Impact of nutrition, genetics and season on reproductive outcomes in sheep.

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Genetics and Prolificacy

- Maternal lines vary from 100-350%
- European short-tailed breeds are highly prolific and have influenced many composite breeds
  - Finn sheep, 250-300%
  - Romanov, 300-350%
- Polyplay (USA) and Rideau Arcott (Canada) are composites now fixed as breeds and well adopted as prolific breeds in intensive sheep farming systems in North America, 200-220%
- Many also create their own crosses using Finn and Romanov germplasm as a critical ingredient
- Booroola F/B gene-single gene (BMP-15 point mutation), ✓ 2-3X greater ovulation for Bb vs. BB
  - Must match B gene with traits for litter survival (“uterine capacity”, milk production, etc.)

European short-tailed breeds of great influence on prolificacy in North America

- Finn (Imported to North America in 1966)
- Romanov (Imported to North America in 1980)

Genetics and mating interval/aseasonality

- Breeds with shorter, shallower (?) anestrus period:
  - Horned Dorset
  - Polled Dorset
  - Rambouillet
  - Merino
  - Romanov
  - Finn
  - Polyplay
  - Many “hair” breeds
- Aseasonal fertility is inversely related to the latitude unless selection pressure was exerted (i.e. Finn, Romanov, Dorset).

Seasonal breeders are animal species that successfully mate only during certain times of the year.

Photoperiod control of reproduction in sheep is directed by changes in the level of melatonin secreted by the pineal gland.
Many "aseasonal" breeds only exhibit estrus cycles in response to ram presence.

Conception rate is typically lower during Spring (long days) but only by a small fraction in well managed, moderately aseasonal ewes.

Conception and lambing rates according to breeding season in a flock of commercial ewes (Dorset x Finn x Ile De France, n=4000, parity ≥2) in an accelerated program with natural mating.

<table>
<thead>
<tr>
<th>Breeding month</th>
<th>Conception rate, %</th>
<th>Lambing rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>91</td>
<td>192</td>
</tr>
<tr>
<td>March</td>
<td>81</td>
<td>182</td>
</tr>
<tr>
<td>May</td>
<td>75</td>
<td>176</td>
</tr>
<tr>
<td>July</td>
<td>83</td>
<td>180</td>
</tr>
<tr>
<td>September</td>
<td>95</td>
<td>212</td>
</tr>
<tr>
<td>November</td>
<td>96</td>
<td>220</td>
</tr>
</tbody>
</table>

Birth weight is lower in Spring mating/Fall lambing but survival to weaning is not different.

Litter size is greater in ewe bred in the Fall (short days) compared to ewes bred in the Spring (long days).
Summary on seasonality and its impact on reproductive outcomes:

- Some breeds are “moderately” aseasonal and can be induced into estrus by exposure to rams
- Many breeds are more seasonal and require photoperiod therapy or hormonal therapies to breed out of season
- Conception rate can be high in well managed, moderately aseasonal ewes during Spring but is always lower than in the optimal season.
- Ovulation rate/litter size, fetal loss, pregnancy length and fetal weight are lower in optimal mating periods

Nutrition and out of season breeding:

Theory:
- The sheep brain responds to signals indicative of energy status to overcome the seasonal constraint on fertility.
- Positive energy balance also improves embryonic survival which may be more important during the suboptimal breeding season

Impact of pre-breeding energy intake on reproduction in an accelerated lambing system during optimal (early Winter) and suboptimal (Spring) breeding seasons

Treatments:
- Energy intake altered during the 21 day period between weaning and the onset of the breeding period (ewes fed a common diet at 115% maintenance during the 5 week breeding period).
- 8 month accelerated system (5 months pregnancy, 2 months lactation, 1 month prebreeding/breeding)
- 21% Restricted TMR (66% TDN; 1.8 lb TDN, 0.36 lb CP per 176 lb ewe)
- 100% Limited TMR (66% TDN; 3.6 lb TDN, 0.75 lb CP per 176 lb ewe)
- Unlimited high energy TMR (73% TDN, 30% NDF; 3.6 lb TDN, 0.75 lb CP per 176 lb ewe)

Animals:
- 99 multiparous Dorset x Polypay ewes, n=33/treatment
- Mature Polled Dorset rams used at 3% coverage, ram rotated daily

Seasons:
- Spring: April 24-May 27
- Early winter: Dec 23- Jan 25
Results:

### Spring mating:

<table>
<thead>
<tr>
<th>% Maintenance energy requirements</th>
<th>50%</th>
<th>100%</th>
<th>200%</th>
<th>PSE²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight change, lbs</td>
<td>-21.6⁹</td>
<td>-4.2⁹</td>
<td>10.8⁹</td>
<td>1.3</td>
</tr>
<tr>
<td>Litter size (by ultrasound)</td>
<td>1.26³</td>
<td>1.12³</td>
<td>1.68³</td>
<td>0.1</td>
</tr>
<tr>
<td>Conception rate (by ultrasound), %</td>
<td>82</td>
<td>82</td>
<td>84</td>
<td></td>
</tr>
</tbody>
</table>

Results are adjusted for parity and number of lamblings. Mean is a percentage of the total number exposed. Different subscripts denote statistical difference at p<0.05.

