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MIDWEST BOAR STUD CONFERENCE II

AGENDA

Wednesday, August 4

7:30 am View booths

8:00 Welcome and 30 years of AI training
Bill Day, University of Missouri-Columbia, emeritus

8:25 Overview of anatomy/physiology
Billy Flowers, North Carolina State University

8:55 Detailed description of sperm motility/morphology and causes of abnormalities
Billy Flowers, NCSU

9:50 Break and view booths

10:20 Boar housing considerations
Don Levis, The Ohio State University

11:00 Hygiene: in the barn and in the lab
Chris Kuster, Kuster Research and Consulting

NOON Lunch and view booths

1:00 Health and biosecurity
Tom Fangman, University of Missouri-Columbia

1:45 Doing in-house research and product/technique comparisons
Tim Safranski, University of Missouri-Columbia

2:15 Break and view booths

3:00 Boar feeding and nutrition
Mark Estienne, Virginia Tech

3:45 Certification programs
Darwin Reicks, Swine Vet Center

4:30 Research notes

5:00 Adjourn

6:00 Depart for Busch Stadium and Cardinals vs Montreal game

Thursday, August 5

7:30 am View booths

8:00 Data on various extenders; viability over time
Billy Flowers, North Carolina State University

8:45 Rate of cooling, storage and QC
Rob Knox, University of Illinois

9:25 Prostaglandins and boars
Mark Estienne, Virginia Tech

10:00 Break and view booths

10:30 Sperm counting methods and instruments
Wayne Singleton, Purdue University, emeritus

11:15 Panel discussion (culling/collection frequency/training/etc.)

NOON Lunch and view booths

1:00 Data: what do you record and how is it used?
Darwin Reicks, Swine Vet Center

1:45 Intrauterine and deep uterine insemination
Don Levis, The Ohio State University

2:15 Summary of survey data and JSHAP survey
Chris Kuster, Kuster Research and Consulting

3:00 Evaluations and Adjourn

Proceedings

An Overview of Anatomy and Physiology of the Boar

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Introduction

The boar has a tremendous impact on the reproductive efficiency of the swine breeding herd. Depending on the collection frequency and insemination dose, semen from a single boar can be used to breed between 750 and 1000 sows per year. As a result, reproductive failure of a single male influences a large number of sows. Consequently, a thorough understanding of the basic aspects of male reproductive physiology is important in managing boars for optimal fertility. This paper will review the anatomy, physiology and sexual development of boars placing particular emphasis on spermatogenesis and the ejaculatory process.

Anatomy of the Boar

The male reproductive system is composed of a variety of different structures including the testes; the urogenital duct system; the secondary sex glands; the pituitary gland; and the hypothalamus. These communicate via the endocrine and nervous system to coordinate normal reproductive activity in boars. Abnormal activity in one or more of these areas can result in reproductive problems.

Hypothalamus and Pituitary Gland - The brain is the component of the male reproductive system that gathers internal signals from within the body and external cues from the environment; integrates them; and regulates physiological and behavioral functions associated with reproduction. The hypothalamic portion (Figure 1) of the brain secretes gonadotropin releasing hormone (GnRH)

