The Breeding Boar- Maximizing Productivity

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Abstract

Boar numbers in a pig enterprise are fewer compared to sows, but one boar is more important than a single sow. Boar productivity is influenced by genetic and environmental factors. A breeding boar should be selected on the basis of genetic potential and physical characteristics. Boar fertility is assessed by seminal volume, number of sperms per ejaculate, morphology, sperm motility and intensity of motion. Adequate seminal analysis should be performed to evaluate fresh boar ejaculate to assess its fertility indicators. Sperm morphology and motility are seminal analysis methods that are easy to perform under commercial conditions but are not sensitive predictors of fertility. When a boar is subjected to stress it takes 14 days before abnormalities in ejaculate are detected. Design of AI catheters that deposit semen into the cervical end of the uterus has made it possible to reduce sperm cell numbers per dose by 80% without change in fertility. There is variability among boars in post-thaw sperm quality variables. Housing design and social comfort of the boar influence semen quality. Energy and protein nutrition of the boar is usually adequate; however, the effect of micro-minerals and vitamins on semen quality should be studied. Many interrelated factors influence boar productivity and each should be given adequate attention to maximize boar productivity.

Keywords: pig, boar, semen, AI, mating, fertility

Introduction

Studies have shown that the reproductive performance of a boar depends on heritability, nutrition, age, breed, temperature, photoperiod, social environment, method of service (natural vs. AI), testicular size, sexual behavior, fertility and health (Marchev et al., 2003; Chenoweth, 2005; Smital, 2009). These factors influence boar fertility which has a major impact on the reproductive efficiency of pig operations. A single boar is more important than an individual sow in terms of affecting the overall fertility of a herd. This is due to the fact that boars normally breed between 50 and 1000 sows in a year depending on the type of mating that is used, whereas sows routinely farrow between two and three litters during the same time period (Flowers, 1997). Boar sow ratio is usually one boar per 20 sows with supervised hand mating, but in small herds or under extensive conditions, the ratio could be between 15 and 18 sows per boar (Taylor et al., 2006). In pen-mating systems, a young boar is required for every 2-4 sows, and an older boar for every 3-5 sows for a 7 day breeding period. Where artificial insemination is practiced, fewer boars are required. This indicates that the number of boars in a pig enterprise compared to sows is comparatively lower. Boars often receive less managerial attention thus lowering their productivity. A boar has a tremendous influence on a farm’s productivity and profitability. In order to maximize the herd’s performance and throughput, boars should receive careful attention (Taylor et al., 2006). A suitable breeding program to utilize a boar(s) to their full potential can be designed, but it is the management that has the greatest impact on how well the boar will perform during his breeding life. Due to the key role a boar plays in a pig enterprise, this paper reviews the factors that influence the productivity of a boar. An understanding of these factors will be a step towards improving/maximizing the productivity of the boar.

Factors Influencing Boar Reproductive Performance

Fertility and Breeding System
The best measure of boar fertility is the production of live offspring, i.e., farrowing rate and numbers of pigs born alive. The increase in the implementation of AI has increased the feasibility of using individual boar records for assessment of fertility. However, there are still several reasons that limit its usefulness for the pig industry (Flowers, 1997). Pigs have a relatively short generation interval due to their short gestation length and young age at sexual maturity. Therefore, to optimize genetic improvement, boars within herds are replaced at a faster rate. It is not uncommon within progressive segments of the pig industry for boars to be used only 12 to 18 months before they are culled. Although this practice is advantageous for genetic improvement, it actually makes the use of individual records for assessing boar fertility very difficult and, perhaps, impractical. It is generally accepted that at least 100 litters per boar are necessary to ensure that differences in litter size are actually due to boar fertility and not sampling errors. Based on the assumption that a young boar could be used to breed 2 sows per week with natural service (4 matings per week) and 8 sows via AI (16 doses per week), then it would take approximately 16 and 9 months, respectively, to obtain enough data to use for assessment of his fertility (Flowers, 1997). For an operation using natural service, adequate reproductive data would not be available before the boar is replaced. The situation is slightly improved for AI boars.

