Opportunities For Improving Reproductive Management And Efficiency Of The Swine Breeding Herd With Artificial Insemination

Robert V. Knox
Swine Reproductive Extension Specialist
Department of Animal Sciences
University of Illinois, Urbana-Champaign

Introduction
Artificial insemination (AI) was first developed for use in swine in the late 1960’s. Since that time, advancements have led to a slow but gradual increase in the use of this technology. This article describes the current status of swine AI, its benefits and applications, and its relationship to current reproductive performance in the USA.

Current Status of AI Use
The USA swine breeding herd has been reported to include 3.9 million sows. Approximately 60% of these sows were determined to have been mated by artificial insemination. Each sow received 6.5 doses of semen annually, for a total of 25 million doses utilized in a single year (1999, Boar Semen Conference). Most of the AI is performed with 3 billion sperm in 80 cc of a 5-day liquid extender. Both bottles (tubes) and bags are used for storage in single doses at a similar frequency. Although frozen boar semen is currently available, there appears to be some limitations since insemination must occur within 8 h prior to ovulation to achieve results comparable to liquid extended semen for farrowing rates and litter sizes.

Reproductive Performance in the USA
PigCHAMP records (1999) indicated that in USA breeding herds, sows average 87 open-days annually. This number is significant since it has been estimated that each open sow day costs $1.50 /sow/day. Therefore, early breeding after weaning and reduced incidences of return to estrus after breeding, are important for returning profit to producers.

Farrowing rates vary by season and from farm to farm, however, average farrowing rate in the USA is reported to be 79%. The average herd has a 22.5-day lactation period and each sow farrows 2.2 times/year. The value of improvement in farrowing rate has been estimated using the Illinois Hog Herd Simulator (1994). This simulator indicates that for each 1% improvement in farrowing rate, returns above feed costs increase 1.5% to 2% for farms with 1000 and 440 sows, respectively.

Global AI Use
Artificial insemination is utilized outside of the USA to both a greater and lesser degree, depending upon the country. In certain parts of Europe for example, estimates of AI use are as high as 90%. However, in other parts of the world, such as areas in Asia, AI accounts for less than 20% of all breedings.

One area of potential benefit for USA producers could be the possibility to ship semen to customers or purchase semen from suppliers, outside of the USA. Currently, regulations are in effect in certain countries for importing animals or semen, due to concerns about specific diseases. The restrictions vary from country to country and are a limiting factor in semen trade. Additionally, the fertile life-span of liquid extended semen limits international shipping, since most semen is typically 24 h old by the
time of shipping in a 5–7 day extender. However, despite its many limitations, the ability to ship or receive semen for AI use in swine is much more practical than animal shipping and handling. Additionally, with AI, disease risk can be minimized more effectively than with live animals. Lastly, collection and extension of semen allows access to valuable genetics worldwide and access to potential customers without the risk of damaging the boar’s health or fertility through exposure to various disease causing organisms and high levels of stress associated with shipping and handling over great distances.

Improvements That Facilitate AI Use
Adoption of AI is even easier and more practical today than it was at any time over the last two decades. Improvements have been made in insemination equipment. This includes the use of disposable supplies that greatly reduce the risk of disease transmission or infections resulting from contaminated equipment. Improvements have also been made in the design of AI catheters, which allow choices to be made based on preference, price, and ease of insemination. Although the storage form of semen is liquid, improvements have been made in the semen containers which facilitate ease of insemination, provide more efficient temperature control, and reduce cost of shipping due to reduced bulk of container.

Semen extenders have also been improved over the years with semen fertility extended from 2 to 5 days. Choices are still available for purchase of a short-term extender or a long-term extender with cost savings associated with the short-term extender. Even semen storage units have been improved with the development of precise temperature control units that can maintain semen temperatures to within ±1° of desired storage temperature. Even semen shipping has been improved with overnight and next-day delivery service available. Shipping containers are also better able to protect and insulate liquid semen in a variety of climates. The semen collection and delivery services today can put semen on the farm within 24 h of collection.

Improvements in breeding systems have also been implemented. For example, the use of vasectomized males has been increasing in order to improve estrous detection when using AI. Additionally, more females are being detected for estrus in crates. This is desirable for more precision with feed intake, for eliminating the stress of group housing, and can also result in considerable labor efficiency when not having to move females for estrous detection.

Another benefit of AI includes the tremendous variety of genetics that can be accessed at a reasonable price. The semen supplier and the purchaser can often agree upon specific sires, costs, collection and delivery dates. New specialization in the industry has also resulted in many AI boars being housed in studs. Custom collect businesses have also emerged with ownership of valuable animals maintained but collection and semen processing delegated to specialists.

