

## Synchronization of estrus in swine

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### Introduction

Production calendars for most swine farms are based upon the reproductive cycle of sows and gilts. The key reproductive event that determines when females begin their reproductive cycles is the onset of estrus. Estrus normally occurs spontaneously in gilts and mature females that are not pregnant or lactating. Once estrous cycles have begun, they normally occur every 18 to 21 days. From a production standpoint, on any given day, it is difficult to predict or control the number of females in estrus. The ability to precisely control the onset of estrus is referred to as synchronization. Effective management and pharmacological techniques for synchronization of estrus in swine are available. However, strategies that work in prepubertal gilts are not effective in mature females and vice versa.

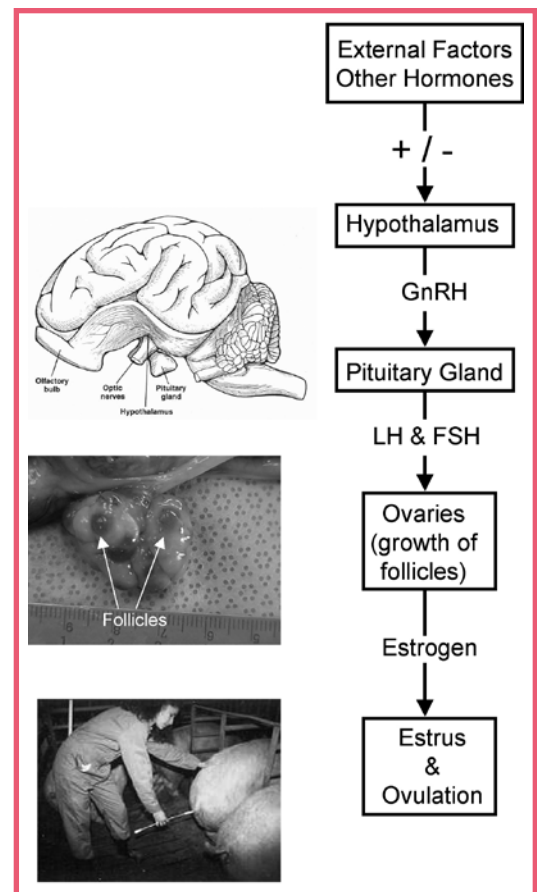
### Objectives

The purpose of this article is to discuss options that are available for estrus synchronization in

- prepubertal gilts,
- mature gilts, and
- weaned sows

### Physiology associated with estrus

Estrus occurs when three organs, the hypothalamus, the pituitary gland, and the ovaries, communicate in a coordinated fashion to produce a group of follicles that produce high levels of estrogen and are ready to ovulate and release eggs (Figure 1). The hypothalamus is located in the brain and receives input from the external environment and from within the animal's own body and translates them into a hormonal signal. The hormone produced by the hypothalamus in response to environmental stimuli is gonadotropin releasing hormone (GnRH). The pituitary gland is located just below the brain and is stimulated by GnRH to produce two hormones, luteinizing hormone (LH) and follicle stimulating hormone



**Figure 1. Schematic diagram of physiology associated with estrus in swine.**

(FSH), collectively referred to as gonadotropins. The pituitary gland basically serves to amplify information processed by the hypothalamus. Small amounts of GnRH secreted by the hypothalamus stimulate the secretion of large amounts of LH and FSH from the pituitary gland. Both LH and FSH cause follicles on the ovaries to increase in size and mature. As follicles mature, they produce estrogen. Estrogen is the hormone responsible for physiological and behavioral changes normally observed in sows and gilts as they approach estrus.

Moderate levels of estrogen stimulate

- increased vocalizations,
- reddening and swelling of the vulva, and
- the secretion of mucus from the vulva that feels "sticky".

High levels of estrogen stimulate

- the standing reflex or immobilization response,
- a surge in LH secretion, and eventually
- ovulation.

Synchronization of estrus involves controlling the time frame over which this sequence of events takes place in a group of females. As a result, strategies that are effective for controlling the onset of estrus manipulate or enhance one or more of these physiological events.

