Optimising reproductive performance of beef cows and heifers

David A. Kenny\textsuperscript{1} & Michael G. Diskin\textsuperscript{2}

Animal and Bioscience Research Department, Animal and Grassland Research and Innovation Centre, \textsuperscript{1}Grange, Dunsany, Co. Meath; \textsuperscript{2}Athenry, Co. Galway, Ireland
Overview

- Background
- Key reproductive targets
- Puberty and heifer management
- Shortening the post-partum interval
- Management during the breeding season
- Oestrous synchronisation/FTAI
- Summary

Background

- Beef cows play an important role in converting forage into high quality protein
- Economic and environmental sustainability questioned
- Reproductive efficiency is key to the biological and economic sustainability
- Achieving reproductive targets underpins system efficiency and profitability
Key reproductive targets for beef cow herds

- 365 day calving to calving interval
- <5% cows culled annually as barren
- >95% of cows calving to wean a calf
- Compact calving with 80% of cows calved in 42 days
- Replacement rates 16-18%
- Heifers calving at 24 mths old; early in calving season

Diskin and Kenny (2014)

Current Reproductive Performance of Irish Suckler Herds

<table>
<thead>
<tr>
<th>Trait</th>
<th>Target</th>
<th>Irish Herds</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calving Interval</td>
<td>365 days</td>
<td>403 days</td>
<td>€2.20/cow/day</td>
</tr>
<tr>
<td>Calves/cow/yr.</td>
<td>1.0</td>
<td>0.8</td>
<td>€170/cow</td>
</tr>
<tr>
<td>Age at calving</td>
<td>24 months</td>
<td>15% of heifers 32.5 months</td>
<td>€1.65/heifer/day</td>
</tr>
</tbody>
</table>

ICBF, 2014
Inefficiency

- Massive cost of ‘non-productive’ breeding females
- Prolonged calving season
- Uneven calf crop
- Low use of AI
- No defined plan to produce replacement heifers

Inefficiency & poor profitability and sustainability?

Strategies to improve cost efficiency

1. Increase output to dilute costs over greater weaning weight produced
2. Reduce costs incurred by the suckler cow – feed costs most important!

Increase lifetime output of cow
Factors Affecting Reproductive Efficiency

- **Age at Puberty**
- **Post Partum Interval**
- **Conception Rate**

Reproductive Efficiency

Puberty in Heifers

**Definition:** The onset of sexual maturation

**Major factors affecting age at puberty**

- Breed
- Plane of nutrition
- Heterosis
- Bull exposure

**Moderate Heritability** ➜ Can improve through genetics
Conception rates at 1\textsuperscript{st} & 3\textsuperscript{rd} heat post puberty in beef heifers

(Byerley et al. 1987)

Effect of Timing of First Calving (24 months) on Cow Longevity

(Cushman et al. 2013)
Neuroendocrine Control of Puberty

- GnRH pulse generator central to onset of puberty
- Initially negative $E_2$ feedback → Positive
- Surge release of GnRH
- Pre-ovulatory surge of LH from the anterior pituitary
  - Elevated nutrition in early life advances high frequency GnRH pulsatility

Senger et al. (2012)

Metabolic Endocrinology of the HPG

- Insulin +
- Ghrelin -
- IGF-1 +
- Adiponectin -
- Leptin +
- Kisspeptin

Kisspeptin
Influence of Growth Rate and Bull Exposure on Age of Puberty

Moderate Growth Rate (0.65 kg/d)
High Growth Rate (0.80 kg/d)

Age at Puberty (days)

No Bull Exposure
Bull Exposure

Roberson et al. (1991)

Effect of maternal nutrition on postnatal reproductive traits of heifer progeny

- Dams offered 0.6 or 2 x maintenance energy requirements from -11 to 110 d of gestation
- No effect on:
  - birthweight
  - postnatal growth
  - age or weight at puberty
- Ovarian antral follicle count lower for heifers from nutrient restricted dams

Mossa et al. (2013)
Nutrition and Puberty

Recommended weights - beef heifers

- 60 to 65% of mature weight at 13.5-14 months
- 65 to 70% at time of first breeding (15 months)
- 85-90% of mature weight at calving (24 months)

