Virginia Cooperative Extension

2005 PUBLICATION 414-038

Using Artificial Insemination in Swine Production:

Detecting and Synchronizing Estrus and Using Proper Insemination Technique

Mark J. Estienne, Swine Research Physiologist, Department of Animal and Poultry Sciences, Tidewater Agricultural Research and Extension Center

Allen F. Harper, Extension Specialist, Department of Animal and Poultry Sciences, Tidewater Agricultural Research and Extension Center

Introduction

In the United States, the proportion of sows bred via artificial insemination (AI) increased from less than 8 percent in 1991 to nearly 70 percent in 2000. AI offers numerous advantages over natural mating. Once collected, a boar ejaculate can be diluted in a semen extender, creating multiple insemination doses that can be used to breed several sows and gilts. This allows more extensive use of genetically superior boars, increasing the rate of genetic improvement within a herd. Fewer boars are necessary on a farm employing AI, and as a consequence, feed, veterinary, and housing costs are reduced. With AI, new genetics can be introduced into a herd with decreased health risks. Finally, use of AI saves time and labor in the breeding barn.

An AI program can be divided into the following major processes: semen collection, evaluation, and processing; detection of estrus; and insemination. This publication discusses the detection and synchronization of estrus and the proper insemination technique.

Reproductive Physiology of Female Swine

To effectively detect estrus (heat) and successfully employ methods of estrus synchronization, the producer must have a basic understanding of the anatomy and reproductive physiology of sows and gilts. Figures 1 through 3 illustrate the endocrine system and anatomy that affect estrus. Estrus begins with the pituitary gland, which is located just below the brain and secretes several hormones into the blood stream, including *luteinizing hormone (LH)* and *follicle-stimulating hormone (FSH)*. LH and FSH are called *gonadotropins*.

In prepubertal (immature) gilts, gonadotropin secretion is low but dramatically increases just prior to puberty (first estrus) at 6 to 8 months of age. During the two- to three-day period just prior to estrus, increasing blood levels of LH and FSH cause the follicles on each of the two ovaries to grow rapidly. These follicles in turn secrete increased levels of the hormone *estradiol*

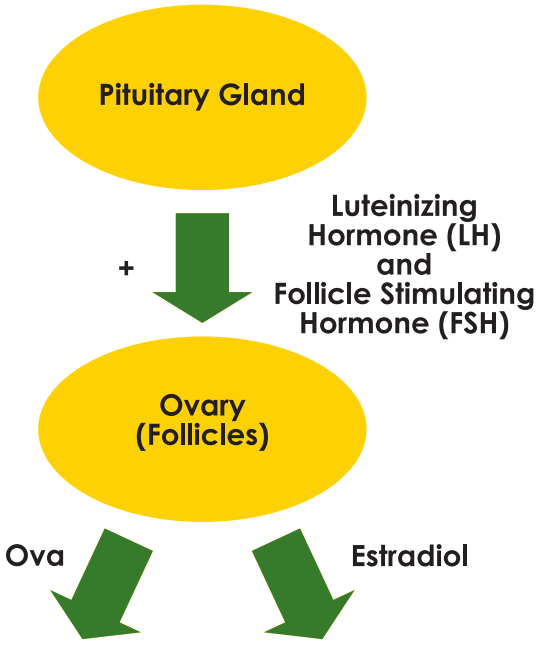


Figure 1. Control of the ovary by the pituitary gland in swine.

