Reproductive technologies
AI and MOET

- Increased selection intensity
- Reduced generation interval
- Increased accuracy of EBV’s
Increased intensity and accuracy ...
Adult dairy MOET scheme

Cow:

MOET progeny:

Normal progeny:

Months:

0 Birth
15 Mate
24 Birth
34 35 Get record Select & MOET
44 MOET Birth

Generation interval 44 months
Juvenile dairy MOET scheme

Cow:

MOET progeny:

Normal progeny:

<table>
<thead>
<tr>
<th>Months</th>
<th>0</th>
<th>13</th>
<th>15</th>
<th>22</th>
<th>24</th>
<th>35</th>
<th>44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select &amp; MOET</td>
<td></td>
<td>Mate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOET Birth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select &amp; MOET</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOET Birth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Generation interval 22 months

Generation interval 22 months
Oocyte harvesting and *IVF* in Australia:

- 26 lambs born from one 13-week old lamb in 1998.
- Over 400 JIVET lambs produced at SARDI (2½ yrs to Nov 2000)
  - 2000: 8 JIVET companies in Australia
  - 450 Oocytes from one 6-week lamb (Oct 2000)
Even more juvenile dairy MOET...

Note that this is a bad design - EBV from grandparents!
Juvenile beef MOET

Cow:

MOET progeny:

Normal progeny:

Months:

0
Birth
Select & MOET

6

14 15
Get records
MOET Birth
Select & MOET

15 months
Generation interval 15 months

21
Get records
MOET Birth

29 30
Generation interval 15 months
Even more juvenile beef MOET

Cow:

MOET progeny:

Normal progeny:

Months: 0 3 12 14 15 24 28

Birth  Get records  MOET Birth  Get records

Select & MOET  MOET Birth  Select & MOET

Generation interval 12 months
Juvenile sheep MOET

Sheep:

MOET progeny:

Months: 0 1½ 6½ 7 8 13 13½

Birth  Get records  MOET Birth  Select & MOET  Get records

Select & MOET  MOET Birth

Generation interval 6½ months
Between versus within family selection

No own information (performance or genotype):
Selection based on parent average
More between-family selection - more inbreeding
Genetic gain versus genetic diversity

• Sustainable breeding programs require optimal selection balancing genetic gain and genetic diversity

• Potential short term benefits from reproductive technologies are inhibited by the need to maintain diversity
The balance between increased merit and inbreeding

![Graph showing the relationship between mean merit and co-ancestry for different breeding methods: Unrestr., IVEP, MOET, and AI. The graph illustrates how mean merit changes as co-ancestry increases, with each method showing a different curve.]
Between versus within family selection

Own information (performance or genotype):
More variation within families
More within-family selection – less inbreeding
MAS combined with reproductive technologies

- Genotype testing provides within family information
- Exploiting this variation allows genetic gain without jeopardizing inbreeding
Sexing semen or embryos

• Ability to sex semen makes little difference to rates of genetic gain:
  • Usually less than 5% extra genetic gains

• However, effect on commercial production efficiency can be dramatic:
  • Eg. producing crossbred gilts in the pig industry.
  • Value in dairy is not high, due to ongoing harvesting – the producers of progeny are also the producers of milk.
The value of semen sexing

Male candidates

Female candidates

Parental Superiority

Progeny

Progeny Superiority

Response

50:50 sex ratio

20:80 sex ratio

Test with “AGES” …
Salvage eggs from abattoir cows

Remove genes

Take a cell from a culture with a million identical cells.

Grow cells in the lab

Get tissue sample from an elite animal. Eg skin

Tissue culture

Transfer to recipients

Some embryos ready for freezing

Some embryos start to develop

Direct Injection merges the two parts

Alternative Monash / Genetics Australia EMT System
from Sandy McClintock
Grow embryo in the lab

Get embryo from elite parents

Break embryo into 20-30 identical cells.

Transfer to recipients when enough have been made. Some can be frozen for later use.

5 to 10 times more embryos each 4 days.