Another approach for assessment of boar fertility is to evaluate semen quality and hope that the various parameters measured are positively correlated with male reproductive performance. The three most common qualitative measures performed on semen are motility, morphology, and acrosome integrity (Flowers, 1997). Spermatozoa morphological characteristics are a useful measure of semen quality (Xu et al., 1998). However, semen characteristics are not significantly related to fertility (Barth, 1992). As the percentage of motile spermatozoa in an ejaculate increases from very low values, farrowing rate and numbers of pigs born alive also increase. However, at a certain point, motility estimates continue to increase, but fertility estimates do not. Flowers (1997) demonstrated that common microscopic tests performed on semen are qualitative rather than quantitative with regard to their relationship with fertility. These microscopic parameters can be used to group ejaculates into two categories, fertile and subfertile. However, for ejaculates within the fertile category, they cannot be used to further distinguish differences in fertility. Acrosome morphology is a more sensitive predictor of fertility than either motility or morphology. Motility evaluations are easy to perform under commercial conditions and probably receive more attention than they merit in terms of being estimates of semen fertility. In contrast, evaluation of normal acrosome morphology requires additional time, technical expertise and equipment compared to the assessment of motility (Flowers, 1997). However, it is a more reliable parameter upon which to qualitatively estimate semen fertility.

The size of the testes is moderately heritable and has been related to early puberty in both male and female siblings and offspring. The weight of the testes at puberty, and in the adult boar, is related to sperm output and even testosterone levels (University of Illinois Extension, 2012). In addition to other genetic and anatomical features, boars with increased testicle size should be given preference over ones with less developed testes. This should increase the sperm production capabilities of the boars selected for breeding. Semen volume has no association with fertility and sperm count is not related to fertility rates (Tardif et al., 1999). Oberlender et al. (2012) reported that boars younger than 15 months had lower semen volumes and higher sperm counts, as well as altered spermatic morphology compared with older ones. The ejaculation time (the time when the boar jumps on the dummy and the collection of semen begins until the completion of the process with posterior penile retraction) is associated with seminal volume (Oberlender et al., 2012). There is a positive correlation between ejaculation time and seminal volume but has no effect on the total number of sperms, motility, intensity of motion and spermatic morphology. Boar fertilization rate can be increased by improving semen quality and increasing the number of spermatozoa inseminated based on estimates of sperm quality (Flowers, 2002). Increasing the number of sperm in the insemination dose results in a positive increase in fertility, but the magnitude of response gradually diminishes as the number of sperm cells inseminated is increased until a plateau is reached (Salisbury and Vandermark, 1961). Boar fertility is reduced because of overuse and high temperatures. For optimum level of sperms per ejaculation, boars should not be mated for more than 1-2
times daily or 5-7 times per week (Lammers et al., 2007). Fertility is markedly reduced about 5-6 weeks after high ambient temperature. Boars should not mate during hot weather (>29°C). Adequate seminal analysis should be performed to evaluate fresh boar ejaculate to assess its fertility indicators. Improving boar fertility may not be easy; a major limiting factor is the absence of a quick, accurate and proactive fertility test for boar semen (Flowers, 2012). Development of such a test would greatly facilitate management of boar fertility. Before improvements can be made in boar fertility, an accurate method of measuring it needs to be available.

In developing countries, pig production is mainly at small scale (1-5 sows per farm). Breeding is by natural mating, with the farmer keeping a boar or hiring the service from “neighbours”. The major challenge is availability of technology for using AI. Use of AI is an improvement in the biological and economic efficiencies of the natural mating system. In artificial insemination systems, boar power is maximized because one boar can service 100 to 200 sows (Pitcher, 1997) compared to 15-20 sows in natural mating (Taylor et al., 2006). Boar power refers to the efficiency with which the boars are used. It depends on how many sows are in heat and the type of breeding management system used. Ejaculating boars at 96-h intervals enhances semen quality and quantity leading to significant improvement in the fertility and litter size of artificially inseminated sows (Umesiobi, 2010). However, with long periods of sexual rest, an increase in the number of degenerating and non-fertile sperm is observed. Sexual stimulation (5-10 min restraint) of the boar prior to ejaculation has been shown to increase the concentration and volume of the boar ejaculate. Sexual stimulation initiates smooth muscle contractions in the tail of the epididymis and the vas deferens (University of Illinois Extension, 2012).

Most insemination doses normally contain between 2 and 4 billion viable spermatozoa (Flowers, 2003). The reason why such a large number of spermatozoa need to be inseminated in pigs is that the site of normal semen deposition for artificial matings is the cervix. Anatomically, this is muscular organ whose inner lining consists of many deep crypts or folds. After insemination, a large number of spermatozoa are trapped in these crypts and once they enter, become trapped and do not have an opportunity to fertilize eggs (Flowers, 2003). To overcome this, several different types of A.I. catheters have been designed to allow deposition of the semen into the cervical end of the uterus. Initial results from field studies using trans-cervical A.I. appear to be promising. Gall (2002) reported that reduction of sperm cell numbers by almost 80% resulted in no change in fertility. It appears that modifications in catheter design have led to A.I technologies that will allow reduced numbers of spermatozoa to be inseminated with no appreciable change in sow conception. It appears that modifications in catheter design have led to A.I technologies that will allow reduced numbers of spermatozoa to be inseminated with no appreciable change in sow fertility. The probability of disease transmission through semen is low, but the potential impact on production and health in sows can be very high (PIC, 2006). Therefore, adequate health and disease control, early detection and treatment through routine monitoring are very important.