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

www.ext.vt.edu

Produced by Agriculture and Extension Communications, Virginia Tech

VT/190/0605/500/252561/414038

VIRGINIA STATE UNIVERSITY

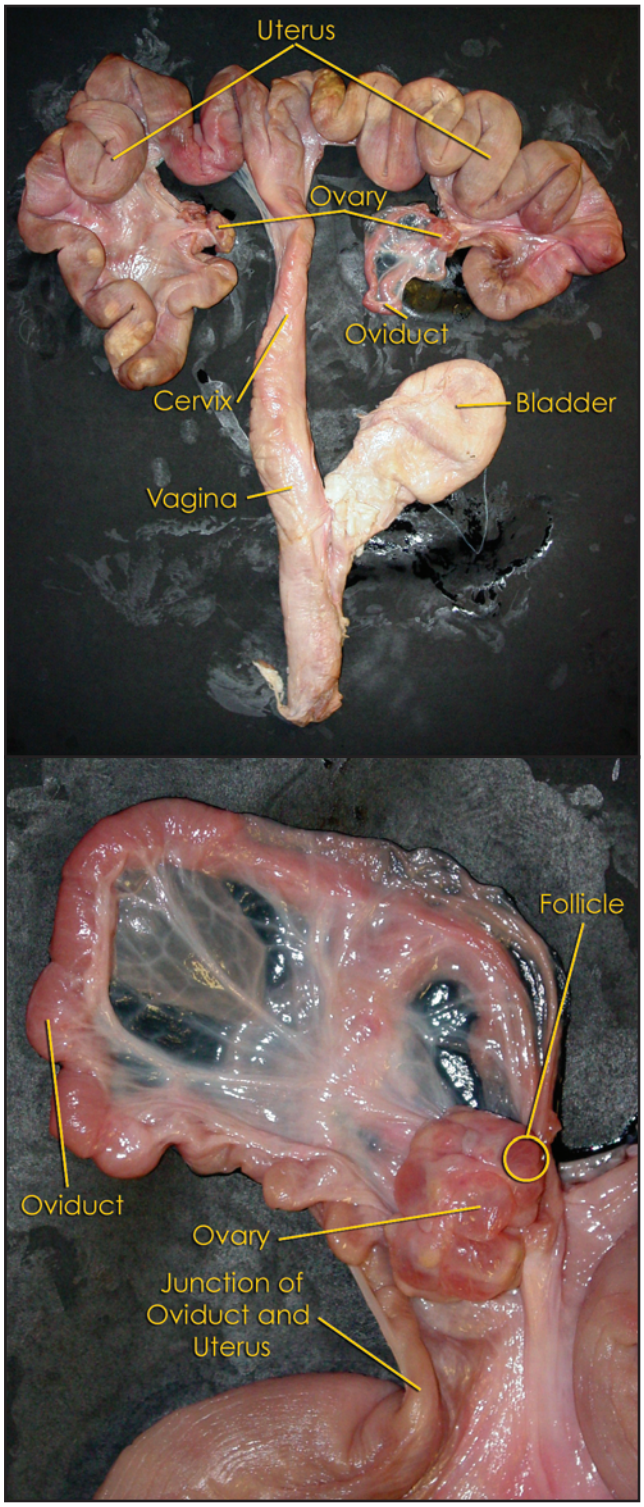


Figure 2. Female reproductive anatomy.

into the blood, causing the behavioral and physiological changes associated with estrus. Moreover, each follicle contains an ovum, which when released and fertilized by a sperm cell, develops into an embryo.

Rising concentrations of estradiol in the blood reach a threshold which triggers a massive release of LH from the pituitary gland around the onset of estrus. This LH

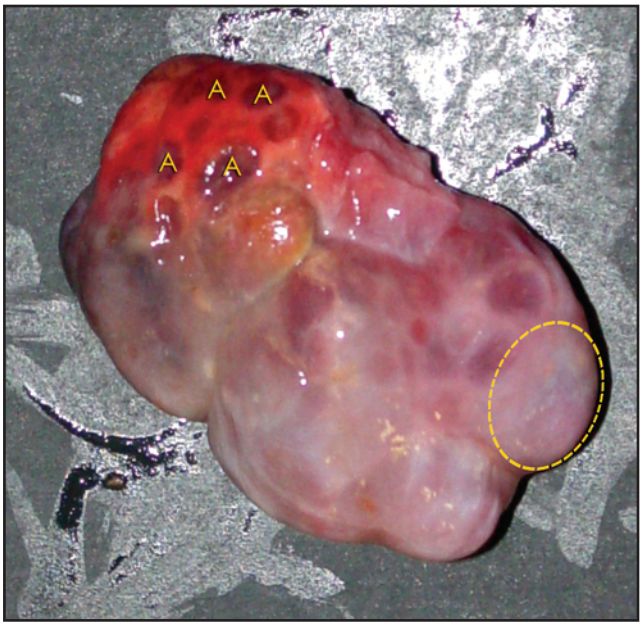


Figure 3. The ovary of gilt showing *corpora lutea* and small follicles. An individual *corpus luteum* is outlined by dashed lines and follicles are indicated by "A"

surge stimulates ovulation, the release of ova from the follicles into the oviducts. Though the timing of ovulation is extremely variable, on average it occurs 40 hours after the onset of estrus. The sperm cells fertilize the ova in the oviducts, the tubes between the ovaries and the horns of the uterus. The fertilized eggs then progress to the uterus, implant, and further develop into embryos and then fetuses.

The sites on the ovaries from which ova are released subsequently form structures called *corpora lutea* that secrete another hormone, *progesterone*, into the blood. During the luteal phase of the estrous cycle (approximately day 4 to day 16), progesterone inhibits LH and FSH secretion from the pituitary gland, inhibiting follicular growth.

