TOOLS, TECHNIQUES AND STRATEGIES TO IMPROVE REPRODUCTIVE PERFORMANCE AND GENETIC PROGRESS

Kilby Willenburg
Reproquest Inc.
6064 McKee Road, Fitchburg, WI 53719 USA
E-mail: willenburg@reproquest.com

and
Michael Dyck*, George Foxcroft, Jennifer Patterson
Department of Agricultural, Food and Nutritional Sciences
University of Alberta, Alberta, T6G 2P5, Canada
*E-mail: michael.dyck@ualberta.ca

INTRODUCTION

The developing trends in the swine industry are to drastically reduce sperm cell numbers per insemination dose, decrease the number of working personnel on the farm, reduce boar numbers in the stud and deposit the majority of sperm cells in the uterus by bypassing the cervix. It is expected that this can be done without decreasing the impressive 90% farrowing rates (FR) and 13 total born (TB) production numbers, which have become the benchmark for the industry. To achieve this, we have to be flawless with all personnel and techniques at all times, in all seasons, in order to not see a reduction in fecundity. The swine industry is already a trimmed down version of its former self in terms of number of swine producers. Our market animals are leaner (3/4” of backfat compared to 3” in 1950s) and have impressive whole herd feed conversion ratios (3 lbs per 1 lb gain) but how much can we improve performance and at what cost?

Have we become greedy as an industry?

There are a number of tools, techniques and strategies that can help improve performance and genetic progress, but as an industry we have to consider each farm individually and look at their respective goals because not every new technology is pertinent for every scenario. Depending on the farm, different levels of emphasis will be placed on fertility parameters and genetic progress. A farm that incorporates in-house multiplication of their breeding stock is going to have a different perspective on fertility and genetic traits than a farm that purchases their replacement stock. This former type of replacement herd system is interested in specific genetic traits and will prefer using the highest indexing boars with the greatest genetic superiority. They may be more willing to sacrifice some level of fertility by using single sire inseminations and thus lower fertility boars to achieve these desired traits. This type of farm might be more indicative of the dairy industry than the swine industry where it is common and acceptable to have 50% conception rates and a very low number of total born, but their goal is genetic progress and heritability, not fertility.

The other type of farm, and perhaps the most common, purchases semen from a local boar stud and buys replacement gilts from a genetic supplier. Pigs per sow per year and carcass traits are considered to be more important than genetic superiority so terminal boars are generally crossed with maternal line females. Pooled semen is generally used to reduce boar and seasonal
variation and has become standard practice in North American boar studs. In this case most doses range between 60-100 mL with 2-4 billion sperm (Knox et al., 2008).

**Post-cervical AI (PCAI)**

In order for farms to reach their goals and maximize their potential whether it’s genetic or fertility there are many commercially available tools such as PCAI (post cervical artificial insemination), low dose AI, boar fertility analysis, estrus characterization, and ovulation synchronization to name a few. These applications may not be applicable for every situation but should help reduce unwanted variation on the farm and allow producers to improve reproductive efficiency.

Post-cervical AI is not a new application (Hancock, 1959; Martinez et al., 2002) but the renewed interest and promotion of this technique has caused the industry to re-examine this method for sow insemination. This technique, also known as IUI (intrauterine insemination), bypasses the cervix and deposits the majority of the sperm cells directly in the uterine body. Bypassing the cervix reduces the amount of semen lost and therefore should require less sperm per insemination to achieve similar reproductive performance as with standard cervical AI. There are many limitations with PCAI such as the fact that it not easily applied in gilts, the catheter is more expensive, it requires retraining of personnel and it can be potentially harmful to the sow if not performed correctly. However, the benefits that can be achieved in labour reduction, decreased AI time and the ability to have more sows bred with semen from superior sires may outweigh those limitations. Perhaps the biggest factor behind the recent PCAI movement is a desire to reduce sperm cell numbers per dose volume so more sows can be inseminated with superior genetics. Sperm numbers of $1 \times 10^9$ per 30 mL is a part of commonly described protocols for PCAI (Vazquez et al., 2008). One of the earliest trials (Watson and Behen, 2002) tested 3, 2 and $1 \times 10^9$ sperm per dose both with conventional AI and PCAI and attained similar fertility results except for the $1 \times 10^9$ dose with conventional AI which resulted in reduced litter size and farrowing rates ($P < 0.001$). There have also been adequate fertility levels attained with $0.5 \times 10^9$ sperm/doses (Mezalira et al., 2005), but some not so acceptable results in other reports at the same level of sperm (Roberts and Bilkei, 2005). This does cause one to question what are the causes of this variable success with PCAI and if this technique is applicable for all farms.