### Synchronization of estrus in prepubertal gilts

The hypothalamus, pituitary gland, and ovaries acquire the ability to function in an adult fashion independently and at different times during sexual maturation. It is believed that the ovary and pituitary gland mature before the hypothalamus. Once each organ has matured fully, there is an additional period of development during which their normal functions become integrated so that they can communicate among themselves as discussed previously (Figure 1). It is during this final stage of sexual maturation that the appropriate use of boar exposure or PG600® (InterVet, Inc., Millsboro, DE) in conjunction with boar exposure can induce a fertile, synchronized estrus. In most genetic lines of gilts, the reproductive organs are mature by 150 to 160 days of age and the final period of maturation during which their functions become integrated occurs between 160 and 180 days of age. Therefore, the best "window of opportunity" for effectively synchronizing estrus in prepubertal gilts is when they are between 160 to 180 days of age.

**Boar exposure.** The sight, sound, smell, and physical presence of the boar are external stimuli that the hypothalami of gilts translate into GnRH secretion, which eventually leads to estrus and ovulation (Figure 2). This is commonly referred to as the "boar effect".

When gilts are exposed to boars between 160 and 180 days of age,

- a typical response is for 70 to 80% of the gilts to exhibit estrus within the next 28 days
- with the largest numbers of gilts showing estrus 10 and 14 days later (Figure 3) [1].

Relocation or mixing of prepubertal gilts is another management strategy that is often used to induce puberty in gilts. Exposure of gilts to a novel environment or a new group of pen mates is believed to have a mildly stimulatory effect on the hypothalamus. A response pattern typical to that observed with boar exposure alone is common when relocation or mixing is done in conjunction with boar exposure. The main difference is that the peak response usually occurs between 2 and 3 days earlier [2]. Relocation and mixing of prepubertal gilts without boar exposure is not an effective strategy for inducing puberty.

When a group of gilts does not respond in this fashion, there are a number of possible reasons, but the most likely explanation is improper or inadequate boar exposure. One of the main components of

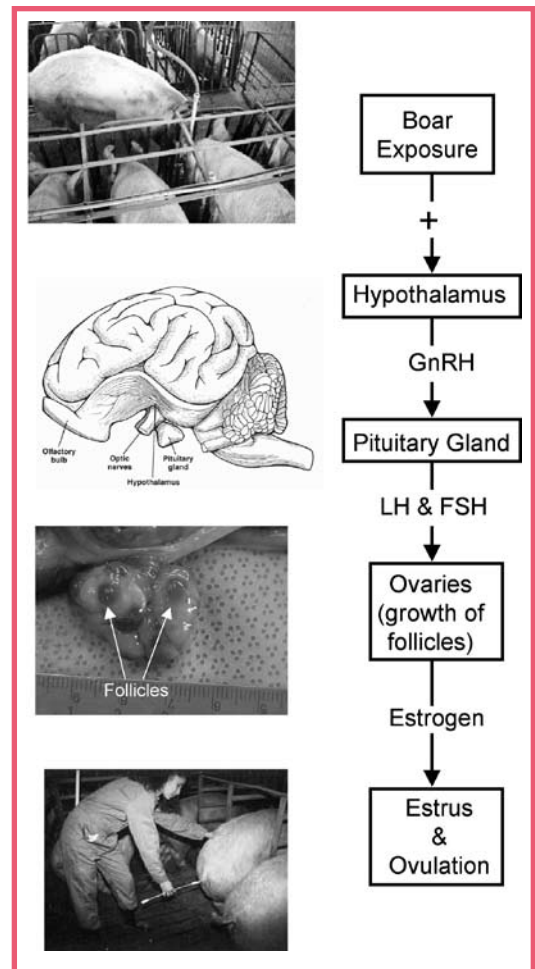
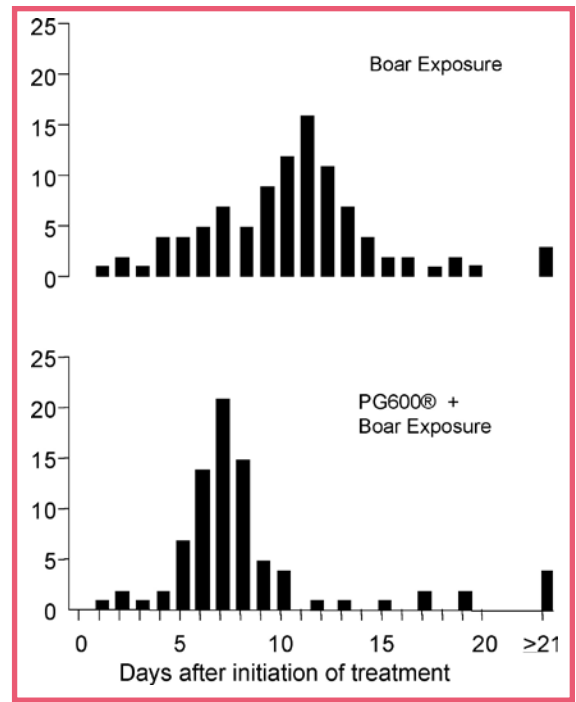


