Swine reproduction for nonswine practitioners
Part 1. Reproductive physiology and management of the breeding herd

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Abstract

In order to gain an understanding of swine reproduction, knowledge of basic physiology and breeding herd management parameters are necessary. Veterinarians need to be familiar with the estrous cycle, estrus synchronization, breeding management, and industry benchmarks. Data and information on when to intervene enables the practitioner to work with producers and managers in order to maintain swine reproduction.

In the past 30 years, swine production systems have hired their own veterinarians and reproductive consultants. Although the commercial swine industry is primarily an integrated system that owns their own sows, boar collection facility, and other facilities involved in housing and breeding of swine, there is a growing population of pastured and niche-market operations requesting expert advice for breeding management of swine. With the majority of veterinary reproductive specialists with a working knowledge of swine being employed by the large swine integrated systems, it can be difficult for clients in these small operations to find a veterinarian to assist with their reproductive needs. This article will describe basic physiology and breeding management strategies to aid a nonswine practitioner to gain a working knowledge of swine reproduction.

Keywords: Pig, reproduction, breeding management

Introduction

In order to begin thinking about the breeding management of swine, review of basic physiology of their hormones and cycles needs to occur. The basic hormone profile is very similar to majority of our other domestic species in that gonadotropin releasing hormone (GnRH) is secreted by the hypothalamus and acts on the pituitary gland. Two gonadotropins, follicle stimulating hormone (FSH) and luteinizing hormone (LH), are released into the blood stream to act on target cells in the gonads.[1] In prepubertal swine, gonadotropin secretion is lower, however it increases dramatically prior to puberty at 6 - 8 months of age (in males and females). Females (gilts) develop a surge center whereas males (boars) maintain a tonic center for secretion of LH. This article will describe estrous cycle of the female initially and then focus on the boar prior to discussing breeding management strategies.

Estrous cycle

Gilts begin to express receptivity to the male (estrus) and cycle regularly every 18 - 21 days after the initiation of puberty.[2] This is caused by the release of FSH to promote follicular development and increasing estradiol concentrations in the circulation. High concentrations of estradiol cause the behavioral and physiological changes associated with estrus: lordosis response, swollen and reddened vulva, vaginal discharge, increase phonation, and motor activity. Estrus is generally exhibited by the female for 2 - 3 days and she is receptive to the boar. Ovulation, in response to the LH surge, will occur ~ 2/3rd of the length of the estrus period. The rising concentrations of estradiol in the blood reach a threshold that triggers a massive release of LH from the pituitary gland near the onset of estrus. This LH surge stimulates ovulation and the follicles rupture and release the ova into the oviducts. Although the timing of ovulation can be relatively variable, on average it occurs 40 hours after the onset of estrus (similar to the 2/3rd time period described above).

Once ovulation has occurred, the ruptured follicle is transformed; granulosa and theca cells that were responsible for secreting hormones to increase estradiol production begin their transformation into small and large luteal cells (luteinization). Corpora lutea that are formed produce progesterone that inhibit FSH and LH secretion from ~ days 4 - 16 of the estrous cycle. If ova are not fertilized during estrus, the uterus secretes prostaglandin $F_{2\alpha}$ to cause luteolysis of corpora lutea. This causes progesterone to decrease rapidly and allows FSH and LH concentrations to increase again to allow follicular growth and return to estrus. If ova are fertilized by mating with a boar, then pregnancy is initiated and prostaglandin $F_{2\alpha}$ is not released. Production of progesterone by the corpora lutea is necessary for maintenance of pregnancy in swine (e.g., CL-dependent). Luteolysis will again occur near parturition to remove the influence of progesterone and allow production of estradiol that will aide in smooth muscle contraction and delivery of piglets.

Estrus management

After the piglets are delivered, the sow will nourish the piglets via lactation. The suckling stimulus of the piglets causes suppression of secretion of FSH and LH. Follicular growth and development to dominant follicles does not occur while the sow is lactating; this species exhibits a 'true lactational anestrus.' When the suckling stimulus is removed at weaning of the piglets, FSH and LH secretion resumes and follicular growth and development occurs rapidly and the sow exhibits signs of estrus.[1,2] In general, sows return to estrus in 4 - 7 days postweaning. This management tools aids swine producers to use this natural event to predict estrus and benchmark weaning-to-estrus intervals as a reproduction parameter. Weaning-to-estrus intervals can be affected by many factors such as genetics, nutrition, parity, litter size, body condition, and lactation length.