The commercial use of AI in swine has been available since the 1960s but little data was available on the optimal level for volume and concentration of semen until the work of Stratman and Self (1960), Hancock and Hovell (1961) and Baker et al., (1968). These experiments used non-extended semen, fresh semen extended in an egg yolk, phosphate, glucose extender and egg yolk bicarbonate extender, respectively, which questions how relevant the data is in today’s industry with the use of long term extenders, data on weaned to estrus interval and AI timing, improved AI technique and catheters to name a few. The data reported above on PCAI using conventional AI as a control has shown that as a whole, the industry can decrease the sperm numbers per dose with a standard AI and achieve impressive fertility numbers, but the data is conflicting. A common theme of the data reported has been management. Farms that are managed properly will probably not have an issue with maintaining high fertility levels with PCAI whereas farms with poor management and low fertility might create more problems with the transition. Post cervical AI does have a place in this industry but it might not be as widespread as all of the excitement. New technologies that either reduce the number of available sperm or inhibit the longevity of the cell (frozen thawed sperm, sex sorted sperm etc) would benefit from PCAI.
Identification of sub-fertile boars and sub-fertile ejaculates

As reviewed elsewhere in these proceedings (Dyck et al, 2012), identifying sub-fertile boars presents unique challenges to the swine industry. Quantitative analysis of physiological aspects of sperm function is currently used in boar studs but may not be the best indicator of boar fertility. One of the techniques employed by genetic companies to identify boars with chromosomal abnormalities is reciprocal translocations (RT). Specifically, it is a special type of chromosome abnormality caused by pieces of separate chromosomes breaking off from their original chromosome and forming with another. The result of such occurrence is a reduction in fertility and occurs in less than 1% of the boars but still could be of importance if single sired inseminations are used.

Fourier harmonic analysis (FHA) is another means to identify low fertility boars. This technique characterizes sperm nuclear shape and has been related to fertility in the bull (Ostermeier et al., 2001) and boar (not published). In a trial using single sired maternal line boars (n = 110) the head size and shape of sperm from an acceptable fertility boar (n = 105) and from unacceptable fertility boar (n = 5) were characterized and a model constructed. The acceptable boars had an average total born piglets (TB) of 12.31 ± 0.80, whereas an unacceptable boar had an average TB value of 9.58 ± 1.30. This model was tested on a new group of boars (n = 55) to validate the accuracy of the test. The results show that the model accurately characterized ~50% of the unacceptable fertility boars and ~85% of the acceptable boars. Although not perfect, this method is a justifiable means to reduce low fertility boars from a herd with minimal effort.

More pressing on a short-term basis is to screen for sub-fertile ejaculates. Boars can temporarily experience a reduction in fertility from acute and chronic stresses (Flowers, 1997) especially during the summer months (Cameron and Blackshaw, 1980). Most commercial AI studs have less than an hour to decide if an ejaculate should be processed or discarded (Knox et al., 2008), which does not allow time for many in vitro tests to be performed. Currently, a sperm motility analysis is conducted on every ejaculate and to a lesser extent sperm morphology to access ejaculate quality (Knox et al., 2008). Therefore, it appears that there are procedures in place but the relevant question is how accurate are these routine evaluations (Flowers, 2009).

Estrus characterization

Proper estrus characterization in the breeding herd is also an inexpensive method to improve reproductive performance and overall efficiency. Data has shown that around 95% of sows express estrus between 3 and 8 d after weaning and that sows mated between 3 and 6 d relative to estrus had increased farrowing rates and litter sizes compared to sows mated between day 7 and 15 (Tubbs, 1995). It has been reported that fertilization rates (Soede et al., 1995a) and litter size (Rozeboom et al., 1996) are lower if insemination occurs more than 24 h before ovulation. Therefore the best predictor of ovulation is frequency of estrus detection because ovulation occurs approximately 38-48 h after onset of estrus (Soede et al., 1995b; Knox et al., 2001) and animals ovulate 2/3 of the duration of estrus (Soede et al., 1995b; Knox and Zas, 2001). Proper herd characterization by monitoring duration of estrus in sows in special regards to parity and lactation length would improve AI timing, decrease the number of AI doses inseminated improve and overall herd fertility. This is true whether a producer is applying standard cervical AI or PCAI, but may be more critical when the sperm number per dose are reduced.
Synchronization of ovulation