Figure 2. Schematic diagram of the positive effect of boar exposure on prepubertal gilts

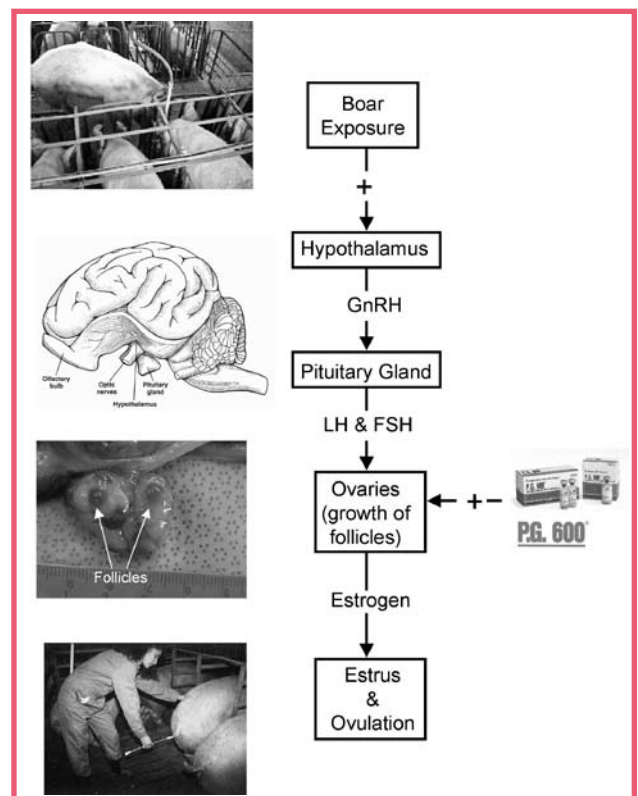
the "boar effect" is the production of pheromones [2]. Pheromones are chemical compounds that are produced in high concentrations in the saliva and urine of boars and emitted into the air. A boar's saliva actually has 20 to 50 times more of the pheromones involved in the boar effect than his urine. Once air-borne, pheromones stimulate the olfactory system of gilts, which leads to an increase in the activity of the hypothalamus and the release of GnRH. Mature boars (> 12 months old) produce large quantities of saliva and urine with high concentrations of pheromones. Consequently, mature boars are the best animals to use for induction or synchronization of estrus in gilts. Young boars (< 10 months of age) are not effective at stimulating estrus in gilts primarily because of reduced pheromone and saliva production [2]. It also has been reported that some mature boars are more effective than others at stimulating puberty in gilts [2]. Definitive reasons for this observed variation among mature boars have yet to be identified. Nevertheless, mature boars that produce large amounts of saliva are likely to be more effective than those that do not. Using several mature boars alternately for detection of estrus in gilts is an another option. In fact, there is some evidence that using more than one boar in a rotational scheme is more effective at inducing a synchronized pubertal estrus than relying on a single individual male.

