Opportunities and challenges for year-round lamb production

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Overview:

• Seasonal lamb supply constrains the lamb industry at several levels:
  ➢ Production
  ➢ Processing
  ➢ Marketing

• Is it feasible to overcome the season barrier to lamb production while maintaining a profitable cost of production?

• Known factors and future directions to explore in overcoming seasonal reproductive barriers in sheep
Consequences of seasonal lamb supply on: Lamb Producers

- Limits cash flow
- Limits opportunity to build high value markets
- Lost opportunity to target lucrative year-round markets
- Inefficient use of facilities and equipment and labor
- Limits potential for expansion and specialization in lamb production
What potential advantages does an accelerated system have over a traditional, annual system?

- Cash flow advantages of accelerated production

*John Molenhuis, Ontario Ministry of Agriculture (OMAFRA), Proceedings of the Ontario Sheep Seminars 2013, Summary of 3 year benchmarking study on lamb production. Ontario Sheep Marketing Agency (OSMA) sponsored study*
Consequences of seasonal lamb supply on: Lamb Processors

- Inefficient use of facilities, equipment and labor
- Build-up of inferior product in supply chain (fat and old) as a consequence of the need to extend lamb supply
Consequences of seasonal lamb supply on: **Lamb Marketing/Sales**

- Inconsistent and sometimes inferior product in the supply chain (fat and old lamb).
- Loss of consistent presence of high quality domestic lamb on retail shelves.
Is year-round lamb production feasible?

• Seasonal breeding is controlled by light (photoperiod)!
  ✓ Seasonal breeding evolved to allow the matching of food resources with nutritional requirements thus favoring survival and procreation
  ✓ Season breeding sheep can be “fooled” into lambing any time of year at peak lambing rate by controlling their lighting
  ✓ Ovulation rate is also controlled by light

• Aseasonal sheep genetics exist!
  ✓ In general, breeds that evolved closer to the equator are less seasonal.
  ✓ Exceptions also exist as some breeds in northern climates have been selected to be aseasonal (e.g. Dorset and Romanov)

• Flock energy status may be critical to year-round production
  ✓ Rams and ewes of many breeds may require a higher plane of nutrition to breed out of season as compared to the optimal breeding season.
Seasonal breeders are animal species that successfully mate only during certain times of the year.
Photoperiod regulates the secretion of **melatonin** by the **pineal gland** which alters secretion of reproductive hormones.
Example of effective photoperiod control of lamb production. “CEPOQ-photoperiod control”

- Nearly continuous production (4 groups)
- Alternating 4 month light intervals (16L/8D; 8D/16L)
- Overlapping 8 month system
- Optimizes ovulation rate and conception
- Limited grazing, mostly confinement
- Maximum production (3.78 lambs per/ewe/year!!)

Cameron et al. 2010; Journal of Animal Science 88: 3280-3290
Light protocol vs. Progesterone CIDRs on production of prolific ewes in an accelerated production system

<table>
<thead>
<tr>
<th></th>
<th>Births/ewe/yr (1.5 max.)</th>
<th>Lambs/birth</th>
<th>Lambs/ewe/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting control</td>
<td>1.37</td>
<td>2.81</td>
<td>3.85</td>
</tr>
<tr>
<td>Progesterone therapy</td>
<td>1.26</td>
<td>2.27</td>
<td>2.86</td>
</tr>
</tbody>
</table>

Note: this productivity is incredibly high compared to systems in the rest of the world!

Conception and lambing rates according to breeding season in a flock of commercial ewes (Dorset x Finn x Ile De France, n=\sim2000+, parity \geq2)

<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>
Sheep breeds in the USA commonly used for year-round lamb production

- *Horned or Polled Dorset*
- Rambouillet
- Romanov
- Finn
- Hair breeds of West African decent
- White or Black Dorper
- Ile de France
Cross breeding may enhance aseasonal fertility:

**Heterosis and complimentarity**

Examples of crosses used in year-round production:

- Finn x Dorset
- Romanov x Dorset
- Finn X Dorset x Ile de France
- Finn x Dorset x Rambouillet
- Dorper x Katahdin x Romanov

Newer breeds:

- Rideau Arcott
- Polypay
How can you select for aseasonality?

