AI Boar Management to Optimize Sow Productivity

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A single sperm is half a pig ……

......it probably requires < 1 thousand sperm at the site of fertilization to produce a litter....

......and the industry norm per litter farrowed probably requires 5-6 billion sperm!
What was AI supposed to deliver?

1. Reduced labor inputs at breeding
2. Improved occupational health
3. Reduced disease risk
4. Easier working environment
5. More consistent production
6. Greater genetic gain
7. Rapid integration of new genes

(From Campbell, 2008 Billy Day Symposium)
Assessing Reproductive Performance

- Despite “rigorous” semen evaluation, certain boars do not have the same reproductive performance

- Routine semen evaluation standards (> 70% motility & < 30% abnormal sperm) detect male reproductive disorders.....

...... but do not predict relative fertility among “acceptable”, healthy sires

(Flowers et al. 1997; Alm et al. 2006; Ruiz-Sanchez et al. 2006)
Relative Fertility of Boars with “Acceptable” Semen (USA boar stud ~ 450 boars)

~25% of boars had PR less than 90%
Opportunities to Improve Productivity through Boar Management

1) **Fertility is generally unknown**
   - Using sub-fertile boars and low quality ejaculates reduces production efficiency
   - USA data suggests up to 20% of boars are sub-fertile

2) **Excessive number of sperm used per litter produced (5-6B)**
   - Increases the numbers of boars needed for semen production
   - Reduces the genetic impact of our best boars

3) **Pooled semen (from poorly defined males) is largely used in NA studs**
   - Breaks the link between known genetic value of individual boars and the paternity of progeny produced
In order to safeguard against unknown “relative” fertility, the industry:

- Uses excessive amounts of sperm in each AI dose.
- Pools semen from several boars
Why use excessive sperm used in each AI dose?

**Compensable** traits are those that can be overcome by introducing large numbers of sperm during insemination (*Braundmeier and Miller, 2001* and *Flowers, 2013*)
- i.e. motility, normal morphology (*Flowers, 2013*)

**Non-compensable** traits are those that male fertility is unresponsive to increases in sperm number
- i.e. those associated with plasma membrane binding and DNA integrity (*Flowers, 2013*)
Why are excessive amounts of sperm used?

There is a positive increase in performance by:
- increasing the number of spermatozoa of the same quality, or
- inseminating similar numbers of spermatozoa of greater quality (pooled semen) results in a positive increase in reproductive performance (Flowers 2013).

(Flowers 2013)

Fertility of some boars is compromised when their semen is inseminated at less than 3 billion sperm/AI dose.
Why are excessive amounts of sperm used?

Fertility of some boars is compromised when their semen is inseminated at less than 3 billion sperm/AI dose.

Fertility of some boars is maintained with AI doses of 1 billion sperm.

(Flowers 2013)
Steps for Improved AI programs & Optimize Breed Herd Productivity

1. Identify boars with **optimal fertility**
   - Characterize boar fertility !!

2. **Eliminate** boars with **limited reproductive capacity**

3. **Retain** boars with the highest **genetic value** for producing commercial progeny

4. Use **high value** boars with proven fertility at lower sperm doses (< 1.5 billion) for PC-AI and/or FT-AI – to optimize production performance

*Boars with optimum fertility & genetic value will have the greatest impact on the breeding herd*
Increasing the impact of elite boars through breeding management
Characterize boar fertility using single-sire AI.

3 → 2 Billion

Removals due to low fertility and “value”.

1.6 Billion

Removals due to overall “value”.

1.6 Billion

Boars with highest value

**PHASE 1**

**PHASE 2**

**PHASE 3**

Pooled → Single Sire

Single sire

Single sire

Multiple breedings, standard AI

Multiple breedings, PCAI

PCAI and Fixed Time Insemination

Proven fertile boars
Boar Fertility Challenge - Reduce AI dose to 2 Billion

3 -> 2 Billion

Characterize boar fertility using single-sire AI.

.........Evaluating the true potential of a boar

- 50 Single sire matings per boar at a concentration of 2 Billion sperm
- Production characteristics measured:
  - Pregnancy & farrowing rate
  - Litter size (total and alive)
Methods - Characterizing boar fertility

- **Boars**
  - **Semen quality included >75% motile and >70% normal**
  - Ejaculates processed at:
    - 2 billion sperm cells/dose ~ conventional AI
  - ~50 Single Sire matings evaluated
  - Semen used within 4-5 days of age

- **Sows**
  - Multiparous (no gilts)
  - WEI 3 to 6 days
    - No returns, aborts or rebreds

- **Data**
  - Pregnancy rate, farrowing rate and litter size

Minimize “sow effect” by selecting sows with optimal fertility
Results: pregnancy and farrowing rates

- Pregnancy rates ranged from 57 - 100%
- Farrow rates ranged from 50 - 100%

25% of boars had PR < 90%
Relationship between pregnancy & farrowing rate

\[ y = 1.1059x - 0.1367 \]

\[ R^2 = 0.7839 \]
Results: Total born

Total born ranged from 7.6 – 15.2

Born alive ranged from 6.2- 14.9
Results: Pigs produced

Pigs produced ranged from 500 - 1500
Relative Fertility of Boars With “Acceptable” Semen

Boar (sorted by pregnancy rate (%))

Pig produced

Total born

Rate (%)
How does Boar fertility affect Sow Productivity?