The frequency and duration of contact between gilts and boars is critical for successful induction or synchronization of estrus. Once started, it is important to provide boar exposure daily and for at least for 5 to 10 minutes per pen or group of females. Situations in which daily exposure is interrupted for as little as two to three days significantly reduce the effectiveness of the boar effect [2]. Conversely, continual exposure resulting from housing mature boars adjacent to gilts also reduces the number of females that show estrus. If boars are being placed in pens with gilts, then it is often necessary for the stock person to encourage the boar to make contact with all the gilts in the pen. Often boars become fixated on one female and spend the majority of their time following her. In contrast, if there are timid gilts in the pen, then they may run away from the boar as he approaches. In either of these situations, boar exposure is not distributed evenly among all the females in the pen and the end result is that estrus is induced in some, but not all gilts. When fence line contact is used, the same problems arise - some gilts may not move to the front of the pen to make contact with the boar or the boar may not spend equal amounts of time checking each pen or crate. In these instances, it may be necessary to restrict the boar's movement to one pen (or groups of 5 to 6 crates) and for the stock person to encourage all the gilts in the pen to move toward the front to make contact with the boar.

It has been well documented that gilts exposed to the sight, sound, smell, and touch of the boar respond better in terms of estrous activity than those subjected to regimens in which one or more of these factors is missing. Consequently, placing boars in pens with gilts where direct contact among animals is possible



**Figure 3. Typical response of prepubertal gilts to boar exposure (top panel) and PG600® + boar exposure [1]. Day 0 represents the first day gilts received either boar exposure or an injection of PG600® and boar exposure. Treatments were initiated when the average age of the gilts was 175 days and the range was 162 to 188 of days age.**



**Figure 4. Schematic diagram of the positive effect of boar exposure and PG600® on prepubertal gilts**

is the most effective way to provide boar exposure [2]. However, fence line contact probably is the most common way prepubertal gilts receive boar exposure on commercial farms. Boar exposure via fence line contact can be very successful for induction of puberty provided that a face-to-face orientation between the boar and gilts is possible and that the boar used spends an adequate amount of time in front of each pen or group of gilts as discussed previously.

There are situations in which adequate boar exposure is provided, but it fails to produce a synchronized pubertal estrus. The most common of these is during the summer. The boar effect is significantly reduced on many farms during periods of elevated ambient temperatures [2]. Direct negative effects of elevated temperatures on the activity of the hypothalamus, decreased physical activity of boars and gilts during estrous detection, and an increase in odors or other factors that interfere with the perception of male pheromones by gilts have all been suggested as possible explanations. Increased attention to ventilation and waste management within buildings and modification of work schedules so that "heat checking" occurs during the cooler portions of the day have proven effective on some farms for overcoming this problem.

The distribution of ages in a group of gilts at the initiation of boar exposure also can affect the degree of synchrony. Typically, estrous responses are often poor and inconsistent when gilts less than 160 days of age are exposed to mature boars. Consequently, the degree of synchronization decreases as the proportion of gilts less than 160 days of age increases [2]. One way to circumvent this problem is to allow the youngest animals in the group to reach 160 days of age before boar exposure begins. The opposite situation in which there is a significant number of gilts in the population that have already reached puberty when boar exposure is initiated can also occur. This scenario would be expected when the average age of the gilts approaches 200 days or older at the onset of boar exposure. In practice, gilts too young to respond to boar exposure is a more common occurrence than gilts that are too old.