It is worthy to mention that valuable information on swine AI can be found through University Extension fact sheets, internet sites, and the Pork Industry Handbook. In addition, many semen and AI equipment dealers have developed their own information sheets which can aid in understanding and successfully using AI. Additional sources of information can regularly be found in popular press magazines such as National Hog Farmer and Pork magazine. The National and State Pork Producer Organizations also have a listing of available resources for AI.

AI Compatible Applications
There are certain management procedures that are uniquely suited for use with artificial insemination in pigs. One of these is the ability to induce a synchronous estrus in animals to be mated. Synchrony of estrus allows groups of sows to be mated and then farrow at the same time. Since each female will require two services within an estrous period, each estrus will require two semen doses (with A.I) or one boar (natural service) for females that come into estrus within a given day. Natural service can obviously produce a need for a great number of boars on the farm. However, with AI, numerous doses of semen can be extended from a single collection and therefore, breeding females expressing estrus at the same time becomes important for cost, time, and space management.
One method of synchronizing estrus in gilts results from regrouping, relocation, and boar exposure near the age of puberty. This procedure can usually induce 30-40% of gilts within 10-15 days of the procedure. Another method of inducing gilts into estrus is with the drug, PG600®. This drug, when administered to gilts near the age of puberty, can often induce estrus in 50-80% of females in five days. In fact, most of these females express estrus within 1-2 days of each other.

Synchronization of estrus in sows occurs with weaning after females have lactated between 15 to 30 days after farrowing. This procedure allows sows to express estrus within 4-7 days after weaning. All of the estrous synchronizing techniques will require access to a large number of boars in order to accomplish natural service or adequate numbers of semen doses to accomplish this task with AI.

A technique that has gained some attention is the desire to use a combination of both AI and natural mating. Flowers and Alhusen (1992) reported that this combination treatment produced an advantage in farrowing rate and litter size when compared to natural service alone or exclusively AI. The suggested reasons for the observed advantage are that the boar is often more efficient in estrous detection than humans performing this procedure. Additionally, natural service can sometimes be a stressful procedure for the female, due to the aggressive nature and size of the boar. It is suggested that AI can reduce levels of stress and improve the quality of the second mating compared to repeated natural service.

One of the valuable lessons that has been learned from the use of AI, is that the incidence of sub-fertile males can occur at a frequency of 1 out of every 10 males. Matings with sub-fertile males will often result in poor conception rates or lower litter sizes. One method to negate the effects of sub-fertile boars has been to pool semen from collections of multiple boars. This has the effect of minimizing the semen of a sub-fertile boar and results in overall improvement in both farrowing rate and litter size. However, for individuals who require a specific sire, individual semen is still readily available.

Lastly, it should be mentioned that advancement is occurring in the areas of sexed semen, frozen semen, and even embryo transfer. These technologies will require AI as an integral procedure for eventual application.

**Improvement of Genetics with AI**

Although there are numerous reasons to utilize AI, its use is most attractive due to the economic benefits associated with access to the best genetics and the resulting improvements in animal performance. The greatest economic benefit resulting from AI occurs with carcass trait improvement in the terminal hog. Advantages in the highly heritable carcass traits, such as backfat, percent lean, and carcass yield, are all associated with the value of the animals at slaughter.

Advantages are also observed in the moderately heritable production traits such as feed efficiency and average daily gain. These traits are valuable since the greatest cost to producers is the amount of feed consumed per hog until reaching market weight. Another area for economic potential from improved genetics occurs with selection of sires for their maternal line traits such as litter size, lactation ability, spermatogenetic potential (testis size), and age at puberty.

**AI Advantages**

**AI versus Natural Service**

When considering AI, examining the potential of the technique to impact reproductive efficiency of the breeding herd should be paramount. An examination of numerous research studies over the last three decades indicates that AI in any combination can equal or even exceed natural service in many circumstances. There is some difficulty in comparing the impact of the different breeding systems on farrowing rate and litter size across research trial, since numerous variables prevent meaningful comparison. However, the overall farrowing and litter size results do show certain trends. One trend indicates that double service, whether natural service or AI, is superior to mating by single service. Additionally, little or no advantages are observed from triple services by natural mating or AI when compared to double matings. A minor trend for improved farrowing rate and
litter size is also observed when comparing twice daily to once daily estrous detection. What is known is that accurate estrous detection allows more precision in the attempt to inseminate females within 12 h before the time of ovulation. This timing allows maximal farrowing rate and litter sizes to be obtained. However, since the time of ovulation after onset of estrus is variable, only accurate estrous detection will allow breeding to occur at the optimal time.