If the ova are not fertilized during estrus, or embryos do not implant in the uterus then beginning around day 16 the uterus secrets the hormone *prostaglandin-$F_{2\infty}$ ($PGF_{2\infty}$)* into the blood. $PGF_{2\infty}$ causes the regression or death of the *corpora lutea* and as a result, progesterone levels decline. Decreasing levels of progesterone allow LH and FSH levels to increase, follicles to grow, and estrus returns. Female swine display estrus at 18- to 22-day intervals throughout the year unless their cycling is interrupted by pregnancy and lactation, poor nutrition, disease, etc.

If fertilization occurs and pregnancy is initiated, then $PGF_{2\infty}$ is not released into the circulation. The *corpora lutea* are maintained and secrete high levels of progesterone

into the blood stream throughout gestation. Progesterone is essential for maintenance of pregnancy. It inhibits follicular growth as well as uterine contractions.

Around day 114 of gestation, the uterus causes the *corpora lutea* to regress by releasing large amounts of $PGF_{2\infty}$ into the blood. Consequently, progesterone levels decrease, uterine contractions commence, and the fetuses are expelled.

During lactation, suckling by the pigs causes a suppression of LH and FSH secretion, keeping the ovaries devoid of large follicles. The removal of the suckling stimulus at weaning allows the secretion of gonadotropin to increase. Follicles grow rapidly and there is the corresponding rise in the circulating levels of estradiol. Sows return to estrus in four to seven days and estradiol elicits the surge of LH, causing ovulation.

Detecting Estrus

One of the most critical components of a successful AI program is accurately detecting estrus. The duration of estrus is variable, but gilts average 38 hours and sows average 53 hours. In response to high concentrations of estradiol in the blood, all or some of the following signs may be exhibited by a sow or gilt approaching or in estrus:

a) red, swollen vulva and enlarged clitoris,
b) mucous discharge from the vulva,
c) nervous, restless behavior,
d) moving back and forth along pen partitions,
e) frequent urination,
f) increased vocalization,
g) decreased appetite,
h) mounting other females and/or standing to be mounted by other females, and
i) elevation of ears (pinning ears), locking knees and elevating the back (immobilization or lordosis response).

The immobilization response is the best indicator that female swine are in estrus and ready to be mated. Sows and gilts in estrus exhibit the immobilization response as a reaction to a combination of visual (sight), auditory (sound), olfactory (smell) and tactile (touch) stimuli originating from the boar. Obviously, the most effective estrus detection system is one that employs all of these stimuli. Thus, wherever possible, producers should place a mature (at least 12 months of age) estrus detection or "heat-check" boar in physical contact with the sows or gilts being checked for estrus.

Females should be checked for estrus once or twice (as close as possible to 12-hour intervals) daily. An advantage of twice-daily estrus checks is that the onset of estrus can be more accurately determined. In the morning, estrus checks should occur before or at least one hour after feeding. During estrus checks, allow each female several minutes of direct boar exposure and closely observe the animals for the signs mentioned above.

Maintaining the immobilization response requires considerable energy expenditure. If a female in estrus becomes fatigued, she may become refractory (unresponsive) to boar exposure and not resume an immobilization response for several hours. Thus, boar exposure during estrus checking should be restricted to small groups of females. When not checking for estrus, housing boars away from the females greatly increases the likelihood that sows and gilts in estrus will display the immobilization response when exposed to the boar during the estrus check.

In many breeding barns, sows and gilts are housed in crates, and it probably is not feasible to allow each female direct, physical contact with the boar. For sows and gilts in crates, slowly moving a boar in front of the females while a second herdsman applies back pressure can be an effective method of detecting estrus. Crated sows that are in estrus will move forward and assume the immobilization response. When pressure is applied to the back, sows in estrus will push back. In essence, they are preparing themselves to be mounted by the boar. If pressure is applied to the back and the sow is not in estrus, she will move in an attempt to escape.

Synchronizing Estrus in Female Swine

AI facilitates the mating of large groups of females that may be in estrus at the same time. Thus, methods for synchronizing estrus and the use of AI compliment one another. Following is a discussion of techniques for synchronizing estrus in sows and gilts, including techniques that employ hormonal products that are approved for use in swine by the U.S. Food and Drug Administration. These hormonal methods are depicted in Figure 4.

Weaned sows. Group weaning serves as an effective tool for synchronizing estrus since sows in good body condition whose sucklings are weaned after a two- to four-week lactation generally display estrus in four to seven days.

