Factors That Affect Prolificacy in Sheep

Keith Inskeep and Bob Goodman
West Virginia University
Prolificacy = Number of ovulations x % fertilization rate x % embryonic survival x % fetal survival x % survival of the birth process.
Prolificacy = Number of ovulations x % fertilization rate x % embryonic survival x % fetal survival x % survival of the birth process.

Prolificacy = Lambs born (alive) per ewe lambing.

Lambing rate = Lambs born per ewe exposed.
How Big a Litter is Appropriate to Conditions?
Prolificacy

• Considered a lowly heritable trait ~ 10%
• Composed of:
  – Follicular development
  – Ovulation rate
    • Influenced by: single gene mutations
      season
      age of ewe
      nutrition
      hormonal factors
  – Fertilization rate
  – Embryonic and fetal survival
Follicular development

- Four waves of development per cycle in most breeds; more in some single ovulating breeds.
- Development to 2 mm in diameter is independent of gonadotropins.
- Recruited into a growing pool by FSH with some LH present.
- Lead follicles gain LH receptors in granulosa to achieve final growth and produce sufficient estrogen to stimulate ovulatory surge of LH.
Ewe # 776 Cyclic
* ovulatory foll.
Potential Ovulation Rate
Actual Ovulation Rate? (3)
What Determines Ovulation Rate?

Influenced by:

- single gene mutations
- season
- age of ewe
- nutrition
- hormonal factors
Which follicles ovulate?

- Ovulatory follicles are normally 4 to 7 mm in diameter.
- Ovulations occur from last and next to last waves.
- More in next to last wave ovulate when progesterone is lower and LH pulses are more frequent.
Single Gene Effects

• Booroola Gene – chromosome 6 – mutation in receptor for bone morphogenetic protein-15. One copy increases ovulation rate by 1 or 2 oocytes; two copies by 3 to 10 oocytes

• Others – X chromosome – in BMP-15 itself – or chromosome 5 – in growth differentiation factor-9 – one copy increases ovulation rate, but two copies yield streak ovaries and no ovulations;
Effect of Breeding Season on Ovulation Rate and Lamb Production in Rambouillet Ewes in Texas

<table>
<thead>
<tr>
<th>Breeding Interval</th>
<th>March 21 to May 2</th>
<th>June 21 to August 2</th>
<th>September 21 to November 2</th>
<th>December 21 to January 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Ovulation rate %</td>
<td>Lambs produced %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ovulation rate %</td>
<td>106</td>
<td>141</td>
<td>175</td>
<td>152</td>
</tr>
<tr>
<td>Lambs produced %</td>
<td>84</td>
<td>97</td>
<td>127</td>
<td>135</td>
</tr>
</tbody>
</table>
Effect of Breeding Season on Prolificacy and Lamb Production in STAR System - Dorset Ewes at Cornell

<table>
<thead>
<tr>
<th>Mating month</th>
<th>No. exposed</th>
<th>Fertility %</th>
<th>Prolificacy %</th>
<th>Lambs weaned %</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>785</td>
<td>49</td>
<td>142</td>
<td>114</td>
</tr>
<tr>
<td>March</td>
<td>1210</td>
<td>28</td>
<td>139</td>
<td>120</td>
</tr>
<tr>
<td>June</td>
<td>1529</td>
<td>15</td>
<td>152</td>
<td>112</td>
</tr>
<tr>
<td>August</td>
<td>2123</td>
<td>46</td>
<td>155</td>
<td>127</td>
</tr>
<tr>
<td>October</td>
<td>1621</td>
<td>69</td>
<td>158</td>
<td>130</td>
</tr>
</tbody>
</table>