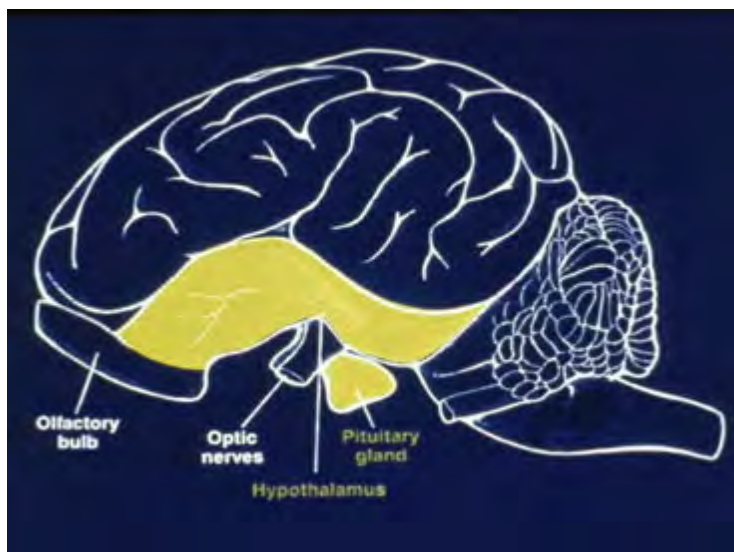


Figure 1. Diagram of the hypothalamus and pituitary gland. Notice the close anatomical association between the optic and olfactory nerves and the hypothalamus. Sights and sounds perceived by the boar, such as a female in estrus travel to the brain via these nerves and stimulate the hypothalamus to secrete GnRH. Secretion of GnRH stimulates the release of LH and FSH from the pituitary, which, in turn, stimulate the production of testosterone from the testes.

which controls the production and secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the pituitary gland (Hafez, 1993). These two hormones are responsible for regulating testicular function.

Testes - The primary functions of the testes (Figure 2) are to produce spermatozoa and hormones. The majority of each testis is seminiferous tubules. The seminiferous tubules are a convoluted network of ducts in which spermatozoa are produced. Sertoli cells are specialized cells involved in the maturation of spermatozoa and hormone production and line the lumen of the seminiferous tubules. Interstitial cells of Leydig, blood and lymph vessels and nerves are located in between the seminiferous tubules. Important interactions between the Sertoli and Leydig cells regulate virtually every aspect of male reproductive function. A series of tubules leave the seminiferous tubules and connect to form collecting duct located in the center of each testis called the rete testis. During spermatogenesis, spermatozoa leave the seminiferous tubules and enter the rete testis during their passage into the epididymis (Setchell et al., 1993). Because the testes are located externally, special anatomical systems are needed for thermoregulation. The most important of which is a complex vascular arrangement of testicular arteries and veins in the spermatic cord called the pampiniform plexus (Garner and Hafez, 1993). The testicular artery forms a convoluted structure in the shape of a cone in which arterial coils are enmeshed with testicular veins. From a functional perspective, this countercurrent mechanism enables arterial blood entering the testis to be cooled by venous blood exiting the testis. In most species, the temperature of arterial blood drops between 2 and 4°C prior