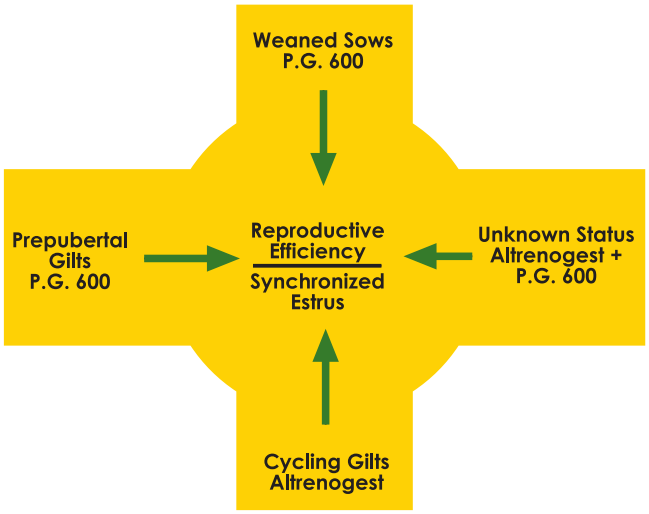


Figure 4. Hormonal products used for synchronizing estrus in swine.

As previously mentioned, weaning of pigs usually causes an increase in the amounts of LH and FSH released by the sow's pituitary gland which then causes the growth of ovarian follicles, estrus, and ovulation. However, in some sows, particularly those weaned in the summer and/or those that are in poor body condition and have displayed poor appetite during lactation, this hormonal system becomes dysfunctional. When the pigs are removed, the increased secretion of LH and FSH necessary to cause follicular growth and estradiol production is delayed or does not occur at all. As a consequence, after pig weaning, sows do not come back into estrus or their return to estrus is delayed.

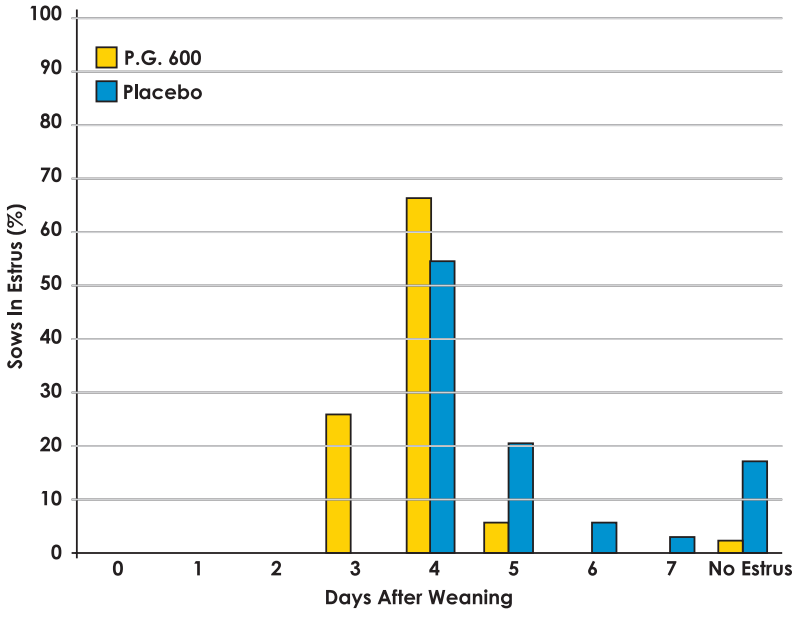
P.G. 600, a drug marketed by Intervet Inc. (Millsboro, Del.), can be used to hasten the onset of estrus in "weaned sows" (those whose pigs have been weaned). P.G. 600, which costs approximately $4.50 per dose, contains 400 IU of *pregnant mare serum gonadotropin (PMSG)* and 200 IU of *human chorionic gonadotropin (HCG)*, hormones that mimic the actions of FSH and LH, respectively. Thus, when P.G. 600 is properly administered to weaned sows, follicular growth is advanced. Estrus and ovulation follow.

Figure 5 depicts the onset of estrus in a group of 70 Yorkshire sows (average parity was 4.6) that were weaned in the summer after a 28-day lactation period. In this experiment, half of the sows received P.G. 600 intramuscularly (i.m.) at weaning and the other half received an i.m. injection of a placebo. The weaning-to-estrus interval (3.8 vs. 4.5 days) and the percentage of sows that did not display estrus in seven or fewer days after weaning (2.9 percent vs. 17.1 percent) were significantly decreased by P.G. 600 compared with controls. Subsequent litter size was similar between groups.

Rather than treating all sows with P.G. 600 at weaning, producers should consider treating only sows at risk for a delayed return to estrus. At-risk females include first and second parity sows, sows in poor body condition, etc.