More than 70% of total variance observed in post-thaw sperm quality variables among ejaculates was attributed to boars (Roca et al., 2006). This indicates that boar is the most important factor explaining the variability among ejaculates in sperm cryosurvival. Optimal sperm cryopreservation is a prerequisite for the sustainable commercial application of frozen-thawed boar semen for AI. Efficient application of frozen-thawed boar semen in commercial AI programs is now feasible due to improvements in cryopreservation protocols and the development of new insemination procedures (Roca et al., 2006). Commercial pig companies are interested in establishing sperm cryobanks that are based on frozen semen with high and consistent post-thaw sperm quality. However, it is not easy to achieve this goal because ejaculated boar sperm show great variability in their survival of the cooling and thawing processes (Larson and Einarsson, 1976).

Age
The biological framework for sperm production as an adult is established early in a boar’s life (Flowers, 1997). In boars, sertoli cells can only support the development of a finite number of germ cells during
spermatogenesis (Sharpe et al., 2003). Sertoli cells proliferation in boars begins during the prenatal period (McCoard et al., 2002) and continues after birth (Franca et al., 2000). It is generally accepted that a very active and critical period of mitotic activity occurs during the first 3 weeks after birth (McCoard et al., 2000). Therefore, it is possible that a boar’s potential for sperm production as an adult might be established by the time it is weaned. Boar’s weaning weight positively influences sperm production. This is related to large quantities of milk which coincides with the active period of sertoli cells mitosis and key developmental periods of other male reproductive organs. It is logical that manipulation of boar’s nutrition before weaning may be a way to enhance their sperm production and other aspects of adult reproductive functions (Flowers, 2006). Puberty is attained more gradually in boars than in gilts. By 5 months of age, most boars can ejaculate sufficient numbers of sperm for fertile mating. The boar continues to increase testes size and spermatogenic output after puberty, and it has been reported that boars less than 9 months of age have both lower ejaculate volumes and concentrations compared to boars 18 months of age or older. By 8 months of age, adequate sperm numbers are produced for use in a breeding program. Flowers (2001) reported that semen production reached adult levels between 10 and 11 months of age for boars whose collection regimen was initiated at 190 days of age compared with 13 to 14 months of age for boars whose collection regimen began at 160 days of age. Once the adult level of semen production was reached, no differences in the total number of spermatozoa per ejaculate were observed between boars collected for the first time at 160 and 190 days of age. This indicates that initiation of collection regimens at 160 days of age does not have a significant, long-term effect on semen production in boars. This demonstrates that total sperm per ejaculate requires a longer period of time to plateau in boars collected for the first time at young ages compared with their older counterparts. Therefore, the age at which semen collection is initiated in boars is an important consideration for boar studs in terms of meeting daily production demands. Age has only a slight effect on semen volume, but has a significant effect on sperm concentration, total sperm in the ejaculate and daily sperm output, there being marked increase in boars over 12 months of age compared with younger boars. Comparing daily sperm output of boars aged between 8 - 12, 13 - 15.5 and 16 - 18 months, output increased with boar age (Cameron, 1985). In order to maximize fertility, boars less than 1 year of age should be collected no more than one time per week and boars over 1 year of age can be collected up to two times per week (University of Illinois Extension, 2012). There will obviously come a time in a boar's reproductive life when fertility is diminished by advanced age. This age is not well established, since there has been a high rate of boar turnover with rapid genetic improvement. The result of this is that many boars are only in stud for a period 2-4 years before culling. However, it has been observed that in older aged boars, there are higher incidences of sperm abnormalities, lower pregnancy rates and litter sizes (University of Illinois Extension, 2012). The spermatogenic cycle in the boar is 35 days, with 10 days for epididymal transport (Pitcher, 1997). Thus 45 days are required from the start of production to ejaculation of sperm. Sperm abnormalities in the ejaculate typically take 14 days to appear due to the time required for sperm that are formed at the time of the stress or injury to travel to the tail of the epididymis where they are ejaculated (University of Illinois Extension, 2012). After this 14-day delay, the length of time and degree to which abnormalities appear depends upon the severity and length of the stress and which stages of sperm cell development were susceptible to injury. Fertile boars are expected to produce large numbers of spermatozoa that are capable of fertilization.