Let us explore some of these factors that affect reproductive efficiency in sows. The producer will make choices with respect to particular genetics but knowledge of breeds that have a high maternal line index (MLI) would assist the veterinarian in advising the client. Maternal breeds used in the swine industry are typically Landrace, Yorkshire, Large White and synthetic crossbreds unique to each genetic company. The maternal line index does place more emphasis on reproductive traits such as days from weaning to estrus, number born alive, number weaned, litter weight adjusted to 21 days, and litter birth weight.[3]

Nutrition of the modern gilt and sow is an intricate science. Rations are balanced for essential amino acids, protein, carbohydrates, and vitamins/minerals. Feeding according to the Nutrient Requirements of Swine,[4] may not always truly meet the needs of current genetics as some maternal lines grow at different rates and definitely produce variable quantities of milk during lactation. This could also be dependent on their age, number of piglets nursing, and number of previous litters. Gilts are still growing during their first farrowing and subsequent lactation. Even a reasonable number of piglets (n = 10 - 12) nursing a gilt can affect her ability to maintain an appropriate body condition score and return to estrus. If a female begins to break down her own fat stores to maintain normal metabolic needs and additional demands (lactation), she will not be able to produce the hormones necessary for her to return to cyclicity (e.g., progesterone and estrogen). Therefore, she will not return to estrus in the appropriate time and will negatively affect weaning-to-estrus interval. For swine producers, this increases nonproductive sow days (days when a female pig is not gestating or lactating) and increases the cost of maintaining that female in the breeding herd.

In the previous paragraph, a reasonable number of piglets nursing was defined as 10 - 12. This is a number that many producers try to maintain on a gilt to ensure proper nutrition for the piglets and less demands on the growing female. The swine industry has, however, selected gilts to be able to farrow a litter size much larger than this. The target values for number of pigs per sow per year have increased significantly over the past 10-15 years.[5] Producers strive to have up to 20.3 pigs born alive per farrowing. This could mean up to 40 piglets produced per sow per year since sows can have up to 2.2 3- 2. litters per year! Gilts would obviously not start this high but could relatively quickly produce these many piglets on the second farrowing and increase her metabolic demands and, therefore, affect her ability to return to estrus and be a productive female in the breeding herd.

Induction of estrus and ovulation

With metabolic demands and other stressors affecting WSI and nonproductive sow days, the industry needs to utilize techniques to induce estrus. Estrus induction methods and medications in swine are described.[6] Briefly, the modern swine producers use weaning management in sows and estrus synchronization via feeding altrenogest in gilts and sows. Altrenogest (Matrix®; Merck Animal Health distributed by Intervet American Inc., Millsboro, DE) is a synthetic progestogen that is fed at a rate of 15 - 20 mg/gilt/day for 5 - 14 consecutive days (at least 14 days in gilts). Females exhibit behavioral estrus in 5 - 7 days after the last feeding of altrenogest.[7] Additionally, they have utilized GnRH analogues/agonists to stimulate ovulation.[8] Triptorelin acetate (Ovugel®; JBS United Animal Health; Sheridan, IN), a GnRH agonist, is given intravaginally to sows 96 hours postweaning. Sow is then inseminated ~ 24 hours (fixed time insemination) posttreatment. These techniques had no negative effects on pregnancy rate (target of > 85%) or litter size when inseminated with good quality semen either artificially or natural service.[8] Therefore, reproductive capacity of the boar used for insemination has to be managed appropriately.

Boar reproductive physiology

As stated previously, boars will reach puberty at ~ 6 - 8 months. They should have the capacity to produce sperm at the threshold number to successfully impregnate a female pig.[9] The frequency and amplitude of production of GnRH postpuberty is relatively steady and release of FSH and LH occur in a routine pattern (i.e., no surge of either gonadotropin). Regulation of Sertoli cells is affected by FSH and supports spermatogenesis. Leydig cells produce testosterone in response to LH and causes masculinization and behavioral signs of the boar. Additionally, testosterone supports sperm production and accessory sex gland secretions. It is important to remember that boars produce pheromones (3α-androstenol and 5α-androstenone) in their saliva that stimulate female pigs in estrus to exhibit sexual receptivity.