• Heritability of fertility during Spring/early Summer estimated at 0.09 to 0.16.

• No EBVs exist for aseasonality on NSIP, difficult to measure this trait as the opportunity for out of season breeding is not always uniform.

• Producers select for aseasonality by selecting breeding stock from ewes that express the trait takes a long time to document thus increasing generation interval.

• Molecular markers may offer promise for selection for aseasonal breeding.
Field Study to identify factors that influence aseasional fertility

What factors other than genetics explain the large variation observed in the field in out of season breeding success?

Two flocks chosen that share the same genetic background - Finn x Dorset with a trace of Romanov and Rambouillet.

<table>
<thead>
<tr>
<th></th>
<th>April-June Mating</th>
<th>Sept.-Dec. Mating</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Fertility Flock</td>
<td>84%</td>
<td>92%</td>
</tr>
<tr>
<td>Low Fertility Flock</td>
<td>25%</td>
<td>87%</td>
</tr>
</tbody>
</table>

Supported by SARE (Sustainable Agriculture Research and Education)
## Findings: Ewe fertility and lambing percentage

<table>
<thead>
<tr>
<th></th>
<th>Low Fertility</th>
<th>High Fertility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fertility</strong></td>
<td>32%</td>
<td>92%</td>
</tr>
<tr>
<td><strong>Lambing Percentage</strong></td>
<td>133%</td>
<td>206%</td>
</tr>
</tbody>
</table>

1. Fertility expressed as ewe lambed/ewe exposed x 100%
2. Lambing Percentage expressed as lambs born/ewe lambed x 100%
Nutritional status of ewes at the start and end of the breeding season

Body weight

- Start of breeding
- End of breeding

Body condition score

- Start of breeding
- End of breeding

P<0.001 Flock
P<0.001 Time
P<0.001 Flock x time
General hypothesis relating nutrition status to aseasonal fertility

Intensity of Metabolic Signal

Low  High

Threshold for Pregnancy

Spring breeding  Fall breeding
Optimal nutritional management will only improve aseasonal fertility in genetics capable of responding to it.

 Applies to both female and male fertility.

[Graphs showing LH pulses per 24 h for different days of experiment, with lines and markers for Well-fed Suffolk, Maintenance Suffolk, Well-fed Merino, and Maintenance Merino.]

Hotzel et al. 2003
Reprod. Fert. Dev. 15:1-9
Energy nutrition during peak lactation (day 30) in 4 accelerated flocks during the winter rearing period

Dietary energy concentration

Feed intake

Spring conception rate

Forage quality as measured by fiber digestibility differed markedly between high and low out of season conception farms
Nutritional management of out of season breeding

• Critical aspect yet has received little study

• Important windows and energy inputs:
  
  ➢ Ewes
    ✓ Energy intake at 1.4? times maintenance during the 2-? week window pre mating
      ➢ In accelerated production this may extend back into the previous lactation
    ✓ Energy intake during the breeding season?
  
  ➢ Rams
    ✓ Energy intake at 2.0? times maintenance for 3-4? weeks pre mating
Is out of season lamb production profitable?

Factors at play:

**Income:**

✓ Are premiums possible for out of season production?
✓ Can premium markets be developed with year-round supply?
✓ How large is the loss in productivity (lambs marketed per ewe) relative to other production systems?

**Expenses:**

✓ Is additional infrastructure needed? If so, what is the cost?
✓ Is additional labor needed? If so, what is the cost?
✓ Are greater nutrition inputs needed? If so, what is the cost?
✓ Is the flock maintenance cost lower or higher than other production systems?
What potential advantages does an accelerated system have over a traditional, annual system?

