<td>Weaning results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calf weaning BW, lbs</td>
<td>543</td>
<td>545</td>
<td>5</td>
<td>0.71</td>
</tr>
<tr>
<td>Weaning rate, %</td>
<td>83.9</td>
<td>89.9</td>
<td>2.4</td>
<td>0.09</td>
</tr>
<tr>
<td>Calf BW/cow exposed, lbs</td>
<td>455</td>
<td>490</td>
<td>6</td>
<td>0.08</td>
</tr>
<tr>
<td>Weaning return/cow, $</td>
<td>820</td>
<td>882</td>
<td>12</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Cooke et al. (2012)
Heat stress leads to decreased oestradiol secretion, which can result in poor oestrus expression and prolonged follicular dominance. This contributes to low fertilisation rate and poor embryo quality. Additionally, heat stress affects uterine environment, increasing embryonic loss. Negative energy balance and decreased feed intake further exacerbate these issues.
Effect of milk production on metabolic heat production

Relative Metabolic heat production

- dry
- 66 lb/d
- 121 lb/d
Average Temperature Humidity Index

Dry Matter Intake (kg)

57

72