Salvage eggs from abattoir cows

Remove genes

Electric pulse merges the two parts

Some embryos start to develop

Monash IRD / Genetics Australia EMT System
from Sandy McClintock
Cloning in animals

- Cloning from embryos, adults and cell lines.
  - Cell lines → easy genetic manipulation.
- Evaluate individuals via their clones ...
  - Evaluations can be biased
  - Fewer genetic individuals as candidates.
- Clone elite individuals for use in industry
  - Eg. beef bulls for natural mating.
Genetic evaluation using clones

- **Breeding value.** This is *the value of an animal’s genes to its progeny.* For when we want to make judgements about breeding animals for generating progeny.

- **Genetic value,** or Genotypic value. This is *the value of an animal’s genes to itself.* For when we want to select animals to make clones of themselves to generate product to be harvested.
Clones versus progeny for direct use

Merit of clones and merit of progeny from a ram with a 1Kg superiority in fleece weight.

- 1.0Kg: Merit of ram
- 0.6Kg: Estimated genetic value
- 0.4Kg: Estimated Breeding value
- 0.6Kg: Expected merit of clones
- 0.2Kg: Expected merit of progeny
- Ewe dilution
# Genetic evaluation using clones

<table>
<thead>
<tr>
<th>Data source</th>
<th>Accuracy of breeding value</th>
<th>Accuracy of genetic value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n progeny of each candidate</td>
<td>$\sqrt{\frac{\frac{1}{4}V_A}{\frac{1}{4}V_A + \frac{V_P - \frac{1}{4}V_A}{n}}}$</td>
<td>$\sqrt{\frac{\frac{1}{4}V_A}{\frac{1}{4}V_A + \frac{V_P - \frac{1}{4}V_A}{n}}} \times \sqrt{\frac{V_A}{V_G}}$</td>
</tr>
<tr>
<td>n clones of each candidate</td>
<td>$\sqrt{\frac{V_A}{V_G + \frac{V_P - V_G}{n}}}$</td>
<td>$\sqrt{\frac{V_G}{V_G + \frac{V_P - V_G}{n}}}$</td>
</tr>
</tbody>
</table>
Genetic evaluation using clones

![Graph showing the accuracy of evaluation for genetic value from clones, breeding value from clones, and breeding value from progeny with respect to the number of clones or progeny.]

\[ \sqrt{\frac{V_A}{V_A}} = 1 \]

\[ \sqrt{\frac{V_A}{V_G}} = 0.75 \]
Cloning
Impact on commercial production levels

Genetic progress in the main breeding program, and in elite clones.

Normal breeding program:

\[ i = 1.4 \]
\[ h^2 = 0.4 \]
\[ L = 3.25 \text{ yrs.} \]

Clone selection:

\[ i = 3 \]
\[ h^2 = 0.6 \]

Result: Today's elite clones are expected to be as good as normal animals born in just over 10 years' time.
Clones can give a more uniform product

Table 2. Predicted range of expression within a cohort for a trait with $V_A/V_P = 0.25$ and $V_G/V_P = 0.45$, relative to unrelated animals $= 100\%$.

<table>
<thead>
<tr>
<th>Cohort type</th>
<th>Predicted range of trait expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrelated animals</td>
<td>100%</td>
</tr>
<tr>
<td>A sire family</td>
<td>96.8%</td>
</tr>
<tr>
<td>A full-sib family</td>
<td>90.8%</td>
</tr>
<tr>
<td>A clone family</td>
<td>74.2%</td>
</tr>
</tbody>
</table>
Controlled cell manipulations

Meiosis in vitro (MIV) ??

Use of genetic markers!
### Summary Reproductive technologies

#### Usage in breeding industry

<table>
<thead>
<tr>
<th>Benefit to rate of genetic improvem.</th>
<th>Dairy</th>
<th>Beef</th>
<th>Sheep</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AI</strong></td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><strong>MOET</strong></td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td><strong>JIVET</strong></td>
<td>+++</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sexing</strong></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Cloning</strong></td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reprod technol. In a breeding design context

Nucleus

Genetic lag

Commercial producers

AI, MOET, JIVET

Genetic improvement

measurement

sexing, cloning

dissemination