**Nutrition**

Nutrition of the boar is often given little attention, but deficiencies or excessive allowances for various nutrients can result in suboptimal reproductive performance, including reduced boar libido, lower sperm production, and poor semen quality (Whitney and Baidoo, 2012). Factors affecting nutrient requirements include age and stage of maturity, body condition, environmental conditions, and ejaculation frequency ((Whitney and Baidoo, 2012). Goals of the boar feeding program differ based on whether the boar is used for natural or artificial insemination. Reproduction functions in young animals appear to be more susceptible to dietary restrictions of energy and protein than in the adult and severe feed restriction may even result in permanent damage to gonadal and neural tissue (Brown, 1994). Restricted feed intake in
adult animals can reduce androgen secretion and semen quality; the effects are temporary as re-feeding previously underfed adult animals usually restores reproductive function. Some nutritional responses imposed on animals can alter volume of ejaculates and androgen activity without necessarily affecting spermatogenesis. Therefore, certain constituents of the diet can differentially affect the production and/or the release of LH and FSH (Brown, 1994).

Prolonged periods of under-nutrition reduce the total number sperm produced. In most of the situations where nutrition limited spermatogenesis, the magnitude of the protein and energy deficiencies were about 20 to 25% and the period over which the restriction occurred was at least 6 to 8 weeks (Flowers, 1997). A common practice in boar management is to limit-feed young, sexually mature boars in order to limit their weight gain. This increases the usefulness of the boar in that he can be used to breed gilts and small sows for a longer period of time. This practice may continue throughout the 12 to 18 month period that the boar is used for breeding or longer. Based on the results of nutritional restriction studies, this practice could be viewed as a mild form of long-term, underfeeding of a young growing boar. Whether or not it is sufficient to influence sperm production has not been investigated extensively, especially in modern, lean genotypes that tend to mature, physiologically, at advanced ages. This practice may need to be re-examined to assess its effects. Spermatogenesis requires between 50 to 60 days in boars, sperm numbers and morphology would not be expected to immediately reflect nutritional deficiencies. Therefore, a problem could remain undetected for several months. In most of the nutritional restriction studies, reductions in boar libido and mating behaviours occurred earlier than any observed changes in sperm production (Flowers, 1997). This is because the physical act of mating requires a significant expenditure of energy. Therefore, changes in normal mating behaviours probably could be used as an early indicator of subsequent problems in sperm production due to nutritional deficiencies in boars. There is little evidence to support an over-supply of nutrients beyond maintenance and moderate growth to achieve an improvement on sperm production or quality (Wilson et al., 2004).

Supplementation of boars with dietary fish oils, rich in long chain n-3 fatty acids, did not influence semen production or quality post-ejaculation (Castellano et al., 2010). Research on minerals for breeding boars is limited (Mahan et al., 2002). The macro-mineral requirements, except for Ca and P, would be expected to be similar to those of gilts or barrows when expressed on a body lean basis. The need for micro-minerals for the development and function of the cells of the testis are unknown. Several micro-minerals are needed for hormone production, whereas others play a role in the structure of the sperm and cells of the testis. The only micro-minerals that have been investigated in the boar are Se and Zn, and both have demonstrated functions that are unique for the male (Mahan et al., 2002). The use of organic minerals in boars may be desirable because of their potentially higher availability and lower interference with other minerals prior to absorption. One study with a combination of organic minerals has implied a benefit in improving semen quality and sperm production.

Improvements in sperm production, sperm morphology and fertility for boars fed diets supplemented with the traditional, inorganic source (sodium selenite) and organic of selenium have been reported (Estienne et al., 2008). Therefore, the use of selenium in boar diets may result in greater conception and farrowing rates in swine operations employing AI. Thongchalam et al. (2012) reported that the source of selenium (organic or inorganic) had no effect on whole semen selenium concentration, semen volumes per ejaculate and sperm concentration. The transfer of vitamins from blood to seminal plasma is limited. Dietary supplements of water-soluble and fat-soluble vitamins may increase semen production during intensive semen collection (Audet et al., 2004). Proper feeding program management can significantly improve leg and structural soundness, and improve overall longevity. Taking into consideration the unique nutrient needs of the adult working boar can provide improvements in efficiencies and economic dividends to the entire breeding herd. Feeding any mycotoxin contaminated products is a serious health risk to pigs. There is little research done regarding mycotoxicity in boars, but the general physiological stress that mycotoxins can cause the reproductive system can affect the overall quality and quantity of the
ejaculate (ReproQuest, 2010). Mycotoxin related symptoms for an ejaculate are poor motility, non motile, straight tailed cells, increase in sperm cell clumping and increase in cellular debris (ReproQuest, 2010).