These weights ensure:

- High proportion cycling regularly at start of breeding season
- Physically well developed at calving
- Early resumption of heat activity after calving

Factors Affecting Reproductive Efficiency

- Age at Puberty
- Post Partum Interval
- Conception Rate

The Irish Agriculture and Food Development Authority
Components of Calving Interval

Factors affecting the PPI

- Maternal-Offspring Bonding ***
- Nutrition
  - Pre-partum ***
  - Post-partum *
- Parity **
- Season *
- Bull effect ?
- Interactions
Early Post-Partum Period: Beef v Dairy Cows

<table>
<thead>
<tr>
<th></th>
<th>Dairy cows</th>
<th>Beef cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergence of the 1st follicle wave</td>
<td>5 to 10</td>
<td>5 to 10</td>
</tr>
<tr>
<td>(days postpartum)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% cows that ovulate the 1st dominant</td>
<td>50 to 80</td>
<td>20 to 35</td>
</tr>
<tr>
<td>follicle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum interval to 1st</td>
<td>15 to 25</td>
<td>25 to 120</td>
</tr>
<tr>
<td>ovulation (days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nature of 1st ovulation</td>
<td>Silent</td>
<td>Silent</td>
</tr>
<tr>
<td>Postpartum interval to 1st oestrous</td>
<td>25 to 45</td>
<td>30 to 130</td>
</tr>
<tr>
<td>(days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% short cycles after 1st ovulation</td>
<td>&gt; 70</td>
<td>&gt; 70</td>
</tr>
<tr>
<td>Predominant no. of follicle waves</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>per normal (18 to 24-day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>oestrous cycle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulation of LH pulse frequency</td>
<td>Declining</td>
<td>Suckling</td>
</tr>
<tr>
<td></td>
<td>energy balance</td>
<td>Calf presence/maternal bond</td>
</tr>
<tr>
<td></td>
<td>BCS at calving</td>
<td>Declining energy balance</td>
</tr>
<tr>
<td></td>
<td>Dry matter intake</td>
<td>BCS at calving</td>
</tr>
<tr>
<td></td>
<td>Disease state</td>
<td>Disease state</td>
</tr>
</tbody>
</table>

Crowe et al. (2014)

Postpartum Anoestrus in Beef Cows

- **Not due to delayed resumption or lack of follicle growth**

  **Rather**

- **Due to failure of recurrent dominant follicles to ovulate**

  **As a consequence of**

- **Sequestration of LH stores in the gonadotrophs in the anterior pituitary due to inadequate pulses of GnRH**
Effect of Suckling Treatment on PPI (Days)

Serum LH at 29 and 34 days postpartum in beef cows
Breaking Maternal-Offspring Bonding (1)

- Commence calf separation at Day 30
- 85-90% of cows ovulate by Day 36 (silent ovulation – not accompanied by overt oestrus)
- 95% of ovulated cows exhibit fertile heat with 8-12 days (short cycle)
- 5% of ovulated cows exhibit fertile oestrus within 17-22 days (normal cycle)
- 10-15% of cows fail to ovulate in response to calf separation (Deep – “Nutritional” anoestrus)

Breaking Maternal-Offspring Bonding

- Alternative to the use of exogenous hormones
- 80% of cows exhibited fertile heat by Day 45.
- Applicable to late calving cows and 1st calving heifers
- Labour demanding
- More applicable to confined systems
Body Condition Score (BCS)

- Describes fat reserves
  - 5 point scale (UK)
  - 9 point scale (USA)
- Simple and inexpensive
- Repeatable
- Independent of body size

Source: IFJ

Effect of BCS at Calving on PPI

P < 0.05

Stagg et al. (1998)
Effect of Post Calving Nutrition on PPI

Plane of nutrition after calving

Stagg et al. (1998)

Factors Affecting Reproductive Efficiency

Age at Puberty

Post Partum Interval

Conception Rate

Reproductive Efficiency

The Irish Agriculture and Food Development Authority
Factors Affecting Probability of Conception

- Accuracy of Heat Detection
- Accuracy of Insemination
- Semen Quality Factors
- "Female" Factors

