Meiotic Recombination in Ruminant Livestock Species

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Goals

1. To quantify, characterize and compare the number of meiotic recombination/crossover (CO) between beefalo, cattle and sheep.

2. Test the relationship between the number of CO and chromosome length.

3. Examine the chromosomal structural integrity.
Meiotic Recombination

- Exchange of genetic material contributes to genetic diversity
  - NOT random
    - Associated with the number of chromosome arms
    - Interference
    - “Hotspots”
    - Sexual dimorphism

- Ensure faithful chromosome segregation
Karyotype: Chromosome Arms

Cattle

Sheep
Mammalian Recombination

Sex averaged linkage map comparison to number of chromosome arms in different mammalian species.

Figure adapted from Coop & Przeworski (2007), Nature Reviews Genetics 8.
Meiosis

- Ensure faithful chromosome segregation

- Mis-segregation or non disjunction leads apoptosis in males

http://www.unal-and-brar-labs.org/unal-cdk/
Method: Cytogenetics

• Allows us to characterize recombination directly
  • Has distinct advantages compared to linkage mapping
    • Reference genome
    • Large number of progeny

• Determine structural integrity
Recombination in prophase (pachytene cell) observed by immunofluorescence.

Recombination observed in gametes are lower due to independent assortment of chromatids.

Average crossover counted in offspring = 1.5
Immunofluorescence

Synaptonemal Complex (SC)
SYCP3
MLH1
Crossover (CO)
**Number of COs**

Each dot represents the number of COs from individual spermatocyte, black bars represent breed mean, and the letters above denotes significant differences (P<0.01).

<table>
<thead>
<tr>
<th>Breed</th>
<th>Number of Spermatocytes</th>
<th>Average CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beefalo</td>
<td>713</td>
<td>42.6(^A) ± 0.70</td>
</tr>
<tr>
<td>Cattle</td>
<td>1017</td>
<td>44.7(^B) ± 0.79</td>
</tr>
<tr>
<td>Sheep</td>
<td>2749</td>
<td>62.5(^C) ± 0.78</td>
</tr>
</tbody>
</table>
Chromosome Length & CO Numbers
Length of Chromosome & CO Number

Beefalo (61 cells, $r=0.53$)
Cattle (86 cells, $r=0.57$)
Sheep (340 cells, $r=0.70$)
Chromosome Length & CO Position

- Locations of CO on SCs with 2 CO
Chromosomal Defect Scoring

A. Missing Crossover
   SYCP3
   MLH1

B. Rings Gaps
   XY
   SYCP3
   MLH1
Chromosomal Defect Scoring

<table>
<thead>
<tr>
<th>Defect</th>
<th>Beefalo</th>
<th>Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>74.6(^\text{A})</td>
<td>83.6(^\text{B})</td>
</tr>
<tr>
<td>Rings</td>
<td>10.3(^\text{A})</td>
<td>3.8(^\text{B})</td>
</tr>
<tr>
<td>Missing CO</td>
<td>8.9(^\text{A})</td>
<td>6.2(^\text{A})</td>
</tr>
<tr>
<td>Gaps</td>
<td>6.3(^\text{A})</td>
<td>6.2(^\text{A})</td>
</tr>
<tr>
<td>Total Defects</td>
<td>25.4(^\text{A})</td>
<td>16.4(^\text{B})</td>
</tr>
</tbody>
</table>

Letters denote significant differences (P<0.01)
Summary

• Sheep exhibit a significantly greater number of COs and cattle exhibit more COs in comparison beefalo.

• Larger chromosomes tend to have a greater number of COs.

• Beefalo spermatocytes have a greater number of structural defects.
Acknowledgements

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Lab

• Rebekka Sawyer
• Hannah Jaeger
• Dominic De La Torre
• Eric Robinson

Testicular Samples

• Pure Country Harvest
• University of Idaho Vandal Meats
• University of Idaho Sheep Experiment Station
• C&L Meat Locker
Questions?
## Number of COs in Cattle

<table>
<thead>
<tr>
<th>Bulls</th>
<th>Spermatocytes</th>
<th>Average CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charolais</td>
<td>112</td>
<td>48.9A ±0.54</td>
</tr>
<tr>
<td>Gelbvieh</td>
<td>97</td>
<td>47.6A ±0.58</td>
</tr>
<tr>
<td>Jersey</td>
<td>100</td>
<td>48.6A ±0.39</td>
</tr>
<tr>
<td>Angus 1</td>
<td>100</td>
<td>43.3B ±0.33</td>
</tr>
<tr>
<td>Angus 2</td>
<td>100</td>
<td>43.4B ±0.30</td>
</tr>
<tr>
<td>Angus 3</td>
<td>101</td>
<td>41.5B ±0.36</td>
</tr>
<tr>
<td>Angus 4</td>
<td>100</td>
<td>42.4B ±0.37</td>
</tr>
<tr>
<td>Angus 5</td>
<td>100</td>
<td>41.7B ±0.41</td>
</tr>
<tr>
<td>Angus 6</td>
<td>97</td>
<td>43.2B ±0.61</td>
</tr>
<tr>
<td>Angus 7</td>
<td>98</td>
<td>46.5A ±0.52</td>
</tr>
</tbody>
</table>