Table 1. 3 year average results – top flocks – per lamb

<table>
<thead>
<tr>
<th></th>
<th>Per Lamb</th>
<th>Accelerated</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td></td>
<td>$202</td>
<td>$195</td>
</tr>
<tr>
<td>Feed costs</td>
<td></td>
<td>$78</td>
<td>$77</td>
</tr>
<tr>
<td>Other variable costs</td>
<td></td>
<td>$51</td>
<td>$54</td>
</tr>
<tr>
<td>(excluding labour)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed costs</td>
<td></td>
<td>$23</td>
<td>$24</td>
</tr>
<tr>
<td><strong>Net enterprise income per lamb</strong></td>
<td></td>
<td>$50</td>
<td>$40</td>
</tr>
<tr>
<td>(before labour expenses)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketable lambs per ewe</td>
<td></td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Number of Ewes</td>
<td></td>
<td>708</td>
<td>918</td>
</tr>
<tr>
<td>Net enterprise income</td>
<td></td>
<td>$66,906</td>
<td>$48,103</td>
</tr>
<tr>
<td>(before labour)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ewes per person (labour)</td>
<td></td>
<td>354</td>
<td>481</td>
</tr>
<tr>
<td><strong>Net enterprise income per person</strong></td>
<td></td>
<td>$33,359</td>
<td>$25,152</td>
</tr>
</tbody>
</table>

* John Molenhuis, Ontario Ministry of Agriculture (OMAFRA), Proceedings of the Ontario Sheep Seminars 2013, Summary of 3 year benchmarking study on lamb production. Ontario Sheep Marketing Agency (OSMA) sponsored study
2010-2013 production from 2000 ewes on an 8 month system: extended light

- 1.34 births/ewe/yr
  - 83% conception for October birth period
  - 93% conception for May and Feb birth periods
- 1.73 lambs weaned/ewe/lambing
- 2.32 lambs weaned/ewe/year
- 2.07 lambs marketed/ewe/year
- 1.76 x maternal weight marketed in 2013
Matching Forage Production to Animal Requirements

Matching Animal Requirements to Forage Production
Forage Growth pattern vs. Accelerated Lambing Program

![Graph showing forage growth and lambing groups](image-url)
Can the nutritional inputs of out of season production be met with low-cost feeding systems (i.e. grazing)?

**Needs:**
- Higher plan of nutrition pre-breeding and during late pregnancy and lactation
- Higher allotment and quality of pasture in grazing systems

**What climates allow for growth of perennial pasture to match these needs?**
- Mediterranean and coastal climates: dry summers and wet, temperate winters
- California, Oregon, Washington, parts of the West and possibly the mid South?
How can annual/perennial forage systems improve whole-farm forage utilization?

• Fill in deficits in perennial pasture production
  ✓ extend the grazing season
  ✓ reduce reliance on stored forage

• Improve forage quality at times of need
  ✓ replace grain for finishing
  ✓ “flush” females pre breeding
  ✓ late gestation and lactation nutrition

• Provide “safe” forages, low in parasite infectivity

• Improve productive capacity of the land
  ✓ Replacement of low productivity pastures
    ➢ Addition of soil amendments (manure, lime, etc.)
    ➢ Replace with more productive and/or palatable species
  ✓ Rests perennials to improve productivity and resilience
  ✓ Annuals can out-yield perennials if strategically planted
  ✓ Allows an increase in total forage output including stored forage
‘Goliath’ kale x rape hybrid, (PGG seeds), planted July 28, photo taken November 15, 2016
Short term perennial pasture-red clover and Italian ryegrass
Oats and purple top turnips planted as a cover crop after wheat harvest. Planted late August, photo taken mid December.
Optimizing out of season production:

- Nutrition
- Genetics
- Lighting protocols
- Hormone therapies
- Ram effect
- Male libido/fertility
Hormonal therapeutics to insure successful out of season breeding and to tighten birth management:

- Progesterone CIDRs
  - FDA approved for use in sheep
  - 40-85% conception in spring
  - Very helpful in synchronizing estrus
  - Results obtained are similar to that found using teaser rams
Ram “male” effect:

- Induces estrus in females “on the edge” of anestrus; synchronizes females that are naturally cycling
- 1 vasectomized male: 50 females
- 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 it work on females that are deep in anestrus?
Summary:

1. Seasonal lamb supply constrains lamb production.
2. Out of season production is feasible and can be profitable when matched with appropriate resources and good management.
3. Out of season lamb production requires genetics for aseasonality with risk reduced when both ewes and rams are well fed just prior to the breeding season.
4. Light therapies are very effective in optimizing male libido, female conception and ovulation rate.
5. Hormone therapies can be used to induce ewes but currently approved methods may not offer significantly greater efficacy over the ram effect.
6. The ram effect is very effective in advancing or prolonging estrus in ewes on the “edge” of anestrus particularly in sheep with fine wool genetics.
7. Research and development needs:
   • Methods/tools to identify sheep with superior genetics for out of season breeding
   • Better understanding of the nutritional inputs needed to optimize out of season breeding success
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Ensuring male fertility:

- Feed males 1.4X maintenance for 3 weeks pre-breeding

- Perform breeding soundness exam
  - Documents fertility but are all fertile males active breeders (have high libido)?

- Light priming: works well on all genotypes
  - 120 day protocol: 30 d (16h L/ 8h); 30 d (8h D/ 16 L), 30 d (16h L/ 8h); 30 d (8h D/ 16 L) then introduce rams/bucks.
  - Ensures high libido even in seasonal breeding rams/bucks
What potential advantages does an accelerated system have over a traditional, annual system?

- **Lambs born and survival to market age/ewe**
  - **Annual:**
    - Lambs born: $0.95 \text{ births/yr} \times 2.0 \text{ lambs/birth}=1.9 \text{ lambs/ewe/yr}$
    - Lambs to market age: $1.9 \times 85\% \text{ survival to market}=1.6 \text{ lambs/ewe/yr}$
  - **Accelerated:**
    - Lambs born: $1.37 \text{ births/yr} \times 1.9 \text{ lambs/birth}=2.6 \text{ lambs/ewe/yr}$
    - Lambs to market age: $2.6 \times 85\% \text{ survival to market}=2.2 \text{ lambs/ewe/yr}$

- ** Marketable lambs: lambs to sell per ewe/yr**
  - Ewe replacement rate is slightly higher but offset by increased lamb production
  - Marketable lambs/ewe, ($\text{lambs/ewe/year} - \text{ewe replacement rate}$)
    - **Annual:** $1.6-0.22=1.38$
    - **Accelerated:** $2.2-0.25=1.95$
    - **Accelerated:** 41% greater annual ewe productivity
Resources required for accelerated production

• **Birth facility** capable of housing 2/3 of flock
• **Must provide a higher plane of nutrition over the year than annual birth** as females are in a more productive state a greater proportion of the time
  - High energy forages (grazing or harvested)
  - Energy concentrates at critical windows (lactation)
• **Chronic disease** issues are more apparent in accelerated lambing (foot rot, OPP, Johnes) as any ceiling imposed on production is more apparent in highly productive animals.
• **Precise management: nutrition, reproduction, health**
  - An Ontario study* suggests that the productivity benchmarks for lambs marketed /ewe/year must be >1.3 for annual and >1.9 for accelerated for either system to be profitable.
  - Implication? If your annual system cannot produce >1.3 marketable lambs per ewe per year, work on improving that before considering a switch to accelerated production.

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What potential advantages does an accelerated system have over a traditional, annual system?

Marketing flexibility:

• Can hit a huge diversity of markets allowing more opportunistic marketing possibilities
  ✓ Large, 140 lb lambs for traditional market
  ✓ Small “roaster”, 40-50 lbs for non-traditional trade

• Year-round supply allows creation/access to new markets

• Reduced risk due to price fluctuations within a year
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 Ile 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?*
Comparison of energy requirements between annual and accelerated systems at 200% crop (expressed relative to maintenance, 1.0):

<table>
<thead>
<tr>
<th>Period</th>
<th>12 mo</th>
<th>8 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>2wk pre-breeding</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>day 0-40 PC</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>day 40-115 PC</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>day 115-term</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>day 0-40 lactation</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>day 40-60 lactation</td>
<td>1.9</td>
<td>2.2</td>
</tr>
</tbody>
</table>