**Boar Evaluation**

AI facilitates frequent evaluation of the boar’s potential fertility. Collection of semen, whether by the semen supplier or on farm, allows evaluation of the boar’s fertility based on ejaculate quality. This can include a gross evaluation of volume, opaqueness, turbidity, color and odor. An ejaculate that does not meet standard criteria for all of these indicators can indicate a potential problem or disease. Further evaluation of the collected sample allows assessment of sperm numbers, motility and abnormalities. All of these characteristics are associated with boar fertility. However, no perfect fertility test has been developed for the boar and still the ultimate test remains farrowing rate and litter size. Unfortunately, waiting for this result is not economically practical since economic return is highly related to reproductive performance, and so earlier assessment of boar fertility becomes critical.

**Structure**

One of the facts of natural mating is that size mismatches frequently result since new boars and gilts are introduced into existing breeding groups of sows and boars. These mismatches can cause problems for mating of young boars to older sows since the boars are often not physically tall enough to achieve intromission. On the other hand, valuable boars grow rapidly due to the effects of testosterone and achieve considerable size and weight. This can often be a problem even with limit feeding boars. Mismatched boars frequently become aggressive and can often be an overwhelming weight to support for females of young age. Also, sows coming out of farrowing crates after lactation commonly show weak skeletal and muscle structure and cannot support the weight of a mature boar for extended periods of time (10 minutes) over a two day period. This can result in an estrous female that will not stand to be naturally mated, a frustrated, aggressive boar, and a female that will terminate the breeding before completion. It is also not uncommon to have a productive female with a slight injury to a foot or leg that prevents them from being able to support the full weight of a mature boar. All of the above instances are remedied by artificial insemination since no physical contact is needed.

**Records**

One of the frequently overlooked benefits of AI is the precision gained in the assessment of reproductive status of females within the breeding herd. For example, AI allows the formation of tight breeding groups, which facilitates more precision in managing females. This can include pregnancy detection occurring at specific days post-breeding, culling, and observation for both regular and irregular returns to estrus. Precision in breeding dates is also needed to implement induction of farrowing effectively. Induced farrowing can produce significant advantages through reduced stillborn piglets. This is accomplished by induction of farrowing to occur during the working hours. Precision in farrowing dates can also aid in all-in all-out management of farrowing houses and nurseries. With AI, genetic identification of animals is more accurate when compared to pen mating with rotated boars.

**Space**

Space for boars is often a concern due to the cost per square foot and limited amount of breeding barn space available. Boars require adequate pen space ~15 sq. ft per boar. This space for free movement is important for natural mating since stiffness can often result from crate housing. However, if natural service boars are maintained in crates, frequent exercise or use is needed. In an AI program, the only boars that are needed are those for emergency matings and for detecting estrus.

**Efficiency**
AI breeding of females allows personnel to perform a greater number of matings per unit time when compared to natural service. Flowers and Esbenshade, (1993) reported that as the number of sows bred per day increased (from 1 to 8 sows) the time to inseminate each sow decreased for AI (34.6 min vs. 17.3 minutes/sow, respectively) but did not change for natural service, regardless of number served (23 minutes/sow). The reason for this observation is that natural service requires courtship, ejaculation of all phases of semen (~300-500 ml), and on average takes 23 minutes per sow mated. On the other hand, for AI, when accounting for collecting, extending, and artificially inseminating sows, a lot of time is invested when only 1-2 sows are mated. However, when mating more than two sows over a 3-4 day period, AI greatly reduces the labor needed to service the same number of females when compared to natural service (hand mating). The time requirements will be substantially less when semen is purchased from a semen supplier.

When comparing natural service (hand mating) of sows and gilts with AI, less time was required for both groups of females when using AI. Detection of estrus did not differ significantly between natural service and AI, but it did require only ~9.5 minutes for sows and 11.8 minutes for gilts before they would stand for breeding. Hand mating sows required 12 minutes and hand mating gilts required 16 minutes. AI on the other hand required only 3.4 minutes per sow and 10.5 minutes per gilt. This labor advantage originates from the fact that AI inseminates ~80 cc of liquid semen when compared to natural service ejaculate volume of 400 cc.