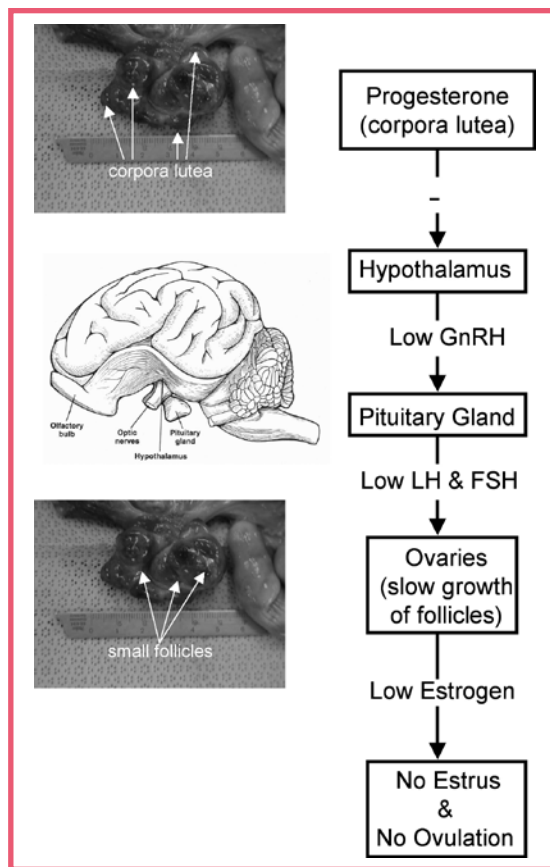
**PG600® and boar exposure.** A pharmaceutical that induces a synchronized pubertal estrus is PG600®. This compound is a combination of two, naturally occurring hormones - equine chorionic gonadotropin (or pregnant mare serum gonadotropin) and human chorionic gonadotropin. When PG600® is used in combination with boar exposure, the hypothalamus is stimulated via external stimuli provided by the presence of the boar and the follicles on the ovary are stimulated via the gonadotropins in PG600® (Figure 4). The result is a more synchronized estrus compared with boar exposure alone, probably because the activity of the ovaries and hypothalamus are enhanced as opposed to just the hypothalamus.

When gilts are given PG600® and boar exposure between 160 and 180 days of age,

- a typical response is for 70 to 80% of the gilts to exhibit estrus within the next 28 days,
- with the peak period of activity occurring between 5 and 10 days after treatment (Figure 3) [1].

It is important to remember that the number of gilts exhibiting estrus in the 28-day period after PG600® and boar exposure is similar to that observed with boar exposure alone. The primary differences are that most gilts respond earlier and over a shorter time interval when PG600® is used. In essence, PG600® improves the synchrony of estrus in gilts that normally would respond to boar exposure alone. It usually does not induce estrus and ovulation in prepubertal gilts that, for whatever reason, are not responsive to the boar. For this reason, when evaluating the effectiveness of PG600®, the basis for comparison needs to be the typical response of gilts in the herd to only boar exposure.

Many of the situations in which gilts do not respond to PG600® are related to poor boar exposure.



**Figure 5. Schematic diagram of the negative effect of progesterone on reproductive activity during the estrous cycle of mature gilts and sows.**

Consequently, many of the guidelines for using boar exposure effectively are appropriate and should be taken into account when treating gilts with PG600®, especially those related to the average age and the distribution in ages of gilts at the time of treatment. For example, when gilts are too young to respond to boar exposure, they generally do not show any of the classical physiological or behavioral changes associated with the onset of estrus. In contrast, when treated with PG600®, gilts that are too young to respond to boar exposure exhibit swollen vulvas and mucus discharges within several days of treatment, but never exhibit a standing reflex. What probably happens in these animals is that there is enough estrogen produced by the direct action of PG600® on the ovaries to induce some of the early changes associated with the onset of estrus, but not enough to stimulate the standing reflex. In contrast, when no overt changes are observed in gilts after treatment with PG600®, then the majority of gilts probably have already reached puberty. Use of PG600® is not effective for induction or synchronizing estrus in mature gilts that are exhibiting normal estrous cycles.

