Reproductive Technologies

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Small Ruminant Genetics

Reproductive Technologies

Benefit

Cost
Most limiting factor in application of reproductive technologies to sheep production?

Complex sheep cervix causes reproductive techniques to be developed that are different from cattle, are more difficult to apply, are less effective and more costly.

Still, in good programs, we achieve the same rates of success for AI and ET in sheep as the North American cattle industry.

But what is required costs relatively more per lamb born (as compared to the cost of technologies used in cattle).

So the reasons for using reproductive technologies, and the likely results, need to be very clear.

Within the sheep industry, no group could benefit more from these techniques than the dairy sector.

**Benefits from Semen Programs**
- Makes high value genetics available at low cost
- International movement of genetics
- High health genetics for closed flocks
- Increase return on high value genetics
- Increased breeding from selected rams
- Establishment of genetic improvement schemes (sire referencing)

**Artificial Insemination**
Fresh semen AI Programs
Frozen semen AI Programs
Evolution of AI for Sheep

1960s - Fresh semen
Vaginal insemination

Fresh semen
Cervical insemination

Frozen semen
Semen freezing
Laparoscopic AI - 1980s

Trans cervical - 1990s
Frozen semen AI

Improved fresh semen
Next day AI

Recent improvements to fresh semen
to 48-72 hrs AI - 2000

Location of Insemination

• Vagina
  easy
  reduced success
  only used with fresh semen

• Cervix
  more difficult - sheep
  success increases as penetration increases
  use fresh and frozen semen

• Uterus
  very difficult - sheep
  best results
  fresh and frozen semen

Fresh Semen Programs

<table>
<thead>
<tr>
<th>GOOD</th>
<th>BAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential for best results</td>
<td>Same-day AI</td>
</tr>
<tr>
<td>Simple insemination techniques</td>
<td>Restricts distances</td>
</tr>
<tr>
<td></td>
<td>Requires high numbers of sperm cells</td>
</tr>
<tr>
<td></td>
<td>Ram performance affects</td>
</tr>
<tr>
<td></td>
<td>Semen quality varies</td>
</tr>
</tbody>
</table>
Fresh Semen AI Used World-wide

French Dairy Sheep Industry
Chinese Fine Wool Industry

Fresh Semen AI

- Rams follow CFIA protocol for testing and quarantine in approved facility
- Semen collected and processed
- Semen cooled and shipped
- Domestic use only

Fresh Semen AI

- Producer deposits semen into vagina - 30%
- On the milking stand - natural heat AI?
- Sire referencing - power of AI for genetic improvement

Future for Fresh Semen AI?

- Improvements in semen extenders to add life to 48 + hours
- Opens opportunities for new programs
### Frozen Semen Programs

<table>
<thead>
<tr>
<th>GOOD</th>
<th>BAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semen collected any season</td>
<td>Location of insemination critical</td>
</tr>
<tr>
<td>Only high quality semen used</td>
<td>Must be deposited into uterus for best results</td>
</tr>
<tr>
<td>Higher health product</td>
<td>Uterine insemination techniques difficult and costly</td>
</tr>
<tr>
<td>Shipment - international</td>
<td></td>
</tr>
<tr>
<td>One collection breeds many ewes</td>
<td></td>
</tr>
</tbody>
</table>

### Laparoscopic AI

- best for frozen semen
- low semen dose
- success 60% +
- (range 30-90%)
- expensive
- restricted to DVMs
- surgical risk
Transcervical AI

Guelph System for TAI
Low cost
Training needed
Inconsistent results

Gourley Scope
Expensive
Training Needed
Results?

Sperm Membrane Changes

<table>
<thead>
<tr>
<th>Time in female tract</th>
<th>Decapacitated</th>
<th>Capacitated</th>
<th>Acrosome Reacted</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT FERTILE</td>
<td>FERTILE</td>
<td>NOT FERTILE</td>
<td></td>
</tr>
</tbody>
</table>

Adding selected seminal plasma to frozen semen (Maxwell and Evans)
Reverses change and extends life and fertility
Typical Results from AI

<table>
<thead>
<tr>
<th>Method</th>
<th>Fresh</th>
<th>Frozen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal</td>
<td>40-50%</td>
<td>10-20%</td>
</tr>
<tr>
<td>Cervical</td>
<td>40-65%</td>
<td>25%</td>
</tr>
<tr>
<td>Transcervical (those penetrated)</td>
<td>60-80%</td>
<td>40-70%</td>
</tr>
<tr>
<td>Laparoscopic</td>
<td>70-90%</td>
<td>50-80%</td>
</tr>
</tbody>
</table>

Factors Affecting Success of AI

- Fresh or frozen semen
- Method of freezing
- Individual ram
- Location of insemination
- Semen dose
- Semen handling
- Insemination frequency
- Teaser rams
- Synchronization program vs natural
- Timing of insemination
- Season
- Ewe stress - before and after
- Body condition
- Diet - plant estrogens
- Diet - high protein diets
- Period since last lambing
- Lactation
Effect of Teasers in AI Programs

• Identify responding animals
• Improve timing of first estrus
• Shorten time to ovulation – adjust program
• Improve sperm transport – oxytocin, PG?
• Replace with GnRH?