Another alternative to injecting all weaned sows with P.G. 600 is to wean sows, check them for estrus daily, and breed sows that return to estrus on their own. Administer P.G. 600 to sows that have not displayed estrus by day 7 post-weaning. These animals should return to estrus within five days after treatment and can be inseminated. With this system, only sows experiencing a delayed return to estrus are treated with P.G. 600.

Figure 5. The onset of estrus in Yorkshire sows that were weaned in the summer after a 28-day lactation period. Sows were administered P.G. 600 i.m. (n = 35 sows) or placebo (n = 35 sows) at weaning. Note that sows treated with P.G. 600 returned to estrus sooner than sows injected with a placebo. Also, the percentage of sows that did not display estrus in seven or fewer days after weaning was significantly decreased by P.G. 600 compared with placebo injections. Subsequent litter size was similar between groups.



Prepubertal gilts. The transport effect and the boar effect are two management practices that can be employed to cause a synchronous estrus in prepubertal gilts. Transportation to a new facility or a new location within a facility, usually in concert with the mixing of animals between pens, can cause a synchronous estrus in 15 percent to 30 percent of gilts that are nearing the normal age of puberty. Exposing gilts that are nearing puberty to a mature boar can cause estrus in 30 percent to 90 percent of the gilts in three to seven days. Many breeding-herd managers use the transport and boar effects in conjunction with one another.

P.G. 600, administered to prepubertal gilts that are at least 5.5 months of age and weigh at least 185 pounds, has effectively induced a synchronous estrus. In an experiment conducted at the Tidewater Agricultural Research and Extension Center (TAREC) in Suffolk, 42 prepubertal, Landrace x Yorkshire gilts received an i.m. injection of P.G. 600 and were checked for estrus daily in the presence of a mature boar. Eighty-three percent of the gilts (35/42) displayed estrus in less than seven days after injection. In these gilts, the average interval from treatment to estrus was 4.3 days. Figure 6 displays the degree to which estrus was synchronized following P.G. 600 treatment.

In this study, gilts were not mated. It is noteworthy that the gilts generally displayed normal estrus cycles following the induction of puberty with P.G. 600. Indeed, of the gilts that originally responded to P.G. 600, 97.1 percent (34/35) displayed a second and 94.3 percent (33/35) a third estrus. In many herds, gilts are bred during the second or third postpubertal estrus in order to maximize the number of ovulations and thus increase potential litter size. P.G. 600 potentially could be used to synchronize a group of gilts for subsequent breeding at the second or third estrus after treatment. However, as shown in Figure 6, the tightness or synchrony of estrus among gilts decreased with time after P.G. 600 treatment.

Randomly cycling gilts and sows. First, it is important to note that P.G. 600 will stimulate estrus in weaned sows and prepubertal gilts but not in mature gilts or sows that are displaying estrous cycles. Therefore, P.G. 600 cannot be used to synchronize a group of randomly cycling females.

In 2003, the U.S. Food and Drug Administration approved the use of altrenogest for estrus synchronization in mature gilts that have had at least one estrous cycle. A 0.22 percent altrenogest solution for use in swine is marketed by Intervet Inc. under the trade name Matrix. As per the label, Matrix (6.8 mL containing 15 mg altrenogest/gilt) is administered once daily for 14 consecutive days by top-dressing on a portion of each gilt's daily feed. The 14-day treatment costs approximately $22 per head. Gilts must not be slaughtered for human consumption for 21 days after the last treatment.

In a number of experiments conducted worldwide, altrenogest use has successfully synchronized estrus in randomly cycling gilts. To summarize a number of studies, daily feeding of altrenogest (12.5 to 15 mg/day) for 14 to 18 days synchronized estrus in approximately 90 percent of treated gilts. The onset of estrus after withdrawal of altrenogest was reported as four to ten days with most gilts beginning estrus in five to seven days.