Postpubertal boars have the capacity to produce billions of sperm ($40 - 60 \times 10^9$) in their ejaculate per day.[1] When evaluated and processed, traditional doses of semen contain 3×10^9 in 80 - 100 ml of extender. Modern research and field investigations have reduced the number of sperm used for insemination to $\sim 1 \times 10^9$; however, an advanced technique for performing artificial insemination has to be utililized.[6]

Semen collection from postpubertal boars can be accomplished by training them to mount a female pig in estrus or a mounting phantom. Breeding is a learned skill; boars learn by watching other boars perform the task and then they can mimic these actions. When training boars for semen collection, patience is necessary. They need to be allowed to be curious and investigate the collection area prior to beginning the process. Once stimulated, boars will mount the phantom and begin thrusting and exteriorize the penis.[10] If this does not occur, the collector can assist by massaging the prepuce of the boar. Once the penis is visualized outside of the prepuce, the collector can grasp the glans penis and apply digital pressure. If the pressure is applied properly, the boar's penis will be extended fully and thrusting is discontinued. Ejaculation will generally begin within a short interval and semen is collected in an insulated container. This is performed using the 'gloved-hand technique' to minimize semen contamination.

Semen evaluation can be performed on the ejaculate when used for breeding via artificial insemination. It can be difficult to collect postbreeding in females even though there is some retrograde loss of sperm. Ejaculate should be opaque (whitish) and has a creamy consistency. Raw motility is examined using a warmed slide and viewed using a 10 x objective on a microscope. Most modern swine producers will evaluate semen using a computer automated semen analysis system validated for boar sperm. Due to the volume of boars being collected on a daily basis, this allows the facility to be efficient and objective in examining ejaculates. On farm evaluation of a boar ejaculate allows the producer to visualize sperm motility and relative concentration, depending on usage of benchtop equipment that has been validated for evaluation of boar sperm. Assessment of sperm morphology is generally not performed on every ejaculate; however, a sample is generally saved in formalin for later examination and determination of normal and abnormal sperm. A normal ejaculate will have > 80% motility and < 25% abnormal morphology.

Breeding Management

The majority of gilts and sows are artificially inseminated (AI) with multiple doses (services) of extended boar sperm based on estrus detection and to some degree estrus synchronization. The commercial swine industry still utilizes the principles of breeding to maximize production parameters and uses cross-breeding systems to increase heterosis. This generally consists of making a crossbred F1 female (most commonly a Yorkshire x Landrace female) bred to a terminal line (Hampshire, Duroc, or crossbred) boar. Purebred and breeding stock producers can also take advantage of breeding 2 maternal lines but will stay within the confines of particular breeds. Doses of semen are color coated by breed or genetic line when delivered to the farm. Producers use production data to determine the mating and the timing is controlled by estrus synchronization methods.

Most gilts are in estrus for ~ 2 - 3 days. Sows can express signs of estrus earlier than the expected 4 - 7 days postweaning and remain receptive to the boar for longer than 3 days. Breeding managers will begin exposing a sow to a boar within a few days postweaning to determine sexual receptivity; they will apply back pressure and see if the sow responds with a lordosis posture. If she 'stands or locks up', then she can be artificially inseminated. Female will undergo estrus detection daily (once or twice depending on the management's schedule) and insemination with at least 2 doses of extended boar semen. It can be difficult to predict when ovulation will occur even though it is estimated to occur ~ 40 hours after the onset of estrus. Gilts or sows are generally inseminated prior to ovulation, if bred multiple times during expression of estrus. This will ensure a high pregnancy rate and litter size. Although there are many other factors that affect these production parameters, breeding at the correct period should increase the chances that the gilt or sow will become pregnant. Number of piglets can be affected by breeding timing (breeding too late can decrease litter size) and semen quality.

Some producers may need to perform natural mating as they are unable to perform estrus detection well in their management system (e.g., small scale or niche pasture producers). The natural sexual behavior of the breeding pair is critical to the success of this mating method. If either the gilt/sow or the boar does not behave properly, breeding will fail and pregnancy will not occur. Small scale and niche market producers want to utilize advanced breeding management techniques like pharmaceutical-induced estrus synchronization and artificial insemination. However, they may not be able to incorporate these technologies into their breeding management system based on inadequate facilities, time to commit to estrus detection, and knowledge of performing AI. This may then be referred to a theriogenologist or large animal veterinarian in the immediate geographical area.

Conclusion

Reviewing female and male reproductive physiology should increase the working knowledge of postpuberty swine behavior. Having knowledge of their behavior and proper timing of events should increase success in breeding management of swine. Commercial swine integrated production systems utilize these strategies on a daily basis to maintain a high level of productivity in their breeding herds. Veterinarians not involved in these systems routinely may not be up-to-date on current swine breeding management; however, they may need to answer questions or assist local clients with appropriate strategies.

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