Embryo Programs

• Highest health standards – clean flocks
• Obtain complete genetics (sire and dam)
• Increase offspring from superior females
• Increase return from superior females
• Sales of genetics

But, ET in sheep

• Requires surgical intervention
• Risk involved – minimal
• Is costly – generally $75–100 per good quality embryo produced
Surgical Embryo Recovery

Problems with ET

Superovulation
- not all animals respond
- response highly variable

Embryo fertilization
- young donors, young rams
- over-stimulation

Premature failure of CLs

Surgical Risk

Expected Success per ET Donor

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Average</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovulations</td>
<td>10</td>
<td>0-50</td>
</tr>
<tr>
<td>Embryos</td>
<td>7.5</td>
<td>0-10</td>
</tr>
<tr>
<td>Unfertilized</td>
<td>2.5</td>
<td>0-10</td>
</tr>
<tr>
<td>Transferable</td>
<td>6</td>
<td>0-10</td>
</tr>
<tr>
<td>Lambs fresh</td>
<td>4</td>
<td>0-32</td>
</tr>
<tr>
<td>Lambs frozen</td>
<td>3</td>
<td>0-?</td>
</tr>
</tbody>
</table>
Factors Affecting Success of DONOR

- age
- breed
- season
- diet
- body condition
- health
- superovulation program – stage of follicular wave
- Stress – premature luteal failure
- breeding management

In vitro Embryo Production

- Mass production of low cost embryos
- Production from mature and juvenile donors
- Production from slaughter animals ovaries
- Production from aged or diseased animals

In vitro embryo production

![Diagram of in vitro embryo production process](Image)
Mature or Juvenile Ewe Ovarian Aspiration

**Slaughter Oocyte recovery**

- Ovaries recovered at slaughter
- Taken to lab
- Unfertilized eggs (oocytes) removed
- Matured and fertilized
- Grown to 6 days
- Transferred or frozen
IVEP Embryo production

100 oocytes → 75 fertilized eggs → 35 blastocysts

16 fresh ET lambs | 13 frozen ET lambs

The OLIBS Model

- **Elite Flock**: Obtain best Ontario dam-line genetics
- **Multiplier Flock**: Embryos transferred into recipient ewes of known health status
  - Ewe lambs and selected ram lambs on ROP
  - Rapid propagation using reproductive technologies: ET, IVF, GIFT, AI
- **Selected Breeder Flocks**: Genetic evaluation, economics, health, management, productivity
- **Terminal Sire Program**: Selected crosses to meat lab for carcass evaluation studies
- **Ewes sold to commercial sheep producers for crossing with terminal sires**: Selected commercial flocks participate in on-farm evaluation using selected terminal sires

- **Obtain useful genetics from world flock**: Evaluate and re-introduce best genetics
- **Ram lambs to meat lab for carcass evaluation studies**
## Disease Transmission from AI or ET

<table>
<thead>
<tr>
<th></th>
<th>Semen</th>
<th>Embryos</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disease risk</strong></td>
<td>Medium to Low risk</td>
<td>Clean - no risk if managed correctly</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>Isolate</td>
<td>Isolate</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>Correct handling</td>
<td>Wash embryos</td>
</tr>
<tr>
<td></td>
<td>Antibiotics</td>
<td></td>
</tr>
</tbody>
</table>

## Disease

<table>
<thead>
<tr>
<th><strong>SEmen</strong></th>
<th><strong>EmBryos</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Caseous lymphadenitis</td>
<td>NO - confirmed</td>
</tr>
<tr>
<td>Johnes</td>
<td>Bluetonge</td>
</tr>
<tr>
<td>Bluetongue</td>
<td>Maedi visna</td>
</tr>
<tr>
<td>Brucella ovis</td>
<td>Chlamydia</td>
</tr>
<tr>
<td>Maedi visna</td>
<td>Pulmonary adenomatosis</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>YES/NO ?</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>Scrapie</td>
</tr>
<tr>
<td>Mycoplasmas/ ureaplasm</td>
<td>RISK ?</td>
</tr>
<tr>
<td></td>
<td>Brucella ovis</td>
</tr>
</tbody>
</table>
Embryos and Disease Control

Zona Pellucida coating protects the embryo from disease

Washing removes all

Estrous Synchronization for AI or ET

Progestagens plus PMSG
**Melengesterol Acetate**

- Oral
- Works as any other progestagen
- .125 mg BID 14 days
- Gonadotropin 6-8 hr after last feed during transition and anestrus
- Advantages
  - Cost
    - no drop out
    - no injury
    - reduced handling
- Milk withdrawl

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**Rejection rate in Rideau ET recipients by month**

![Bar chart showing rejection rates by month](chart.png)

 Rejects (no CLs) □

 Accepted □
Gonadotropin Use/dose?

Light Control Programs

- Interpretation of light/dark = melatonin
- System responds to decreasing day length (more melatonin per day) (short days - long nights)
- But, first needs long days to become sensitive to the reducing day length
- After period of months system becomes refractory to that stimulus
Thanks to Chris and Axel