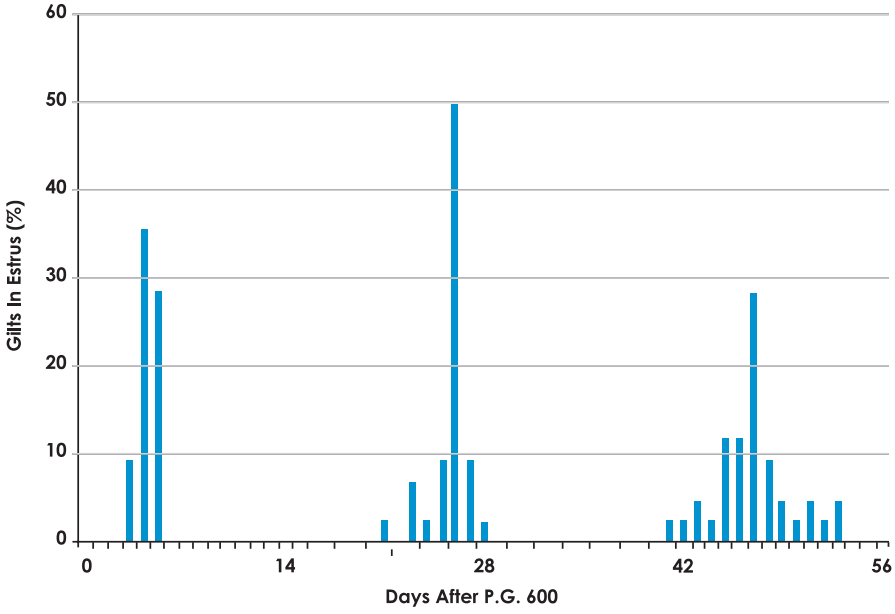


Figure 6. The onset of estrus in prepubertal, Landrace x Yorkshire gilts (n = 42 gilts) injected i.m. with P.G. 600 at day 0. Eighty-three percent of the gilts displayed estrus in less than seven days after injection and the majority of gilts displayed normal estrous cycles after estrus was induced. Note, however, that the synchrony of estrus among gilts was decreased during the second and third estrus periods.

In a study conducted at the TAREC, 32 gilts that had displayed at least two normal estrous cycles of 18 to 22 days were given a daily ration containing 15 mg altrenogest for 18 days. Following withdrawal of altrenogest, 90.6 percent of the gilts displayed estrus in less than seven days with an average withdrawal-to-estrus interval of 5.3 days. Figure 7 shows the synchrony of estrus expression following altrenogest withdrawal. Also depicted is the anticipated occurrence of estrus (based on the cycling history of the gilts) had altrenogest not been included in the feed.

It is important to note that altrenogest will not effectively stimulate estrus in prepubertal gilts. Altrenogest is an orally active progestin and has progesterone-like activity. When altrenogest is fed to a group of cycling gilts, the gonadotropin secretion is suppressed and as a consequence, ovarian follicle growth is blocked. In terms of follicular development, ovaries remain in an essentially quiescent state for the duration of altrenogest treatment (usually 14 to 18 days). When altrenogest treatment is stopped, gonadotropin secretion increases and follicular growth ensues. Ultimately, gilts display a synchronized estrus.

One may question why altrenogest must be administered for at least 14 days. This is because mature gilts will probably be randomly cycling and altrenogest feeding may commence when a portion of the gilts are in the luteal phase of the estrous cycle, with *corpora lutea* actively secreting progesterone. As mentioned above, the progesterone inhibits gonadotropin secretion and follicular development. These particular gilts must be given time for the *corpora lutea* to regress naturally. Otherwise, they would not show a synchronized estrus even though altrenogest feeding may have ceased.

Mix of prepubertal and randomly cycling gilts. In breeding operations, it is not uncommon to have groups of replacement gilts that represent a mix of prepubertal and mature, cycling individuals. Moreover, the cycling status of a group of gilts is sometimes unknown. P.G. 600 stimulates the onset of estrus in prepubertal gilts, but does not synchronize estrus in cycling females. On the other hand, altrenogest alone is highly effective in synchronizing estrus in mature, randomly cycling gilts, but is at best marginally effective at stimulating estrus in prepubertal females. Thus, a combination of altrenogest (15 mg/day for 14 days) and P.G. 600 treatments 24 hours following altrenogest withdrawal represents a method of synchronizing estrus in a mix of prepubertal and mature gilts. The use of P.G. 600 will stimulate estrus in prepubertal gilts and the termination of altrenogest therapy will result in estrus in cycling gilts. Moreover, work at the TAREC has consistently shown that P.G. 600, given 24 hours after withdrawal of altrenogest, will increase the ovulation rate in mature, randomly cycling gilts.

Inseminating Females

There are literally dozens of insemination catheters commercially available. However, few research studies have been conducted comparing reproductive performance in sows bred using different types of catheters. Claims that one catheter is better than another are purely speculative. Economics and personal preferences usually dictate which catheter is used on a swine farm. To protect herd health, do not use insemination equipment on more than one female; use disposable AI equipment and one-use-only catheters for insemination.