Methodology	Prepuberal Gilts	Mature Sows / Gilts*	Weaned Sows
Boar Exposure Effective: Typical Responses:	-YES -70-80% gilts show estrus in 28 days -40% of estrus periods occur 10-14 days after initial contact	-NO	-YES -proper boar exposure after weaning is necessary for estrous activity
Boar Exposure + PG600® Effective: Typical Responses:	-YES -70-80% of gilts show estrus in 28 days -80% of estrus periods occur 5-10 days after PG600® injection	-NO	-NO
Matrix® Effective: Typical Responses:	-NO	-YES -80-90% of females exhibit estrus 4-9 days after end of feeding	-NO
Batch Weaning Effective: Typical Responses:	-NO	-NO	-YES -90% of sows exhibit estrus within 10 days after weaning

**Table 1. Summary of Methodologies for Synchronization of Estrus in Swine**  
\*Sows and gilts need to be exhibiting normal estrous cycles.

## Synchronization of estrus in mature sows and gilts with normal estrous cycles

Once females reach puberty and begin to exhibit normal estrous cycles, boar exposure and PG600® cannot be used to synchronize estrus. The primary reason for this is that during the majority of the 21-day estrous cycle a hormone called progesterone is present. Follicular cells remaining on the ovary after ovulation form corpora lutea, which begin to produce progesterone. Progesterone has a suppressive or quiescent effect on the ovaries. Its main mode of action is to decrease the release of GnRH from the hypothalamus. It reduces GnRH secretion just enough to prevent the growth of medium to large follicles and, thus, ovulation, but not enough to keep small follicles from reaching medium sizes. As a result, there is always development of small to medium follicles when progesterone is present, but not the development of medium to large follicles (Figure 5). The stimulatory effects of boar exposure and PG600® cannot override the suppressive effects of progesterone on follicular development.

During the estrous cycle, corpora lutea produce progesterone for 12 to 14 days. After this, they regress or die and progesterone concentrations decrease. Follicular growth is no longer stopped when follicles reach the medium size range, because the quiescent effect of progesterone on the hypothalamus has been removed. This will eventually result in the presence of large preovulatory follicles on the ovary, estrus and ovulation. Therefore, in contrast to prepubertal gilts, strategies for synchronizing estrus in mature sows and gilts need to create a situation in which the decrease or removal of progesterone occurs at the same time in all animals.

**Matrix®.** Matrix® (InterVet, Inc., Millsboro, DE) is an orally active, synthetic progesterone-like compound

for synchronizing estrus in mature sows and gilts. When fed for 14 days it produces estrus, on average, 4 to 9 days after its removal from the feed (or 18 to 23 days after the first day of feeding). Females can be at any stage of the estrous cycle at the onset of feeding (Figure 6). Because Matrix® is a progesterone-like compound, it has the same quiescent effect as progesterone on the release of GnRH and the growth of follicles.

For gilts and sows in the early stage of their estrous cycles, the feeding of Matrix®

- coincides with progesterone production from corpora lutea;
- endogenous progesterone decreases at the same time Matrix® is removed from the feed;
- medium-sized follicles begin their final stages of growth; and
- ovulate.

For gilts and sows in the middle of their estrous cycles,

- corpora lutea regress;
- progesterone levels decrease between days 12 and 14;
- Matrix® prevents resumption of follicular growth; and
- estrus will not occur until it is removed from the feed.

Finally, for gilts and sows in the latter stages of their estrous cycles, progesterone is decreasing and medium follicles begin to grow. When these females consume Matrix®,

- the quiescent effect of progesterone-like activity is reinitiated very quickly;
- the growth of medium follicles stops; and
- small follicles replace them until the feeding period for Matrix® ends.

The end result is that the removal of progesterone occurs at the same time in all females, which produces a synchronized estrus.

When gilts and sows exhibiting normal estrous cycles are fed Matrix® for 14 days,

- typical responses are for 85 to 90% of the treated animals to be in estrus between 4 and 9 days after its removal,
- with the majority exhibiting estrus on either days 4, 5 and 6, or on days 5, 6, and 7 (Figure 7) [3-7].

