Low Concentration, High Fertility; Every day Dutch AI Practice

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Introduction

High Performance and continuous improvement are key success factors for the successful swine producer of tomorrow. For decades TOPIGS has been focused on improving the performance of its breeding pyramid and the performance of its clients. Being a producer-owned organization, TOPIGS’ focus has always been to add value to the pork production chain. Low semen concentration (or, more accurately, “low sperm count”) of 1.2 billion motile cells/dose is resulting in efficient semen production of more than 3,700 doses/boar/year. With annual averages of 14.4 live born per litter and 91% farrowing rate the fertility results of artificial insemination (AI) remains high and is being implemented by all the leading farms in the pork industry. The genetic distribution infrastructure developed in the past 40 years is not only efficient and highly prolific, but also results in the ability to offer semen of more superior boars to clients; this results in a better performance of the entire production chain (Foxcroft et al, 2008 and Broekhuijse, 2012).

Low sperm count (LSC) in The Netherlands

If we look globally, there is a huge variation in the number of sperm cells that are used in one dose of semen. Many countries are still using 3 or even 4 billion sperm cells per dose, a sperm count that has been used since the commercial use of AI began in the 1970’s. Over time, however, we see a trend of using fewer sperm cells per doses. This trend is not developing at the same pace globally. Where many countries are currently still using high sperm counts per dose, other regions have dropped this number to around 2 billion sperm cells per dose. In the Netherlands, TOPIGS has dropped below 2 billion motile sperm cells per doses since 2005, while the producers use intra cervical insemination techniques and has continued to reduce the number of sperm cells per dose in the years that followed. This reduction in sperm count is implemented without a

\begin{figure}[h]
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\includegraphics[width=0.5\textwidth]{ Figure1.png}
\caption{Figure 1. History of sperm count decrease at TOPIGS AI stations in the Netherlands}
\end{figure}
change to post cervical insemination technique. In many other countries or organizations, the reduction in concentration has been implemented together with the introduction of the post-cervical insemination technique in a variety of volumes and sperm counts. These introductions vary in their success (Watson et al, 2003; Rozenboom et al, 2004; Serret et al, 2005;) and include an intensive process of sow management alteration. Quality of semen, heat detection and insemination time become more important when implementing LSC dose; a conclusion that was drawn by TOPIGS in the mid 1990's and led to a series of research projects focusing on these subjects.

With a good control over essential management aspects, TOPIGS’ boar studs continue to reduce the number of sperm cells per dose without a loss in fertility and with a reduction in variation in the fertility performance (Broekhuijse et al, 2011). In 2011, TOPIGS used a concentration of 1.5 billion motile cells per dose in the Netherlands, but research is showing that concentrations as low as 1.2 billion motile cells per dose still do not affect the fertility on the farm (Leenhouwers et al, 2011). Our expectations are that this is not yet the critical lower limit and that well controlled semen production will allow us to go further down in sperm count levels. Post cervical insemination is not necessary for the use insemination doses with the current low number of sperm cells; with intra cervical insemination technique it is possible to achieve the equal results.

**TOPIGS AI Research**

For many years the AI research program of TOPIGS has been focusing on the factors affecting semen fertility results and how to eliminate negative factors. Semen production and insemination management are both essential for good fertility performance. Factors in both areas of production in general may have a negative impact on fertility performance. The Dutch AI research program of the past 35 years has focused on these factors and has led to several successful and groundbreaking research results (Feitsma et al, 2009). Over the years, topics like AI boar nutrition requirements (Kemp et al, 1989), timing of insemination relative to ovulation (Soede et al, 1995), phagocytosis of boar spermatozoa in vitro and in vivo (Woelders et al, 2001), optimizing timing of insemination (Steverink et al, 1997), the role of the boar for AI (Langendijk et al, 2005), predictive semen quality assessment (Broekhuijse et al, 2012), and morphological effect on fertility (Feitsma et al 2006) were investigated and have contributed to improved semen production control in TOPIGS boar studs.

**Controlled semen production**

A variety of measures to control semen production at the AI station and semen usage on the farm have been investigated and implemented over the past 15 years. Boars are intensively screened before entry into the AI stations; semen quality standards must be met and must be stable before entry. Boar management in the boar stud is optimized and intensive individual care of the boar is applied. High hygiene levels and extreme low usage of antibiotics in boar treatments are applied to create a sound foundation for semen production. Much effort is invested in objective semen quality assessment and improvement of the accuracy and repeatability of this assessment. Effective and controlled semen storage and transport are applied to reduce the risk of damage to the sperm cells after production. The client farms are intensively trained and educated in semen handling and sow management. Accurate estrus detection and timing of insemination have been found to be essential elements for successful farm production. Effective control over the semen production process has allowed TOPIGS already for many years to lower the sperm count, increase the output per boar and therefore use fewer boars at its AI stations.
Monitoring / analysis effect of changing production standards

These research results and improved production control have allowed the Dutch AI organizations to gradually drop their sperm count, without a decrease in fertility. TOPIGS continuously monitors its semen fertility performance in the field. Using its large breeding database (PIGBASE), TOPIGS Research Center IPG is able to make a link between field performance of the semen and the database of its AI stations, allowing TOPIGS to create a database with over 1.2 million ejaculate records and over 12 million litter records. These merged databases can be used to monitor the fertility performance of the AI stations closely and to apply a statistical correction for other fertility performance affecting factors.