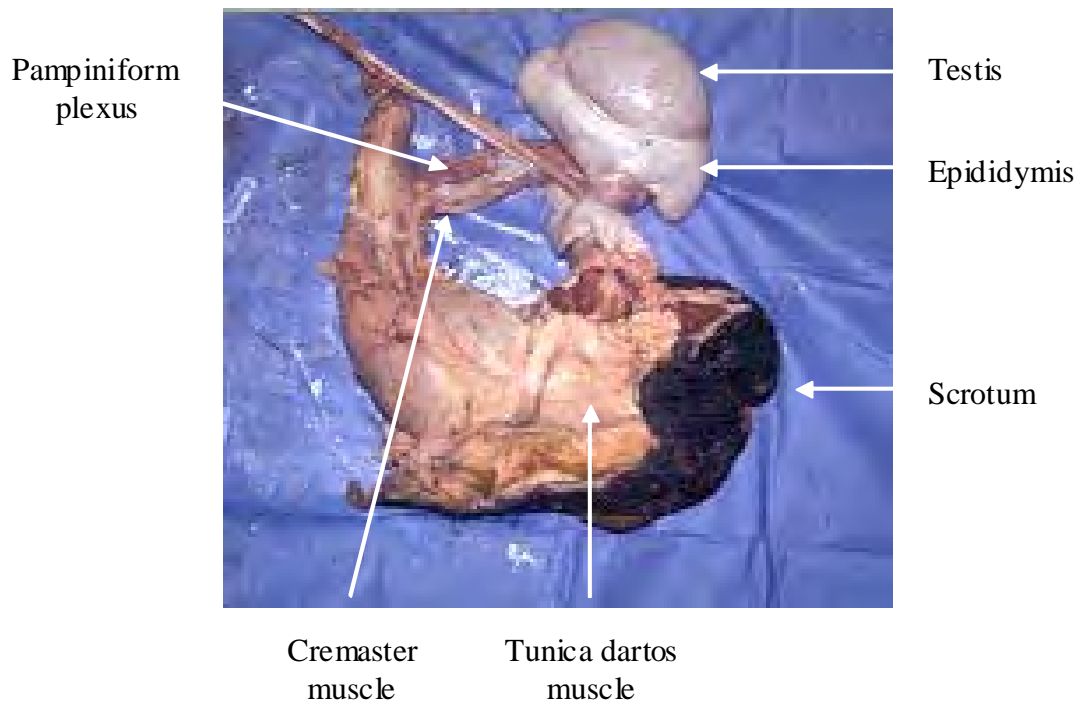


Figure 2. Testes and associated structures from a boar. The testis and epididymis in the upper right hand corner of the picture have been separated from the connective tissue, tunica dartos, and scrotum that normally surround them. The other testis and epididymis, which still is surrounded by the connective tissue layers, are located in the lower left hand corner of the picture.

to its entry into the testes. In addition, two groups of muscles, the tunica dartos and cremaster, play an important role in thermoregulation. The tunica dartos lines the inside of the scrotum and controls its proximity to the testis. It contracts during cold weather pulling the scrotal sac closer to the testis for added insulation and relaxes during warm weather allowing the scrotum to recoil into a distal position. The cremaster muscle is located in the spermatic cord and is attached to the thick membranous sac surrounding the testis. It contracts during cold weather pulling the scrotal sac and testis closer to the body core and relaxes during warm conditions allowing the testis to return to its normal position. Both muscles have an abundant supply of nerve fibers that respond to temperature sensors located in the central nervous system. Because boars do not have pendulous testicles like bulls, the tunica dartos is more important than the cremaster muscle in the regulation of testicular temperature.

Epididymis - The rete testis enters the efferent ducts, which eventually form a single coiled duct called the epididymis. The epididymis is similar to the seminiferous tubules in that it coils back upon itself many times and forms three distinct sections - the caput (head), corpus (body) and cauda (tail) epididymi. The convoluted duct of the epididymis is surrounded by a prominent layer of circular muscle fibers and contains pseudostratified columnar, stereociliated epithelium. Masses of spermatozoa are commonly found along the entire lumen of the epididymis (Setchell et al., 1993).

The primary function of the epididymis is sperm maturation, transport and storage. Spermatozoa entering the epididymis are neither motile nor fertile. It takes spermatozoa between 9 and 14 days to migrate from the head to the tail of the epididymis, the primary storage site. It has been estimated that the tail of the epididymis contains about 75% of the total epididymal spermatozoa. Spermatozoa become motile and acquire fertilizational competence in the body of the epididymi due to the secretion of factors by the cells located in this region. Movement of spermatozoa through the epididymi is thought to be due to the flow of rete fluid, the action of the stereociliated epithelium and contractions of the circular muscle layer. Unejaculated spermatozoa are gradually eliminated by excretion into the urine. Spermatozoa that are not excreted in the urine undergo a gradual aging process. During the aging process, fertilizational competence is lost first and is followed by a decrease in motility (Garner and Hafez, 1993). Eventually, dying spermatozoa disintegrate. Ejaculates with dying spermatozoa often appear "clumpy", i.e. - have large groups of spermatozoa bound together by their heads.

Vas Deferens, Accessory Sex Glands and Penis - The vas deferens (Figure 3) is a thick, heavily muscled tube through which sperm are transported from the tail of the epididymis to the pelvic urethra, at which point the paired genital systems of the boar meet and converge with the urinary tract just before the bladder. Adjacent to the pelvic urethra are three secondary sex glands: the vesicular glands or seminal vesicles; the prostate gland; and the bulbo-urethral glands (Hafez, 1993).