**Stress**

Since breeding swine naturally or with AI requires the use of boars, inherent risk exists for humans since boars can be unpredictable and often very aggressive. Moving boars can be frustrating and dangerous. They are powerful, can turn quickly, and are reluctant to move when near other boars, females or feed. Although AI utilizes boars for estrous detection, these boars can often be smaller and should be culled for aggressive behavior since their value is inherently low. AI also typically utilizes only fence-line contact between boars and females and separation and movement risks can be minimized. In contrast, natural service requires daily separation of boars from females not in estrus, or following mating, as standard practice. Semen collection from boars on farm also poses considerable risk (even more so than natural service) and therefore, is not absent from AI. However, when semen is purchased, the risk is minimized compared to on farm collection. Regardless of system used, always use caution when handling or working with boars.

AI does significantly reduce the risk of injury to sows and gilts from aggressive boars. Natural mating and physical boar contact with females can often be a physically rough experience for females since boars can get frustrated when they do not receive expected physical behaviors from the female, cannot quickly achieve erection, intromission, or correct orientation. Females can therefore be injured or will refuse to mate properly under these circumstances.

**Boar use**

Artificial insemination allows much more effective boar utilization with AI than with natural service. One ejaculate may contain between 40-100 billion sperm cells. This will result in 10-40 AI doses and will cover the mating of 5-20 females. In contrast, with natural service, two natural services consecutively in a 24-h period will deplete sperm reserves for a single boar. This allows only 4-5 services per boar per week maximally before fertility is reduced.

**Boar Requirements**

Levis (Univ. Nebraska) reported a formula for determining number of boars needed on farm when compared to AI. The formula included breeding group size (e.g. 30 sows), farrowing rate of herd (80%), number of matings for each sow (2 per sow in estrus), the maximal limit of 4 matings per boar per breeding period, and the percent of active boars on the farm (95%). Some of the boars in the herd may not be active due to quarantine, illness, or recent use.
Natural Service Boar Needs
(30 sows/80% FR) x 2 matings/sow = 75 matings
4 matings per boar x 95% active = 3.8 matings
= 20 boars needed for 75 services per week

AI Ejaculate
1 ejaculate produces ~60 billion sperm cells
Semen dose = 3.0 x 10^9 sperm per dose
60 billion/ 3.0 billion = 20 doses

Costs
Todd See from N.C. State (National Hog Farmer, 1996) reported the costs associated with natural service and AI, AI with on farm collection, and AI with purchased semen. The costs that were taken into account included minutes per mating, labor, boar fixed-costs, semen cost when purchased, AI lab structure and equipment costs, costs for on-farm collection and processing, and the cost of disposable equipment for AI use. The final cost of each system is listed.

<table>
<thead>
<tr>
<th>System</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural service</td>
<td>$23.61</td>
</tr>
<tr>
<td>AI/purchased semen</td>
<td>$19.20</td>
</tr>
<tr>
<td>AI/on Farm collect (200 sows)</td>
<td>$15.45</td>
</tr>
<tr>
<td>AI/on farm collect (1000 sows)</td>
<td>$13.82</td>
</tr>
<tr>
<td>AI/on farm collect with 50 head boar stud</td>
<td>$11.92</td>
</tr>
</tbody>
</table>

In natural service, the labor and fixed costs for the boars significantly increased the cost of breeding. On farm semen collection reduced the cost of breeding compared to purchased semen but once again the risk associated with this activity and skill needed to be effective should be considered. Obviously on farm collection can reduce breeding costs but access to desired genetics may be limited due to cost of boars.

Risks
AI is a technique with a long track record for success in swine production operations and has provided producers of all sizes with great flexibility and numerous advantages when properly implemented. However, it is important to mention that there are certain phases in the AI procedure that can be potential areas for AI failure. Whether purchasing semen from an outside semen supplier or on farm collecting, improper semen handling which does not maintain high quality of the extended semen can result in failure to settle females. It is important to maintain a constant cool temperature (62-64 F), avoid excessive changes in semen temperature, rotate semen daily in storage, use semen quickly after removing from cool storage, protect from temperature change (warm and cold), protect from excessive pressure, and use semen as soon as possible after collection and extension. Even the highest quality semen cannot compensate for poor estrous detection and improperly timed inseminations. Detect for estrous once or twice daily by providing adequate boar exposure with face to face contact, and inseminate females twice during estrus.

Do not attempt to breed too many females in a given time period as inseminator fatigue can reduce fertility rates (multiple breeding technicians may be needed). Do not allow poor hygiene with AI techniques, as this can introduce infectious organisms into the uterus and cause infertility or abortion. Reduce animal stress before, during, and after mating that result from poor equipment and facilities, undesirable or unhealthy environment, and untrained or improper animal handling personnel.

For more information contact:
Robert Knox,
Swine Reproductive Extension Specialist
Department of Animal Sciences
University of Illinois Champaign-Urbana
217-244-5177
knox@uiuc.edu

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