### Early winter mating:

<table>
<thead>
<tr>
<th>% Maintenance energy requirements</th>
<th>50%</th>
<th>100%</th>
<th>200%</th>
<th>PSE²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight change, lbs</td>
<td>-15.2⁹</td>
<td>-4.2⁹</td>
<td>8.8⁹</td>
<td>1.1</td>
</tr>
<tr>
<td>Litter size (by ultrasound)</td>
<td>1.59⁴</td>
<td>1.56⁴</td>
<td>2.04⁴</td>
<td>0.1</td>
</tr>
<tr>
<td>Conception rate (by ultrasound), %</td>
<td>100</td>
<td>89</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Results are adjusted for parity and number of lamblings. Mean is a percentage of the total number exposed. Different subscripts denote statistical difference at p<0.05.

What have we learned?

- Flushing has a huge impact on lambing percentage regardless of season, ≈30-40% increase in an accelerated system.
- Continuation of a high energy diet during mating is not necessary and may even have high negative effects on conception.
- Flushing has a large return on investment (≤$1 investment pays $20).
- Body condition at the beginning of flushing is also an influential factor in determining lambing percentage.

Critical management areas to improve reproductive outcomes year-round

- Breeding management
- Ram fertility screening
- Ram and ewe nutrition prior to mating

Ensuring Ram fertility throughout the year is critical to out of season breeding success:

- **Genetics**—only certain breeds are both fertile and active breeders in the Spring
- **Temperature**—a key environmental factor to control as lack of shade exposure in Summer can drastically reduce semen quality
- **Nutrition**—providing a high plane of nutrition will improve fertility and sex drive of aseasonal rams
- **Screening**—reduce the number of infertile rams in a breeding group
- **Light**—light priming has been shown to help on all breeds but requires specialized ram housing
Ensuring Ram fertility:

Nutrition:
- Feed rams 2.0 times maintenance for 4 weeks pre-breeding
  - Total diet TDN 66-70%
- Target BCS 3.5
- Group rams according to nutritional needs
  - Growing rams: especially those under 12 mo old
    (↑ energy and protein)
  - Mature rams: 2 yrs and older (↑ energy, 12% CP)
  - Terminal rams vs Maternal rams?
    - Mature size of terminal rams may be 50% greater so they need more and better feed

Ensuring Ram fertility:

- Perform breeding soundness exam (BSE) or at bare minimum, palpate testicles and do a general health exam
  - BSE documents fertility but are all fertile rams active breeders (have high libido)?
  - Service tests on young rams can help but are not very practical to apply (ID ewes in heat with teasers and then join them with young rams)
  - Monitor libido by recording mating activity with a marking harness.
  - Avoid using unproven rams in spring

Why do a BSE exam?

- About 75% of problem rams are identified by testicular palpation and general soundness exam.
- Finding the remaining 25% requires a BSE
- Gross sperm motility alone tells you a lot and accounts for most of the failed exams
- Defective sperm account for about 10% of failed exams and are often associated with other problems.
Breeding management:

- Ram to ewe coverage needs to be greater during the spring breeding season
  - 3-4% coverage with no estrus synchronization
  - Keep service less than 6 ewes per ram per 24h
- Use ram fertility screening methods to remove subfertile/nonfertile rams
- Grouping strategy?
  - Most successful flocks breed in large groups with rams screened by BSE, or at a minimum by palpation

What is the ram effect?

- Induces estrus in females “on the edge” or ones “lightly” in anestrus
- Acts to synchronize ewes
- Coverage should be at least 2% for best effect.
- Isolate females from males 30 days prior to exposure
- Introduce vasectomized males and remove 14 days later, females will exhibit estrus in two modes either 17-18 or 22-23 days following initial male exposure.
- Does not work on genetics that have a strong seasonal anestrus

Why is the ram effect important in breeding Feb 15 to Aug 15?