The seminal vesicles lie lateral to the terminal portion of each vas deferens. In the boar, they are large, lobulated and relatively diffuse. They often appear to have an orange color. They are responsible for the majority of the fluid volume of boar semen. In addition, they secrete high levels of fructose and citric acid as well as inositol, ergothioneine, several amino acids and glycerylphosphorylcholine. Most of these compounds are used as energy substrates by ejaculated spermatozoa (Garner and Hafez, 1993).

The prostate gland is located next to the vesicular glands with the majority of its body being embedded in the muscle layer surrounding the pelvic urethra. Secretions from the prostate gland during ejaculation are primarily alkaline and contain calcium, acid phosphatase and fibrinolysin. The

primary function of the fluid from the prostate gland is to neutralize the acidic vaginal secretions (Setchell et al., 1993). Secretions from the prostate gland also are believed to give semen its characteristic odor.

The bulbourethral glands are long cylindrical glands in the boar located on either side of the pelvic urethra near the ischial arch of the pelvis. The bulbourethral glands secrete the gel fraction of the semen characteristic of porcine ejaculates. Many functions for the gel component of semen have been postulated, but few have been proven.

The terminal portion of the boars urogenital system is the penile urethra, which is the central tube within the penis. The penile urethra opens into the glans penis. In the boar, the glans penis has a counter