Farrowing rates and litter sizes are similar to those of unsynchronized females on most farms. In some situations, reproductive performance is better in sows and gilts treated with Matrix® than their unsynchronized contemporaries [4-5,7]. Reasons for this observation are not clear, but probably are related to improved insemination techniques and reduced semen ages at insemination due to better semen delivery schedules.

Three criteria need to be met in order for most farms to realize the effectiveness of Matrix® for synchronization of estrus:

- Sows and gilts must be mature and exhibiting normal estrous cycles. Matrix® will not synchronize estrus in prepubertal gilts or mature animals that are anestrus.
- Matrix® needs to be fed for 14 days. Feeding periods less than 14 days typically are not sufficient to control follicular growth and estrus for females in the early stages of the estrous cycle.
- For the best results sows and gilts treated with Matrix® need to be fed individually. In group-feeding situations, it is unlikely

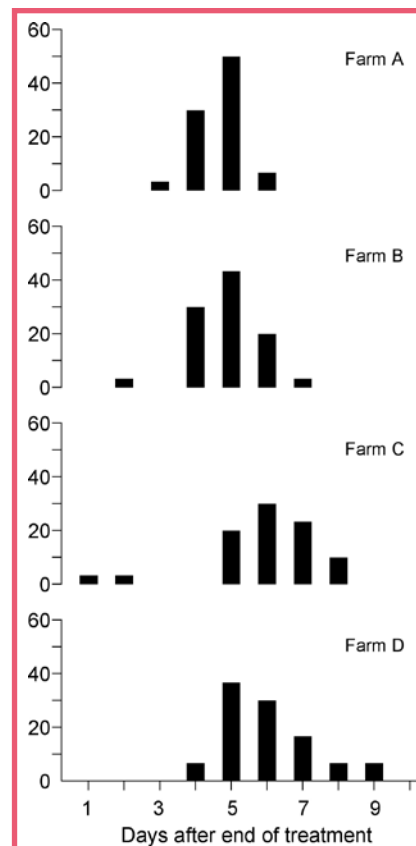


Figure 7. Synchronized estrus in gilts (n=40 per farm) on 4 farms after feeding Matrix® for 14 days [2-7].

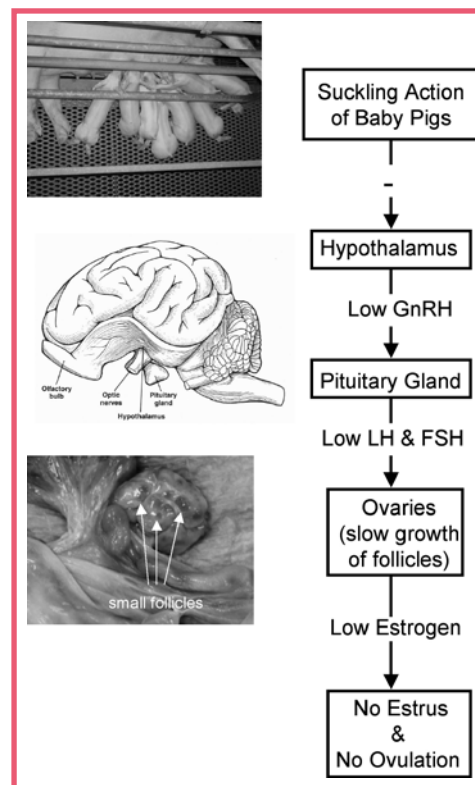


Figure 8. Schematic diagram of the negative effect of the suckling action of baby pigs on reproductive activity in lactating sows.

that all females consume the same amount of feed. As a result, those whose feed intake is reduced will not receive sufficient amounts of Matrix® on a daily basis for effective estrus synchronization.

## Estrus in weaned sows

Synchronization of estrus in weaned sows normally is achieved on most farms with routine management. During lactation, the suckling action of the nursing piglets has an inhibitory effect on the hypothalamus and the release of GnRH. This results in reduced levels of LH and FSH and small to medium-sized follicles on the ovaries of sows during lactation (Figure 8). When the litter is weaned, the suckling action of the litter is terminated and its inhibition on the hypothalamus is removed; LH and FSH levels increase; and the follicular growth is allowed to finish culminating in estrus and ovulation. Thus, weaning groups of sows on the same day is a naturally occurring, effective means of estrus synchronization [8].