<table>
<thead>
<tr>
<th>Category</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnancy rate</td>
<td>85.5%(^a)</td>
<td>93.9%(^b)</td>
<td>97.7%(^c)</td>
</tr>
<tr>
<td>Farrow Rate</td>
<td>80.6%(^a)</td>
<td>90.5%(^b)</td>
<td>94.2%(^c)</td>
</tr>
<tr>
<td>Total born</td>
<td>13.2(^a)</td>
<td>13.8(^b)</td>
<td>13.8(^b)</td>
</tr>
<tr>
<td>Born alive</td>
<td>11.8(^a)</td>
<td>12.5(^b)</td>
<td>12.5(^b)</td>
</tr>
<tr>
<td>Pigs produced*</td>
<td>1065.0(^a)</td>
<td>1245.5(^b)</td>
<td>1294.9(^c)</td>
</tr>
</tbody>
</table>

*Estimated on 100 sows bred

What is the genetic value of pigs produced? +200 pigs produced for 100 sows bred
Results: Pigs produced vs genetic index

No relationship between index and fertility
Why is an index important?

A high indexing commercial boar passes these traits on to his progeny.

1. Improved feed conversion
2. Fewer days to market
3. Decreased mortality

PRODUCTIVITY !!!

*The optimum environment must be provided for a pig to reach its genetic potential.
Advanced AI Technologies in Pigs

- Boars with Proven Fertility are ideal Candidates for AI Technologies like PC-AI & FT-AI
- PC-AI & FT-AI allow for fewer sperm to be used per insemination & better use of Superior Boars
Post-cervical AI (PCAI)

- Allows the sperm cell number to be reduced without impairing reproduction.
- The lower limit of reduction may be 1-1.5 billion in ideal conditions (boar fertility tested, excellent sow farm management, etc.)
- Requires minimal training by stockman
- Does not require extra time for insemination
- No welfare implications
- May be a challenge in some primiparous sows.
Production “Value” of a boar = Pigs produced x index

- **Phase 1**: 3 – 2 b
  - Identify boars with low performance

- **Phase 2**: Further reduce concentration to 1.6b using PCAI

![Value trend graph with boar numbers and value indices]
### Increasing the impact of elite boars using post-cervical-artificial insemination (PC-AI).

<table>
<thead>
<tr>
<th></th>
<th>STAN</th>
<th>PCAI</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. boars</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. matings per boar</td>
<td>53.4</td>
<td>46.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Concentration</td>
<td>2.1</td>
<td>1.6</td>
<td>0.02</td>
<td>0.0001</td>
</tr>
<tr>
<td>Pregnancy Rate (d30), %</td>
<td>95.5</td>
<td>95.6</td>
<td>0.5</td>
<td>0.88</td>
</tr>
<tr>
<td>Farrowing Rate, %</td>
<td>93.6</td>
<td>93.3</td>
<td>0.6</td>
<td>0.67</td>
</tr>
<tr>
<td>Total Born</td>
<td>13.3</td>
<td>13.7</td>
<td>0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Born Alive</td>
<td>12.0</td>
<td>12.5</td>
<td>0.1</td>
<td>0.003</td>
</tr>
<tr>
<td>Pigs Produced</td>
<td>1123</td>
<td>1172</td>
<td>20.2</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Presented at the 2013 Banff Pork Seminar
Fixed-time AI

- Control/induce the timing of ovulation so only a single insemination is required
- Reduces semen requirements by reducing the number of inseminations needed to produce a litter
- Reduces labor needed for estrus detection and multiple inseminations
- Allows the semen of superior boars to be used in an optimal manner

Current Strategies and Technologies for Reproductive Management of Gilts and Sows

Stephen K. Webel¹, Robert R. Kraeling² and Michael E. Johnston¹

Advances in Pork Production (2017) Volume 28, page 111
**Phase 3 – Single fixed time insemination using PCAI at 1.6b**

Further reduce concentration to 1.6b using a single fixed time insemination using PCAI
Optimizing AI Boar Use

- Goal to breed 1500 sows per week

- PHASE 1: 2 Billion, 2.3 matings
- PHASE 2: 1.6 Billion, 2.3 matings
- PHASE 3: 1.6 billion, 1 mating

More pigs produced
Higher value
Benefits Optimizing AI Boar Use

- **Boar inventory**
- **Boar fertility**
- **Doses per boar**
- **Sow Productivity**
Factors to Consider

- Monitoring of field fertility data
- Biological Markers of Boar Fertility
- Cytogenetic Screening & Chromosomal Abnormalities
Monitoring of field data is the key to success!!
(an example of a boar evaluation report)

Monitor the number of breedings per boar to ensure 50 matings are achieved.

Identify boars with low fertility (Farrowing rate & litter size)

Early identification of potential issues at the stud or sow farm.

Note the impact of low fertility (individual boar or potential issues on sow farm) on pigs produced (profitability)
Biological Markers of Boar Fertility

- Allow identification of boars with low reproductive capacity at a young age
- Allow identification of low reproductive capacity boars with more confidence
  - Less affected by environmental factors (compared to field fertility evaluations)
- To date, potential markers have been identified, but more work needs to be completed.
- Field fertility studies remain the best way to evaluate boar fertility.
Male Fertility Evaluation Using Biomarkers in Livestock

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Abstract

While much attention is paid to the fertility of breeding females in livestock production systems, less attention is given to the fertility of breeding males. Male fertility is a complex trait, and while semen quality assessment is an important tool, it is more suitable for identifying males with reproductive problems than predicting relative fertility. The cascade of events required for fertilization and embryonic development limit the usefulness of functional assays which measure a single trait. However, there is potential in the use of genomic and proteomic markers to better predict relative fertility performance of sires. This review will describe current methods for evaluating male fertility in livestock, the physiology underlying these fertility outcomes as well as potential biological markers for predicting fertility performance of sires in livestock production systems.
Prevalence and consequences of chromosomal abnormalities in Canadian swine herds

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THANK YOU!!