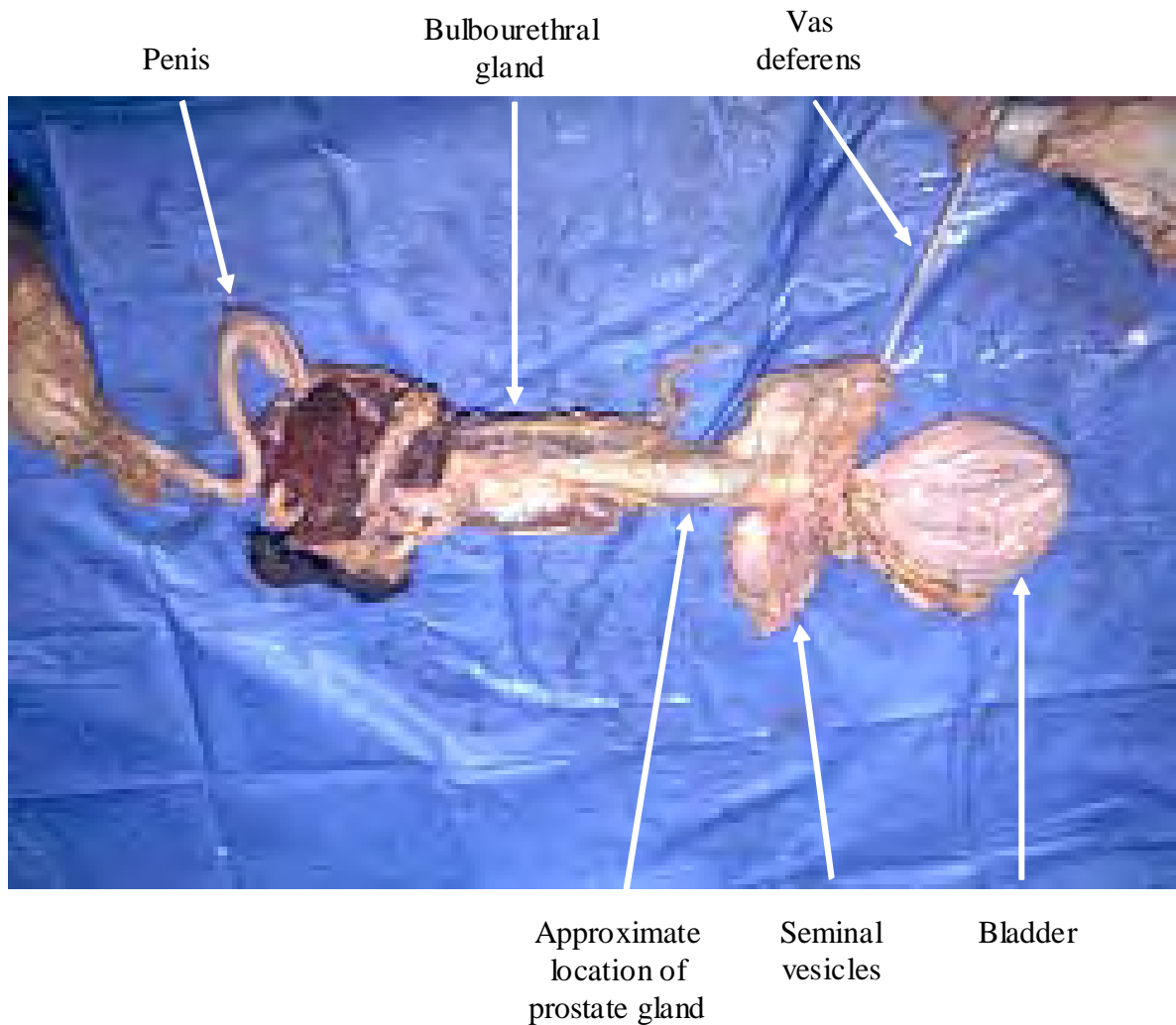


Figure 3. Vas deferens, secondary sex glands, bladder, and penis (urogenital tract) from a boar. The seminal vesicles and bulbourethral glands are paired glands. The prostate gland is embedded in muscle and cannot be seen without additional dissection. The vas deferens originates from the tail of the epididymis. The glans penis is highly innervated and must be stimulated properly for normal

ejaculation to occur. The porcine penis also contains three cavernous bodies or sinuses that surround the penile urethra. During erection blood is pumped into and retained in these areas. In the resting state, the porcine penis is retracted and forms a characteristic "S" fold called the sigmoid flexure. The free end of the penis in the retracted state resides in the prepuce or sheath (Figure 4). In young prepubertal boars, the glans penis cannot be extended fully because it is fused with the lining of the prepuce. As a boar matures, androgens produced by the testis initiate keratinization of the inner preputial lining and the penis is eventually freed from its connection with prepuce. Persistent frenulum is a condition in which strands of tissue did not keratinize fully and are still attached to the penis (Garner and Hafez, 1993). When this occurs, the end of the penis curves back toward to the prepuce during erection and ejaculation. Removal of these strands of tissue with a pair of sterile scissors corrects this situation. Near the end of the prepuce is a diverticulum called the preputial sac. Urine, semen and secreted fluid collect in this sac and are broken down via bacterial action. Contents of the preputial sac are often expelled during detection of estrus or natural matings and often believed to be the source of the odor associated with mature boars.



Figure 4. Sheath and preputial sac. The general area of the preputial sac is outlined by the white box.

Preputial
sac

Opening
of sheath

Physiology of the Boar

Endocrine Activity within the Testes - Leydig cells and sertoli cells are the two primary endocrine producing cells in the testes. Luteinizing hormone (LH) released from the anterior pituitary gland stimulates production of androgens from the Leydig cells. The primary androgen produced is testosterone. Testosterone has a variety of important functions in spermatogenesis and male sexual behavior. Follicle-stimulating hormone (FSH) stimulates the Sertoli cells to produce androgen-binding proteins; convert testosterone to dihydrotestosterone and estrogen; and secrete inhibin

(Bartke et al., 1978). Androgen-binding protein forms a complex with androgen and is carried along with the spermatozoa to the epididymis. High local levels of androgen are necessary for the normal function of the epididymal epithelium. Inhibin diffuses out of the seminiferous tubules; enters the vascular system; and transported to the brain where it has a negative effect on the secretion of FSH. Inhibin production by the testes is an important component of gonadotropin regulation in the male. In the boar, high quantities of estrogen are found in semen. The source of these estrogens is the sertoli cells, which convert testosterone to estrogen via the aromatase enzyme (Setchell et al., 1993). It appears that the primary role of seminal estrogens is to stimulate important reproductive events in the female reproductive tract during breeding.