Conceptus

Pregnancy Rate
Heat Detection x Conception Rate

<table>
<thead>
<tr>
<th>Heat Detection Rate %</th>
<th>60</th>
<th>50</th>
<th>40</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>96</td>
<td>91</td>
<td>83</td>
<td>71</td>
</tr>
<tr>
<td>70</td>
<td>91</td>
<td>82</td>
<td>73</td>
<td>61</td>
</tr>
<tr>
<td>50</td>
<td>76</td>
<td>68</td>
<td>59</td>
<td>48</td>
</tr>
<tr>
<td>40</td>
<td>67</td>
<td>59</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>
Primary Sign of Heat
Factors Affecting the Expression of Heat

1. Size of the Sexually Active Group

2. Under foot surface Conditions

Aids to improve heat detection rate

- Tail paint/ Chalk
- Heat Mount detectors
- Scratch Cards
- Restricted suckling
- Teaser Bull
- Synchronisation
Effects of concurrent nutrition on embryo survival rate in heifers

<table>
<thead>
<tr>
<th>Level of Nutrition</th>
<th>Low-Low</th>
<th>Low-High</th>
<th>High-High</th>
<th>High-Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers (n)</td>
<td>66</td>
<td>65</td>
<td>60</td>
<td>56</td>
</tr>
<tr>
<td>Embryo Survival (%)</td>
<td>70</td>
<td>71</td>
<td>65</td>
<td>38</td>
</tr>
</tbody>
</table>

Dunne et al. (1999)
Protein requirements of cows

- Adequate in most situations
- N.R.C. recommendations for cow with peak milk yield of 14 kg
  - Maximum value 12.3% in month 2 of lactation
  - Minimum value 6.0 % about weaning
- High Protein Diets v Cow Fertility?

Embryo survival rate within quartile concentrations of plasma urea (range 1.5 to 25 mmol/l)

<table>
<thead>
<tr>
<th>Interquartile range of plasma urea concentration</th>
<th>n=29</th>
<th>n=30</th>
<th>n=29</th>
<th>n=28</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Kenny et al. (2001)
Dietary Fat

- Energy source
- Fed 3-5% of ration (max)
- Rumen Protected (esp. polyunsaturated FA)
- Increases pre-ovulatory follicle size?
- Increases systemic progesterone?
- Stimulatory and inhibitory effects on PG
- Affect uterine endometrial GEx
- Direct effect on embryo?

Effect of n-3 PUFA supplementation on pregnancy rate

 Effect of n-3 PUFA supplementation on embryo GEx

Doyle et al. (2015)

Childs et al. (2008)
Trace Elements

- Imbalance can cause problems
- Establish herd status
- Variable responses to supplementation
- Different forms fed – organic v inorganic
- Major elements – no major effect
- Cu, Zn, Se, I – important; also Vit E
- Supplement pre-calving to minimise incidence of retained placenta

Other Factors

- Pathogens
- Extent of contribution to infertility not clear
- Large on-farm study underway
  - 200 herds; 5000 beef cows
  - Seropositivity for IBR, Leptosporosis, BVD and Neospora Caninum
  - Serum concentrations of Trace elements (Copper selenium and iodine)
  - All cows body condition scored during the breeding season
  - All cows blood sampled for DNA
  - All fertility data recorded
Reproductive performance in Grange spring calving herd

- 13 year period
- Cows presented for breeding = 978
- Pregnancy rate = 93.7%
- Calving interval = 367 days
- Top 15% on HerdPlus

Oestrous Synchronisation

- Suboptimal use of AI in beef cows
- Labour and heat detection seen as major obstacles to AI use
- Use of synchronisation and fixed time AI gaining much interest in South America
- Potential for high submission and pregnancy rates early in the breeding season
- Need for practical, low labour and effective protocols for pasture based herds
Main Goals of Oestrous Synchronisation Protocols

Three primary goals for synchronizing oestrus and ovulation in beef herds:
- develop reliable protocols that rely solely on TAI
- develop systems that require a maximum of 3 animal handlings
- ensure that systems are successful in anoestrous or peri-pubertal and cyclic females at any stage of the oestrous cycle.