**Temperature**

There are marked seasonal effects on the reproductive physiology of boars in terms of both sperm production and libido (Mackinnon, 2009). Exposure to elevated ambient temperatures has immediate, severe and consistent effects on spermatogenesis (Flowers, 1997). These include ejaculation of a large proportion of spermatozoa with morphological abnormalities, decreased sperm numbers and reduced fertility. Heat stress has deleterious effect on spermatogenesis and sperm motility (Mackinnon, 2009). Heat stress resulted in a decrease in plasma testosterone concentration, which caused suppression in spermatic maturation and boar to exhibit less courting behavior (Wetterman and Desjardins, 1979; Winfield et al., 1981). High temperatures during hot months may result in lower feed consumption and create stresses that result in the inhibition of spermatogenesis (Kunvongkrit, 2005). Boars exposed to at least 3 days with temperatures greater than 30°C should be considered as being "at risk" of experiencing the negative consequences of heat stress. A boar's ability to dissipate body heat is influenced by both the ambient temperature and humidity. Consequently, a heat index probably is a more accurate way to monitor the climatic environment for boars. At 25°C within a pen, if the humidity is greater than 90%, then the boar's body may actually react like it is being exposed to temperatures greater than 30°C. The best management strategy to minimize the negative influence of heat stress on spermatogenesis is to design the pens to maintain ambient temperature between 18-25°C. Some studies have examined alterations in sperm output from boars exposed for extended time periods to temperatures in the upper range of their thermal comfort zone, 26 – 29°C. Within this temperature range, a significant increase in the number of ejaculates that were rejected due to poor quality and a corresponding decrease in the number of insemination doses per ejaculate were observed. The downward trend in the number of doses per ejaculate began five to six weeks after the weekly high temperatures stabilized at 27.5°C. Evaporative cooling systems built into boar accommodation are often used to reduce fluctuations in both temperature and humidity during the hot and humid months seen in tropical countries (Kunvongkrit, 2005). The system has become popular in AI boar studs, where it is reported to reduce stress and improve feed consumption. A housing system, called an evaporative cooling system (EVAP) or tunnel ventilation, has been introduced to improve the microclimate for livestock production in regions with hot climate. The EVAP system is a closed housing system, which aims to reduce the temperature via humidification process. There was a higher diurnal variation and range over the year for both temperature and humidity in the conventional housing system (CONV) system compared to the EVAP system. The average maximum temperature was lower and the average minimum humidity was higher in the EVAP system, than in the CONV system (Einarsson, 2008). Chiang and Hsia (2005) reported that total semen volume, density of sperm, total sperm per ejaculate, sperm motility and morphological abnormality were better for boars raised in wet pad and forced ventilation than for conventional open design house. In most studies, an increased proportion of abnormal spermatozoa have been found after heat treatment, but the results vary among boars, and are also related to the different regimes for causing heat stress (Wetterman et al., 1976; Larson et al., 1984). This indicates that the stress, imposed by elevated ambient temperature, may not be of the same magnitude for all boars.

**Housing and Social Comfort**

The boar should be provided with a comfortable accommodation, with adequate space to feed, sleep and exercise (The Pig Site, 2006). The pen should be free of obstructions and the area should be well lit to allow for easy observation. The floor surface should neither be rough nor slippery. The floor should be hard and well finished for the comfort of the boar. When the pen is used to house the boar and doubles as a service area, during mating if the floor surface is slippery, a sow may have difficulty standing for the boar. She could easily slip causing severe injury to herself or to the boar. When a boar mounts a sow, his hind feet are often placed level with or in front of the sow’s feet. As he thrusts, he gains leverage from his feet. If he happens to slip, he could easily injure himself. During ejaculation the boar is immobile but if
the floor is slippery, he may fail to complete the service and become frustrated. Providing a service area covered with litter/bedding material provides excellent mating conditions. The pen should provide a microclimate (temperature, lighting, humidity, ventilation) that enhances the productivity of the boar. Libido and ejaculate volumes are lower in boars raised in physical isolation from other males or females. Research has shown that up to about 30 weeks of age, young boars need contact, particularly physical contact, with other pigs in order to develop high serving performance (The Pig Site, 2006). After puberty, it is important to house boars near female pigs to maintain courting and mating behaviour. The females can be either oestrus or non-oestrus gilts or sows but must be housed next to the boar pen.

References


Flowers B. 2012. Improving boar fertility. Downloaded from the internet on 29/01/2012.