Lewis et al., 1996
Effect of age of ewe on prolificacy

<table>
<thead>
<tr>
<th>Age of dam</th>
<th>No. ewes exposed</th>
<th>Lambing %</th>
<th>Prolificacy %</th>
<th>Lambs weaned / ewe bred %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>732</td>
<td>87</td>
<td>126</td>
<td>83</td>
</tr>
<tr>
<td>3</td>
<td>647</td>
<td>91</td>
<td>131</td>
<td>98</td>
</tr>
<tr>
<td>4</td>
<td>515</td>
<td>93</td>
<td>137</td>
<td>112</td>
</tr>
<tr>
<td>5</td>
<td>427</td>
<td>92</td>
<td>143</td>
<td>105</td>
</tr>
<tr>
<td>6</td>
<td>288</td>
<td>90</td>
<td>145</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>190</td>
<td>94</td>
<td>141</td>
<td>105</td>
</tr>
<tr>
<td>8</td>
<td>109</td>
<td>90</td>
<td>145</td>
<td>93</td>
</tr>
<tr>
<td>9+</td>
<td>54</td>
<td>82</td>
<td>153</td>
<td>99</td>
</tr>
</tbody>
</table>

Sidwell et al., 1962
Nutritional Effects – “Flushing”

- Static effect – body condition
  - acts primarily through growth hormone and insulin like growth factor
- Dynamic effect – short term increase in nutrition – known as “flushing”
  - act primarily at the ovary through glucose and insulin – energy more effective than protein unless on low protein forage
## Effects of Energy and Protein

<table>
<thead>
<tr>
<th>Protein</th>
<th>Energy</th>
<th>No. of Ewes</th>
<th>No. of Corpora Lutea</th>
<th>% Multiple Ovulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>23</td>
<td>1.83</td>
<td>78</td>
</tr>
<tr>
<td>272 gm</td>
<td>5.2 mcal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>25</td>
<td>1.92</td>
<td>88</td>
</tr>
<tr>
<td>3.2 mcal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>25</td>
<td>1.52</td>
<td>48</td>
</tr>
<tr>
<td>68 gm</td>
<td>5.2 mcal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>25</td>
<td>1.32</td>
<td>28</td>
</tr>
<tr>
<td>3.2 mcal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Memon et al., 1969
Hormonal Factors

Ovulation rate can *sometimes* be increased by:

- Lower progesterone
- Injection of gonadotropins-FSH followed by LH
- Equine Chorionic Gonadotropin (FSH like)
- Human Chorionic Gonadotropin (LH like)
- Combination of eCG and hCG (P.G. 600)
- Sequential treatments with gonadotropin releasing hormone
Hormonal Factors

Immunization against ovarian hormones:
  Estrogen – to reduce negative feedback on gonadotropin releasing hormone and thus increase FSH

Androstenedione – precursor of estrogen
  Applied extensively in Romney ewes in New Zealand

Inhibin – to reduce negative feedback on FSH directly at the anterior pituitary
Fertilization Rate

• Low early in the breeding season – 36 to 66 %

• Ram fertility is a major factor – 31 to 48 % of failures were due to poor sperm

• Decreased by high temperature – 56 to 60 % at 90°F vs 81 to 95 % at 70°F

• Breeding soundness exams are very important!
Embryonic and Fetal Losses

Most losses believed to occur early:

- 20 of 29% total in one study by day 18
- 28% of mated ewes not pregnant at day 26 in another study
- only 3% of corpora lutea on day 7 not represented by embryos on day 26 in the latter study
- but losses do occur after day 25
Pregnancy Diagnosis - Ultrasonography
Ewes Not Retaining Embryos Present at Day 25 of Gestation By Type of Loss
Embryos Present at Day 25 That Were Lost During Late Embryonic or Fetal Development

% of Embryos Lost

25-45
45-65
65-85
85-TERM

Day of Gestation
Corpora Lutea (Ovulations) Not Represented By Lambs Born in Ewes Treated With Three Dosages of FSH

Knights et al., 2002
Data in Prolific Barbados Blackbelly Ewes
Conclusions on Losses

- Embryonic and fetal losses occur throughout gestation.
- Three to 4% of embryos/fetuses were lost every 20 days in ewes that were pregnant at day 25. Losses differ with breed of ewe, breed of ram and individual sires of the embryo/fetus.
- Partial losses are greater than complete losses.
- Losses increase as ovulation rate increases and with age of ewe.
Overall Conclusion

Prolificacy is an important trait in any sheep operation, but selecting the goal will vary with each operation and requires careful study of all the factors involved.