- It is hard to find truly aseasonal ewes that cycle equally well throughout the year
- Most ewes stop cycling in early March and begin again in late July
- Adding rams to ewes not exposed to rams previously will get many of the modestly aseasonal ewes cycling for at least a few cycles.
- Seasonal ewes will not cycle at all even with ram exposure
- Many use the ram effect to breed ewes using fertile rams only.
  - Most ewes show behavioral estrus on the second heat.
  - Will using teasers improve conception and lambing percentage in these flocks?

Summary on ram/breeding management:

- During the mid winter to mid summer, active mating behavior is critical to induce estrus and active and fertile rams are needed to settle cycling ewes.
- Managing ram power through feeding, lights, screening and proper coverage will help ensure out-of-season breeding success
- Don’t rely on seasonal terminal sires to breed your ewes during to suboptimal season unless you take special measures to ensure fertility/libido such as light priming.

Pre-Breeding/Flushing:

- Concept: the sheep brain responds to signals indicating that the ewe is well-fed by increasing ovulation rate (viable eggs produced).
Flushing protocols:

Factors to consider:
• Short and long term nutritional both play a role in determining ovulation rate (fatness and current feeding).
• Increased nutrition (primarily energy) for as little as 4-5 days can improve ovulation in under-fed ewes.
• Ewes in positive energy balance (actively gaining weight) will ovulate at higher rates.
• Fat ewes (C.S. >4) show little response.

Pre-Breeding/Flushing:

Nutritional target:
• ~2 times increase in energy intake over maintenance for 2-3 weeks.
• 65-73% TDN, 11% CP, unlimited intake (2.7 - 3.6 lb TDN per 176 lb ewe)
• Increase in body condition score of 0.5 units over this period, (~5-10 lbs).
• Key is to place animals in positive weight gain
• Increase or decrease length of flushing program based on condition score
• Can be done with grazing systems with correct stocking rate and forage quality
• Can be done precisely in feeding programs with energy supplement (corn, barley, quality forage, etc.)
Pre-Breeding/Flushing:

Responses to Expect:
- Increases of 25% are typical, increases up to 57% have been observed in thin ewes
- Flushing response may be lost if ewes go into negative energy balance (loose weight!) in early pregnancy due to embryonic loss
- Maintenance or slightly better feeding (1.1x maintenance) is needed during early pregnancy or gains during flushing may be lost via enhanced embryonic loss.
- Continuing a high energy diet during the breeding season will not improve litter size and may have negative consequences.

Summary
- Ram management and nutritional management are the keys to profitable lamb production regardless of production system.
- Flushing defined by feeding to achieve significant positive weight gain before breeding (state of positive energy balance) is needed to optimize ram activity and ewe lambing percentage regardless of season.
- Creating a strong ram effect and increasing coverage of active, fertile rams during Spring mating are key in obtaining good conception rates in moderately aseasonal ewes.
- Highly seasonal breeds require light and/or hormone therapy to breed out of season.

Extended day protocol:
- 60 days of 24 hrs light followed by 60 days of ambient lighting condition - turn in rams.
- 100 lux (10 FC) at ewe eye level (3.5 FC minimum)
- How I do it:
  - Bring ewes in from winter pasture on Jan 5.
  - Set lights to come on at dusk and off at dawn starting Jan 5.
  - Ewes lamb Jan 25 - Feb 20
  - Turn lights off on March 5, natural light thereafter
  - Put in rams May 5.

Extended day: under evaluation...

Field application in 2008 with 300 ewe flock:
- No change of spring conception rate in aseasonal ewes (Finn x Dorset x Île de France, n=140-182).
  - 92% natural light (3 yr average [2005-7], n=132-186)
  - 94% extended day (2008, n=182)
- Huge change in spring conception rate in seasonal ewes (purebred and ¾ suffolk ewes, ).
  - 0% natural light (2 yr average [2006-7], n=13-17)
  - 92% extended day (2008, n=16)

Extended day:
- Cost of $1.60/ewe/year for electricity use
- Bulbs cost $0.25/ewe/year
- Barn was lighted during winter lambing which created a stable environment for ewes and nice atmosphere for the shepherd
- Will it overcome the negative effect of sub-par nutrition on spring conception?
Ensuring Ram fertility:

- Light priming: works well on all genotypes
  ✓ 120 day protocol: 30 d (16h L/ 8h D); 30 d (8h D/ 16h L); 30 d (16h L/ 8h D); 30 d (8h L/ 16h D) then introduce rams.
  ✓ Ensures high libido and fertility even in seasonal genetics
  ✓ It has been indicted that rams remain robustly fertile at any time point after 4 months of protocol duration if the protocol is maintained.