# AI Management to Optimize Sow Productivity

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## 1. Introduction

The use of artificial insemination (AI) has had a major impact on genetic improvement in the swine industry over the last 40 years. However, the overall production efficiency of the breeding herd is highly dependent on the reproductive capacity of the boars used for breeding and the genetic merit of the boars for offspring performance. Given the widespread use of AI in swine production, boar quality can impact the reproductive outcome of numerous females. We instinctively know that not all boars are of equal quality, and all ejaculates collected for use in AI are subjected to standard semen analysis in commercial boar studs. The ultimate measures of boar performance in production are pregnancy rate and litter size born. However, these are retrospective measures and can be highly influenced by breeding management and the quality of the gilts and sows bred (Colenbrander et al., 2003).  Boar stud managers have come to accept that a combination of thorough physical examination of the boar and conventional semen evaluation (concentration, morphology, motility) can provide an alternative to actual fertility data (Gibson, 1989). While these evaluations can establish that an animal is either sub-fertile or infertile, they cannot identify the relative fertility of boars that meet accepted industry standards for sperm and ejaculate quality (Dyck et al., 2011, Diether and Dyck, 2017).  In general, the predictors of fertility currently applied in most commercial AI centers provide a very conservative estimate of the relative fertility of individual boars. Furthermore, the relatively high sperm numbers used in commercial AI practice, and the pooling of semen from multiple boars, masks the limited fertility of some sires. However, these differences in fertility become evident when lower numbers of sperm are used for AI and boars are evaluated on an individual basis.

Effective prediction of relative boar fertility is essential and will allow for the early removal of less reproductively efficient boars from commercial studs. This in turn will optimize the use of proven, high fertility boars with high genetic value at lower sperm numbers per AI dose. At the nucleus level this will allow for increased selection pressure by increasing the number of offspring bred per collection from high ranking boars. At the level of terminal line production, this would allow for considerable improvements in production efficiency to be realized by capitalizing on boars with a high index for traits such as growth rate, feed conversion efficiency and carcass characteristics of their progeny. If these changes in production strategy are to be realized, it is critical to identify boars of relatively low fertility that will not perform well when used in the more challenging situations of reduced sperm numbers per AI dose.

## 2. Assessing Boar Fertility

There is a long history behind the search to find a single or combination of tests that can accurately predict male fertility from a semen sample. Unfortunately, there appears to be no simple answer to this very complex question (Rodriguez-

Martinez, 2003). Laboratory assays often examine all of the sperm present in a sample for fertility, yet only 30 or so sperm are necessary to fertilize all available oocytes. Braundmeier and Miller (2001) indicated that the sperm that actually fertilize may be a small, highly selected, sub-population that is not representative of the average sperm evaluated in the sample. They also suggest that, because sperm must meet many requirements for successful fertilization, testing a single attribute is unlikely to be a true measure of ultimate fertility. Using similar reasoning, Rodriguez-Martinez (2003) suggested that to accurately predict semen quality it is necessary to test all key sperm attributes within large and heterogeneous sperm populations that potentially affect fertilization and embryonic development. Nevertheless, the markers of relative fertility selected must ultimately predict the relative fertility of boars when using low sperm doses of extended semen for AI (Rodriguez-Martinez et al., 2009). Braundmeier and Miller (2001) reviewed a number of functional and molecular tests used to assess male fertility. In this review they described two different sperm traits that affect fertility.

- *Compensable* traits are those that can be overcome by introducing large numbers of sperm during insemination. Problems with motility and morphology will reduce the number of sperm that are able to reach the oocyte, but by introducing large numbers of sperm the reduction in fertility can be minimized.
- *Uncompensable* traits are those that cannot be overcome by introducing larger numbers of sperm. These defects affect fertilization and embryo development and include nuclear vacuoles, sperm chromatin structure issues and morphological problems that do not inhibit fertilization.

Therefore, to effectively predict relative fertility, it is essential to discriminate between compensable and uncompensable traits in an ejaculate. Conversely, evaluation of relative boar fertility *in vivo* using high sperm numbers per dose (e.g. 3 billion sperm) will mask differences in compensable traits and will not allow the industry to identify boars that will perform well in more demanding applications of AI.