Currently, there is a new product seeking FDA approval in the US for synchronizing ovulation in weaned sows, which, in theory could facilitate a single timed AI with no heat checking. Data has shown that an intravaginal dose of 100 µg of a GnRH agonist (triptorelin) given at 96 h relative to estrus or at estrus advanced ovulation and when used with a timed AI resulted in farrowing rates and litter sizes comparable to sows mated based on estrus (Knox et al., 2011). This product could reduce labour and the cost of insemination doses saving the farm thousands of dollars assuming the product is priced competitively. In Canada, Zak et al. (2009) have demonstrated that administration of porcine Luteinizing Hormone (pLH) at the onset of behavioural estrus to control ovulation not only facilitated fixed-time insemination, but also resulted in reduced semen usage, less labour devoted to estrus detection, as well as improved sow productivity. These data demonstrate that administration of pLH at the time of estrus detection would allow for the application of a single fixed timed administration 24-30 hours after pLH treatment. In situations in which the synchrony of estrus after weaning may not allow the effective application of either pLH or GnRH at a fixed time after weaning, the alternative strategy of using ovulation induction after an initial treatment at weaning with eCG continues to be explored with acceptable results (Cassar et al., 2005). The eCG/pLH protocol has been successfully applied in combination with post-cervical AI with reduced sperm numbers per AI dose, without adversely affecting sow fertility. The results of these studies has prompted work to evaluate the application of pLH at the onset of estrus followed by a single, low semen dose, 24-30 hours later using post-cervical AI (studies on-going). These and other results suggest that the implementation of single fixed-time AI programs in a well managed sow herd can be a reality. Linked to the use of proven superior sires, post-cervical insemination catheters and lower doses of semen this fixed-time insemination will allow the pork production industry to apply the genetic value of elite boars to breeding programs that are competitive with other livestock species.

Equipment

The last, and possibly the easiest, thing to ensure is that all equipment is adjusted and working properly. The swine industry has become very mechanized since the advent of AI and we have become very dependent on the equipment in our daily routine. Protocols should be implemented to reduce the inherent equipment variation. Microscopes should be checked monthly and the personnel at the stud should know how to adjust the scope. If you cannot see a proximal droplet then your scope needs adjustment. Photometers and CASA machines should be adjusted to achieve less than 5% variation between doses. Semen storage units should be kept in clean, dry, heated room so the unit can maintain a 16-18°C temperature range. Pipettors should be checked on a weekly basis and calibrated if needed. If the industry is pushing toward lower dose inseminations and single AIs then we have to make sure we are confident in the accuracy and consistency of the equipment.

CONCLUSIONS

The swine industry is an exciting and progressive industry but there needs to be continued development if this industry is to improve and be more profitable. It is not uncommon for farms to average over 90% farrowing rates and 13 total born. In 2010, according to PigChamp (2011) the average Canadian FR and TB was 84.06% and 13.07, respectively, with 49 farms reporting data. In the US it was 81.46% and 12.86 with a total of 329 farms. This in comparison to the
data from 2001 for both Canada (74.9% and 11.5, 455 farms) and US (69.0% and 11.3, 786 farms) shows impressive strides in performance. The next decade will probably not produce another 10% increase in FR and greater than 1.5 pigs per litter but it wouldn’t be unexpected to see improvement. On a short-term basis we should concentrate on identifying sub-fertile ejaculates especially during times of stress. We should also work towards identifying sub-fertile animals, both male and female, and working toward single sired inseminations to increase the genetic superiority of our herds. Single sired matings are taboo in our industry because of multiple AIs per pig, large numbers of sperm inseminated and significant boar variation but this would establish accurate reference points for male reproductive performance (Flowers, 2009). Then tools such as PCAI would be increasingly valuable since we would ideally be able to use the highest fertility and indexing boars across all of the sows.

REFERENCES