The effect of CASA introduction

Until 2006, TOPIGS AI stations in the Netherlands were using microscopic motility assessment. Database analysis showed significant influence of AI station on the fertility level and a significant but small negative effect on fertility of decreased sperm count. From 2006 on, Computer Assisted Semen Analysis (CASA) was introduced and implemented on all AI stations. Analyzing the period from 2006 to 2011 clearly demonstrated the effect of CASA system implementation: no longer could an effect of AI station be demonstrated and lowering the sperm count as far as 1.2 billion motile cells no longer affect fertility in the farms (Leenhouwers et al, 2011).

The implementation of Ultimate® CASA systems in our AI stations has been an intensive process. In the start of using CASA systems, undesired variation in concentration and motility assessments continued to be observed. However, with intensive training, continuous education, and periodic testing of the laboratory technician, the desired accuracy and the reduction of variation were achieved. This eventually resulted in the elimination of the AI station and technician effects as influencing factors for farm fertility. The implementation of the CASA systems allowed us to expand our research into motility factors and their relationship to semen fertility. CASA systems in general produce a variety of motility parameters, but their relationship to fertility was unknown until recently. The merged data of both TOPIGS AI and sow farm data allowed Broekhuijse et al (2011) to demonstrate that there was a relationship between the different semen motility parameters and fertility. Parameters affecting farrowing rate were different of those affecting litter size. Furthermore the nature of the relationship was different per genetic line of the boar. Based on the boar’s genetics and the ejaculate’s motility parameters, a prediction on farrowing rate and litter size can be made.

New semen parameters for identification of sub fertile boars

Our most recent research subject involved flow cytometry technique in combination with fluorescent staining for different semen characteristics (Broekhuijse et al, 2012). This research demonstrated that the chromatin structure test was significantly related to litter size and farrow rate and disproved four other theoretical relationships. Thus, other non-visual aspects of semen cell functionality, not currently assessed on routine basis, are also found to be related to fertility and can therefore be used to distinguish between high and lower fertile ejaculates and boars. This outcome could, however, be related to the boar population used for this analysis. This specific AI boar population is already screened for sub-fertile boars over the years, since AI in the Netherlands is already commercially used for more than 30 years.
Benefits

LSC doses are only one side of the coin. Why would sow farms want to receive insemination doses with a low number of sperm cells?? Why pay more for less?? Why accept a more diluted product??  Because it is not less of a product, but actually more. Annually the Dutch AI stations are able to demonstrate their client an increase in fertility performance. Sperm count per dose is not the focus of breeding farms; sow farms want good fertility resulting in reliable production and high number of piglets. As of 2008 the 10% best farms in the Netherlands have been weaning more then 30 piglets per sow per year and in 2009 that same group passed the boundary of 14.0 live born piglets per litter. These fertility results make the Netherlands one of the leading countries in sow fertility. Considering this performance level, in combination with the extreme LSC doses, demonstrates that efficient production is possible, without compromising on fertility. The benefit of using LSC doses is that the genetic gap between the nucleus and the field is reduced. The same number of sows can be inseminated with fewer boars. If AI stations select the boars with the highest genetic merit, the average genetic index of the AI boars will increase. High productivity of boar studs in combination with efficient use of semen at the sow farms has resulted in a genetic dissemination rate of 1 boar for every 500-700 sows. In 2011 the Dutch AI organization sold on average 2,453 doses/boar/year, including maternal lines. This is a 100% increase in boar:sow ratio compared to the global average ratio of 1 boar to 250 sows. A higher boar:sow ratio allows TOPIGS to increase the selection intensity in boars. Based on the boar population, the type of market or integration level of the boar stud a selection criterion can be chosen that fits best. In most cases it will be most beneficial to select for boars with a better genetic index. A selection of the best boars can easily result in an improvement of 10 selection index points on the average genetic index in the boar stud. Each point represents an economic value of $0.10 on finisher level. For a 10,000 sow production system this results in an additional economic benefit of approximately $250,000 ($1 per finisher, $25 per sow/year, $5 per insemination dose; Table 1).

Fertility performance

*Annual average, 10% best farms, 10-50k sows*

![Figure 2. Dutch fertility performance of TOPIGS farms over the last 10 years.](image-url)
From an AI station perspective, the high productivity of the boars has allowed TOPIGS AI stations to control the cost price of the semen. The savings due to efficiency are mostly reinvested in improvement of the production process and research.

From TOPIGS’ perspective, the lower limits on LSC per dose and the upper limits on fertility have not yet been reached. We expect that an even lower sperm count per dose is possible and the challenge remains to achieve this in a controlled manner. Continuous research on the management factors influencing semen quality and fertility will remain essential to achieve this goal especially with the implementation of genomic selection becoming a reality.

Genomic selection will allow TOPIGS to increase the speed of genetic improvement, but will also allow us to early identify superior boars with a much higher reliability. Efficient semen production will allow the AI stations to use the superior boars more effectively. A more advanced use of the genomic data is to relate the DNA profiles to boar specific semen characteristics. In the future this may allow TOPIGS to predict the boars fertility based on its DNA profile.

**REFERENCES**


Broekhuijse MLWJ. Prediction of porcine male fertility. Dissertation Faculty of Veterinary Medicine, Utrecht University, the Netherlands, 2012; ISBN: 978-90-393-5776-7


**Table 1. Impact AI Efficiency**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference</th>
<th>2 billion/dose</th>
<th>1.5 billion/dose</th>
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<td># sows</td>
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<td>cells/dose</td>
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<td># boars needed</td>
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<tr>
<td>$ per dose</td>
<td>$2.95</td>
<td>$ 4.91</td>
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</tbody>
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Watson PF, Behan JR. Intrauterine insemination of sow with reduced sperm numbers: results of a commercially based field trial. Theriogenology 2002;57:1683-93.