Conventional semen evaluation generally includes a measure of seminal volume, sperm concentration, and the percentage of progressively motile and morphologically normal sperm (Amann et al., 1995). Although some of these parameters are correlated with fertility in the boar (Flowers, 1997; Xu et al., 1998), several authors suggest that this information, while important, does not accurately predict whether a male is truly fertile (Brahmkshtri et al., 1999; Correa et al., 1997; Rodriguez-Martinez, 2003). Existing analyses are also usually inadequate for predicting relative fertility in healthy boars with ejaculate quality that meets normal industry standards (>70 % motility and <30% abnormal sperm) (Flowers, 1997; Alm et al., 2006), even though the reproductive efficiency of these boars may still be substantially different (Flowers, 1997; Tardif et al., 1999; Popwell and Flowers, 2004; Novak et al., 2010). Differences in relative fertility become increasingly evident when low sperm doses (<2.0 billion sperm) are used for AI (Tardiff et al., 1999; Watson and Behan, 2002; Ardon et al., 2003; Ruiz-Sanchez, 2006). This approach likely averts the compensatory effect of using excessive sperm numbers per AI dose (Saacke et al., 2000; Alm et al., 2006), thereby revealing important fertility differences among boars.

Another consideration that has come to light as a factor in boar fertility is structural chromosome abnormalities. In a recent study by Quach et al (2016), they assessed the prevalence and consequences of chromosome abnormalities in commercial swine operations in Canada. In the population investigated, they found carriers of chromosomal abnormalities at a frequency of 1.64 % (12 out of 732 boars). These carrier boars consistently showed lower fertility values, with the total number of piglets born for litters from carrier boars was between 4 and 46 % lower than the herd average. They also found that carrier boars produced litters with a total number of piglets born alive that was between 6 and 28 % lower than the herd average. Given the potential impact of these chromosomal abnormalities on fertility they suggest that screening of potential AI boars would minimize the risk of carriers of chromosome aberrations entering artificial insemination centres. This would avoid the large negative effects on productivity for the commercial sow herds and reduce the risk of transmitting abnormalities to future generations in nucleus farms.

## 3. AI Technologies and Optimized Use of Superior Boars

Although identification and selection of the most productive boars is a key step in optimizing productivity of the breeding herd, taking steps to make the most effective use of these boars also plays a role. The application of more efficient AI technologies would allow the merits of these “elite” boars to spread across a larger proportion of sows bred. However, with some common AI practices in the industry, these substantial differences in boar productivity and the link to known progeny produced by individual boars are confounded by 1) the use of pooled semen and

2) high sperm numbers per AI dose. Furthermore, the application of advanced AI techniques, such as post cervical AI (PCAI), single fixed time AI (sFT-AI) or the 2 techniques in combination could dramatically increase utilization of the most desirable sires (Willenburg and Dyck, 2012).

As reviewed by Bortolozzo et al (2015), PCAI allows for the number of sperm per AI dose to be reduced without impairing reproductive performance. Even in the early work with PCAI, the total number of sperm inseminated was reduced to 1 billion with no significant reduction in fertility (Watson and Behan 2002). Later, PCAI was successfully performed without impacting fertility using 0.5 billion sperm per dose (Mezalira et al. 2005). In principle, by depositing semen PCAI into the uterine body, a similar number of sperm reach the site of fertilization around ovulation time when compared to conventional AI, even with a threefold reduction (1 vs 3 billion) in the number of sperm used. Although the use of PCAI is becoming more common the number of sperm per dose is not yet standardized (Bortolozzo et al (2015). However, any reduction helps to increase the number of AI dose per ejaculate and facilitate the effective use of superior boars.

As mentioned, and recently reviewed by Webel et al (2016), breeding practices to limit the number of sperm needed for AI can also include the use of sFT-AI after synchronization of ovulation. The use of ovulation induction with AI in pigs has been reviewed extensively (Brussow et al. 1996; Huhn et al. 1996; Brussow et al. 2009) and new ovulation induction products have become available (Knox et al. 2011; Draincourt et al. 2013; Knox et al. 2014). The use of this technology has been shown to be successful on commercial production systems. However, on-going work is needed to establish the overall effect of these sFT-AI protocols based on farrowing rates and litter sizes generated in relation to the effectiveness of ovulation induction, number of sperm required, and the timing of insemination. Eventually, the benefits of breeding more sows using AI with lower numbers of sperm from fewer numbers of superior boars will be realized at several levels.

## 4. Implications

The evaluation of relative fertility amongst commercial AI boars, and a move to single-sire AI programs in combination with advanced AI techniques holds significant potential economic benefits to the swine industry. Data collected from initial boar evaluations would allow for elimination of the less fertile boars at an early stage. The characterization of AI boars that maintain high productivity at even lower numbers of sperm per AI dose then allows the industry to capitalize on established and emerging AI technologies like post-cervical, and single, fixed-time, insemination. These changes would be made without any loss in productivity, as measured in terms of pigs born per sow per year. The boars retained for commercial use would then have the highest genetic merit among boars available at any point in time, and would be used across a greater number of gilts and sows. This would suggest that the relative value of commercial progeny could be increased and would largely reflect the genetic merit of elite boars in terms of growth performance and feed utilization efficiency of their offspring.

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