Oestrous Synchronisation - issues for Beef Cows
- Anoestrus is a major contributor to poor reproductive efficiency of beef cow herds
- Exposure to progesterone is a prerequisite to first postpartum behavioural oestrus in most cows.
- Duration of luteal phase after first PP ovulation often shorter than normal, resulting in an infertile short-cycle
- For anoestrous cows, a dominant follicle must be developed and the resulting short oestrous cycle, circumvented.
- GnRH/PG based strategies alone are not adequate for anoestrous beef cows
Two Main Base Protocols for Beef Cows

7-day CO-Synch + PRID/CIDR: GnRH administered at PRID/CIDR insertion followed 7 d later with PG at PRID/CIDR removal. Inseminate 66-72 h after PG and CIDR removal coincident with GnRH administration.

5-day CO-Synch + PRID/CIDR: GnRH administered at PRID/CIDR insertion, followed 5 d later with PRID/CIDR removal and administration of 2 injections of PG; the first at PRID/CIDR removal and second 12 h later. TAI is performed 72 h after first PG and CIDR removal concurrent with a second GnRH injection.

Use of eCG in Oestrous Synchronisation Protocols

Treatment of cows with eCG (PMSG) at removal of an intravaginal progesterone device in a FTAI protocol increased:

- Preovulatory follicle size
- Ovulation rate,
- CL growth rate,
- Systemic progesterone concentration
- Pregnancy rate
On-Farm Study

To develop a robust fixed timed artificial insemination (FTAI) protocol for Irish beef cow herds

Randi et al. (2015)

On-Farm Study (1)

- 3 synchronisation/FTAI protocols
- Total number of cows synchronised: 2205
- Average no. of cows per farm: 27
- 74 herds across the island of Ireland
On-Farm Study (2)

- All cows at least 35 days calved
- Cows were scanned before commencement of the treatments
- Farmer covered cost of AI
- Cows were scanned for pregnancy (Day 30)
- Drugs provided by CEVA Animal Health

Protocols

Option 3

GnRH
SCAN
7 DAYS
PRID
PG
GnRH + FTAI
72 hours

eCG
## Pregnancy Rates (%)

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spring 2014</strong></td>
<td>59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>69&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Autumn 2014</strong></td>
<td>52</td>
<td>54</td>
<td>49</td>
</tr>
<tr>
<td><strong>Spring 2015</strong></td>
<td>53</td>
<td>-</td>
<td>55</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>54</td>
<td>52</td>
<td>57</td>
</tr>
</tbody>
</table>

*Randi et al. (2015)*

## Cyclicity v Pregnancy rate in Spring Calving Cows

![Cyclicity v Pregnancy rate in Spring Calving Cows](image)

*Randi et al. (2015)*
Table 1  Pregnancy rates in Bos taurus beef cows and heifers synchronized with progesterin devices and estradiol with or without eCG (adapted from Menchaca et al., 2013)

<table>
<thead>
<tr>
<th></th>
<th>With a CL^1</th>
<th>Without a CL^1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cows (n = 453)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With eCG</td>
<td>67.6% (25/37)^a</td>
<td>64.9% (134/201)^a</td>
<td>65.4% (149/228)^a</td>
</tr>
<tr>
<td>Without eCG</td>
<td>63.6% (28/44)^a</td>
<td>50.8% (92/181)^a</td>
<td>53.3% (120/225)^a</td>
</tr>
<tr>
<td><strong>Heifers (n = 749)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With eCG</td>
<td>48.7% (73/150)^a</td>
<td>44.2% (100/227)^a</td>
<td>45.9% (173/381)^a</td>
</tr>
<tr>
<td>Without eCG</td>
<td>41.2% (54/131)^a</td>
<td>32.1% (76/237)^a</td>
<td>35.3% (130/368)^a</td>
</tr>
</tbody>
</table>

^1^eCG = equine chorionic gonadotropin.

^a^Proportions within a column with different superscripts differ significantly (P < 0.05).