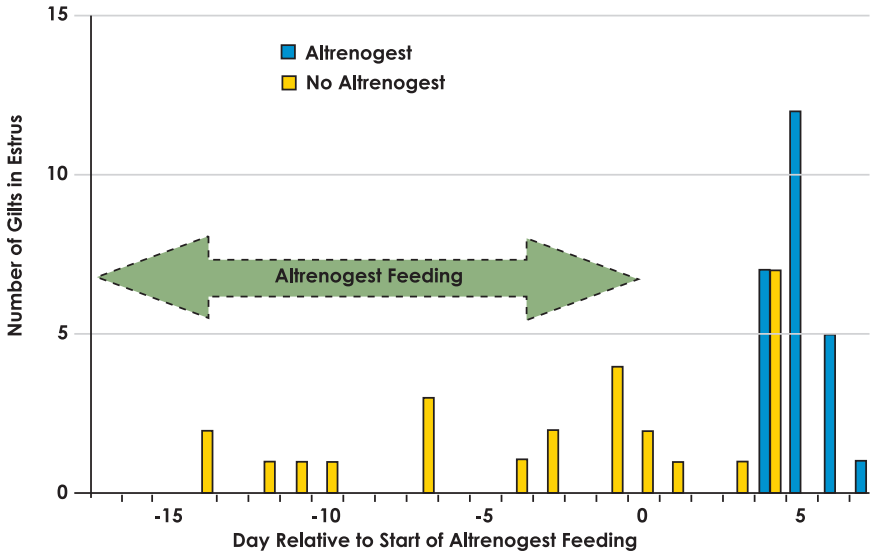


Figure 7. The onset of estrus in crossbred gilts (n = 32 gilts) following withdrawal of altrenogest at day 0. Gilts were fed a daily ration containing 15 mg of altrenogest for 18 days. More than 90 percent of the gilts displayed estrus in less than seven days after altrenogest withdrawal (indicated by the darkened bars). Also depicted is the anticipated occurrence of estrus (open bars; based on the cycling history of the gilts) had altrenogest not been included in the feed.

Prior to the insemination, clean the vulva with a paper towel and coat the tip of the catheter with a non-spermicidal lubricant. Spread the lips of the vulva and insert the breeding catheter. Angle the catheter slightly upward while moving it through the reproductive tract; this helps prevent entry into the urethra, the tube leading to the bladder. Slide the catheter gently through the vagina until you feel resistance, indicating that the catheter has reached the cervix (Figure 8). With spirette-type catheters, turn the instrument counter-clockwise until it locks into the cervix; to remove the spirette, turn it clockwise while gently pulling outward. With foam-tipped catheters, apply firm forward pressure to the catheter until the bulbous tip is locked into the cervix; to remove the bulbous catheter tip, pull it gently outward.

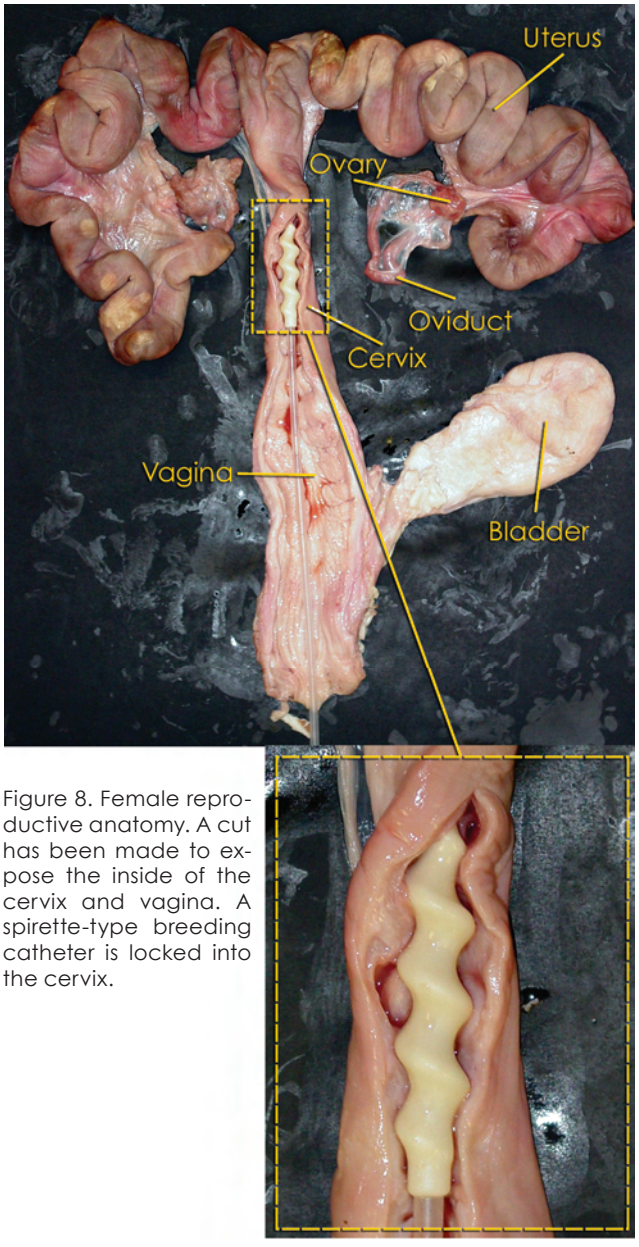


Figure 8. Female reproductive anatomy. A cut has been made to expose the inside of the cervix and vagina. A spirette-type breeding catheter is locked into the cervix.