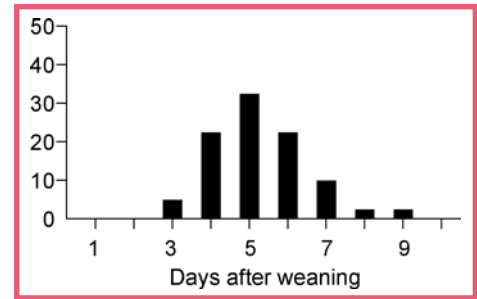


Figure 9. Typical distribution of weaning-to-estrus intervals in sows [8].

In well-managed herds, typical responses after weaning are

- to have 90 to 95% of sows in estrus within 10 days after weaning
- with the majority of females in "heat" on days 4 through 7 (Figure 9) [8-9].

In contrast to the situation with prepubertal gilts and mature females, the natural situation physiologically is for sows to exhibit a synchronized estrus (after weaning). When it doesn't occur, there are usually deficiencies in management including

- Feed intake during lactation,
- lactation length, parity,
- boar exposure after weaning, and
- elevated ambient temperatures associated with the summer months.

Therefore, when post-weaning estrus is delayed, any one or combination of these factors could be involved. In general, feed intake during lactation has a negative relationship with the weaning-to-estrus interval in sows - as feed intake decreases, return interval increases. Several studies have shown that even short periods, 3 to 4 days, of reduced feed intake during lactation can affect rebreeding success [8]. Extended weaning-to-estrus intervals in sows can occur after both short (< 16 days) and long (> 28 days) lactation lengths [8]. Short lactation lengths are problematic because, often, the hypothalamus and pituitary gland have not had sufficient time to recover after farrowing to elicit normal hormonal responses to weaning. With long lactation lengths, metabolic demands often exceed nutrient availability, which results in excessive loss of body tissues and poor subsequent reproductive activity. In sows, anytime the goal is to stimulate or induce estrus, then boar exposure is important. Criteria for adequate boar exposure in weaned sows are identical to those discussed previously for prepubertal gilts.

The combination of first parity sows weaned during the summer months is especially problematic in terms of the occurrence of timely weaning-to-estrus intervals [9-10]. On many farms, feed intake, boar exposure, and lactation lengths all appear to be managed appropriately, yet estrus after weaning is still delayed and unpredictable. In these situations, several studies have shown that use of PG600® reduces both the weaning-to-estrus interval and the percentage of sows that failed to show estrus during a 10-day period after weaning [9-10]. In these same studies, weaning-to-estrus intervals for older sows during the summer and for all sows during other seasons were not affected by use of PG600®. In contrast, there are reports that use of PG600® on the day of weaning increases the proportion of older sows exhibiting estrus within 7 days after treatment. As mentioned earlier, it is important to note that use of PG600® in sows during the summer is hormonal therapy designed to counteract a negative environmental situation and not synchronization of estrus. Consequently, depending on the severity of the environmental insult, it is not surprising that the effectiveness of this strategy often varies among farms.

## Summary

The occurrence of estrus in prepubertal gilts and mature females that are not pregnant or lactating normally occurs randomly over time. Management techniques that allow producers to exert control over when estrus occurs in these females are available.

These are summarized in Table 1 and include:

- Boar exposure and PG600® are effective strategies for inducing a synchronized estrus in prepubertal gilts, but will not work in mature females exhibiting normal estrous cycles.
- Feeding Matrix® for 14 days produces good estrus synchronization in mature, cyclic females, but is not effective in prepubertal gilts.

In contrast, estrus in sows after weaning is not a random event, but occurs in a synchronized manner with good management. When weaning-to-estrus intervals become delayed or unsynchronized, there are management deficiencies that need to be addressed.

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