Bô and Baruselli (2014)
**FTAI for beef heifers**

- Similar protocols to beef cows – shorter duration from PG to AI
- Not as successful as traditional PG based/Heat detection approach
- Primary reason for poor results with FTAI seems to be the inability to synchronise follicular waves at the same level of success as that achieved in cows.
- Following administration of GnRH at random stages of the oestrous cycle,
  - 60 to 90% of postpartum beef and dairy cows ovulate
  - 48 to 60% of beef and dairy heifers ovulate

---

**Prostaglandin Based Protocols for Beef Heifers**

**Fig 3a.** Commonly used prostaglandin-based synchronisation protocol for heifers

- Day 0: PG
- Day 11: PG
- Prostaglandin B
- PG in “non-responders”
- Detect oestrous & AI

**Fig 3b.** Alternative prostaglandin-based regimen for replacement heifers. This is the most cost-effective regimen for heifers.

- Day 6: PG
- Day 17: PG
- Detect heat & AI for 6 days
- Detect heat & AI for 5 days
- Detect heat & AI for 5 days
Long Term usage of FTAI

Table 2 Number of cows FTAI and pregnancy rates over a 10-year period in Angus cows and heifers in ‘Estancia Santa Dominga’, Olavarria, Argentina

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of cows AI</th>
<th>Pregnant</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>528</td>
<td>259</td>
<td>49.1</td>
</tr>
<tr>
<td>2001</td>
<td>1169</td>
<td>697</td>
<td>59.6</td>
</tr>
<tr>
<td>2002</td>
<td>1905</td>
<td>1102</td>
<td>57.9</td>
</tr>
<tr>
<td>2003</td>
<td>1928</td>
<td>1179</td>
<td>61.2</td>
</tr>
<tr>
<td>2004</td>
<td>2021</td>
<td>1168</td>
<td>57.7</td>
</tr>
<tr>
<td>2005</td>
<td>2326</td>
<td>1345</td>
<td>57.8</td>
</tr>
<tr>
<td>2006</td>
<td>2534</td>
<td>1404</td>
<td>55.4</td>
</tr>
<tr>
<td>2007</td>
<td>2219</td>
<td>1242</td>
<td>56.0</td>
</tr>
<tr>
<td>2008</td>
<td>2682</td>
<td>1402</td>
<td>52.3</td>
</tr>
<tr>
<td>2009</td>
<td>2953</td>
<td>1429</td>
<td>48.4</td>
</tr>
<tr>
<td>2010</td>
<td>2784</td>
<td>1496</td>
<td>53.7</td>
</tr>
<tr>
<td>Total</td>
<td>23050</td>
<td>12723</td>
<td>55.2</td>
</tr>
</tbody>
</table>

FTAI = fixed-time artificial insemination; AI = artificial insemination.

Bó and Baruselli (2014)

Postpartum Uterine/Ovarian Pathology

- Occasionally proposed as affecting beef cow fertility
- On Farm Study 1409 cows across 61 herds
- Incidence of:
  - **Uterine infections**
    - Spring: 2.7% (19/702)
    - Autumn: 13% (92/707)
  - **Cystic Ovaries**
    - Spring: 2.3% (16/702)
    - Autumn: 5.37% (37/707)

Randi et al. 2015 (unpublished)
Genomics

- Functional Genomics/Proteomics
- SNP genotyping platforms
- GWAS
- Genomic Selection
- Low heritability, ‘difficult traits’

Take Home Messages

1. Heifers
   - Have heifers well grown at 12 - 13 months of age
   - Restrict breeding to the first 6 weeks of the breeding season and use easy calving bulls
   - Aim for a BCS of 3 at calving

2. Cows
   - Monitor BCS through last 1/3 of gestation & adjust feeding accordingly
   - Calve down cows in moderate to good BCS
   - Restricted suckling can advance the onset of cyclicity

3. Breeding management
   - Avoid fluctuations in feed supply during the breeding season
   - Heat detection critical when using AI
   - Vigilance for bull fertility particularly with young bulls

The Irish Agriculture and Food Development Authority
4. Oestrous Synchronisation and FTAI

- Must be simple, low labour input and efficacious
- Acceptable pregnancy rates can be achieved with FTAI
- Modifications still on-going
- Target cows to breed replacements/late calvers
- Can combine with ‘clean up’ natural service
- Resynchronisation of repeats
- Protocols for sexed semen
- Not a substitute for good animal husbandry and technical skill

Thank you for your attention