After gentle mixing the semen and extender, connect the semen bottle, tube, or bag to the open end of the catheter. Dispense the semen by gently squeezing the container over a three- to five-minute period, taking care to avoid excessive back-flow of the extended semen out of the vulva. Occasionally, the tip of the catheter may be locked against cervical tissue blocking the flow of semen. If this happens, reposition the catheter by turning it.

Although it is not necessary for successful AI, in general the insemination process is easier if the female is exhibiting the immobilization response. Therefore, having a boar in an adjacent pen can facilitate AI. Keep in mind, however, that the immobilization response requires considerable energy expenditure and that the female may become fatigued. If large numbers of sows are to be bred, some females may become refractory to the boar stimuli prior to AI.

The presence of the boar during insemination has been reported to cause the sow's pituitary gland to release *oxytocin* into the blood stream. Oxytocin is a protein hormone, and among its effects is the stimulation of muscle contractions of the uterus and oviducts. These contractions will cause the semen to be drawn into the reproductive tract (self insemination) during AI. Self insemination can also be facilitated by the AI technician applying firm back pressure and rubbing the flank or udder of the sow during insemination.

Research conducted at North Carolina State University has demonstrated that an i.m. injection of 5 IU of oxytocin two to three minutes prior to insemination improved farrowing rate and litter size in situations where inexperienced technicians were inseminating females or the semen being used was more than 72 hours old. In these two situations, fewer than the optimum number of viable sperm cells were deposited into the female's reproductive tract and the oxytocin injections probably caused muscle contractions that helped move the sperm cells to the site of fertilization. Two additional situations where insemination doses may contain reduced numbers of motile sperm cells for breeding and where oxytocin treatment may be warranted are: 1) when an effort is being made to increase the number of sows bred to a single boar for multiplication of superior genetics, or 2) when using aged semen due to difficulties in the coordination of semen delivery and the estrus activity of sows.

Research has also shown that the technician doing the AI can dramatically affect the farrowing rates and litter sizes. The AI process is best performed by patient, meticulous individuals. Other research has demonstrated that technicians performing more than ten inseminations before taking a break have farrowing rates that are reduced by 8 percent to 9 percent.

Timing of Inseminations

The success of an AI program is highly dependent on accurate estrus detection. Timing of inseminations is usually based on the time when estrus is first detected. Because farms have extreme variation in duration of sow and gilt estrus, onset of ovulation, duration of ovulation, and the life span of sperm cells and ova, it is very difficult to describe an insemination protocol (number and timing of inseminations) that is suitable for all operations.

In general, the optimal time to inseminate a female is prior to ovulation (0 to 24 hours before ovulation in sows and 0 to 12 hours in gilts). Since producers cannot accurately determine the exact time when a female ovulates, performing at least two inseminations during estrus increases the likelihood that one will occur during the optimum time. Table 1 shows suggested timing for two matings when gilts and sows are checked for estrus once or twice daily. If swine are in standing estrus for three days, there may be some benefit to an additional (third) mating. It is extremely important, however, that females that have gone out of estrus not be inseminated because reproductive performance (conception rates) will be adversely affected.

Table 1. Suggested timing of matings when employing AI.

Frequency of estrus detection	Best time to inseminate relative to the first detection of standing estrus:	
	Gilts	Sows
Once daily	0 and 24 hours	0 and 24 hours
Twice daily (12 hours apart)	12 and 24 hours	24 and 36 hours

Summary

When compared to natural mating, AI offers producers a number of advantages. Benefiting from this technology, however, requires a high level of management and a commitment to performing the necessary procedures correctly. If AI is performed correctly, reproductive performance is equal to or greater than that achieved with natural mating. A critical component of a successful AI program is the ability to accurately detect estrus. The most effective estrus detection system is one that employs a mature estrus-detection or heat-check boar. AI allows the mating of large numbers of females at the same time, and there are a number of effective strategies for synchronizing estrus in swine. Placement of the semen into the female reproductive tract is a relatively simple procedure that can be learned with a minimum of training. Finally, performing at least two matings during estrus increases the likelihood that one of the inseminations will occur during the optimum time (i.e., prior to ovulation).