Recent investigations have demonstrated that both Sertoli and Leydig cells have receptors for a variety of growth factors including IGF-I, EGF and TGF. It has been proposed that growth factors may be produced in response to gonadotropin or growth hormone action on testicular tissue and mediate many of the actions of these hormones (Hafez, 1993). In addition, growth factors are believed to be the primary mode in which Sertoli cells and developing spermatozoa regulate each other's secretion of proteins along the length of the seminiferous tubule (Setchell et al., 1993).

Erection and Ejaculation - Sexual stimulation causes dilation of the arteries supplying the sinuses in the penis. It has been suggested that parasympathetic fibers originating from the pelvic nerve are responsible for providing the neural signal for dilation and thus the initiation of erection. At the same time vasodilation begins, the ischiocavernosus muscle begins to contract repeatedly which causes blood to be pumped into the sinuses in the penis. In the boar, no veins drain the distal portion of these spaces, which facilitates the increase in pressure within the penis and ultimately, erection. As pressure increases from blood being trapped in the sinuses, the retractor penis muscle relaxes allowing the sigmoid flexure to straighten and the penis to protrude from the sheath. Several studies demonstrate that erection failures in boars are caused primarily by structural defects rather than psychological problems (Benson, 1993).

Ejaculation is primarily under neural control and involves contractions of smooth muscles. The process is initiated by rhythmic contractions of smooth muscles lining the tail of the epididymis and the ductus deferens. These contractions are controlled by sympathetic nerves that arise from the pelvic plexus of nerves, which is a branch of the hypogastric nerve. During ejaculation, the bulbospongiosus muscle compresses the penile bulb and forces blood into the remainder of the cavernosus tissue resulting in a slight enlargement of the glans penis in boars.

Spermatogenesis - Spermatogenesis is divided into two basic processes: spermatocytogenesis and spermiogenesis (Figure 6). In a general sense, spermatocytogenesis is the process involved with the mitotic and meiotic divisions of sperm cells, while spermiogenesis refers to the maturational phase of development. Although both hormones are important, it is believed that LH plays a more active role than FSH in spermatocytogenesis, while FSH is the main hormone involved with spermiogenesis.

Spermatocytogenesis - Just prior to puberty in boars, undifferentiated germ cells called gonocytes differentiate to form type AO spermatogonia. These are the precursor sperm cells from which all other sperm cells originate. There is some evidence that the number of AO spermatogonia is directly related to the sperm production capacity of adult males. In adult boars, AO spermatogonia differentiate into A1 spermatogonia which divide progressively to form various types of immature sperm cells. The final mitotic division during spermatocytogenesis occurs in primary spermatocytes.

Although the average number of mitotic divisions cells would undergo between the A1 and primary spermatocyte stages is a subject of some controversy, a figure of 6 to 8 is commonly used (Garner and Hafez, 1993). This means that between 32 and 124 primary spermatocytes are formed from a single spermatogonia. After the formation of primary spermatocytes, no new DNA synthesis occurs and the resulting secondary spermatocytes divide to form haploid cells known as spermatids. The entire divisional process of spermatocytogenesis occurs in the testis. It is interesting to note that many of the divisions are actually incomplete in that small cytoplasmic bridges that are retained between most cells originating from a common type A1 spermatogonia. Some researchers speculate that these bridges are important in coordination of development of sperm cells as a group (Setchell et al., 1993).

Spermiogenesis and Spermiation - The round spermatids are transformed into spermatozoa by a series of morphological changes referred to as spermiogenesis. Maturational changes that spermatozoa undergo during spermiogenesis include condensation of nuclear material, formation of the sperm tail and

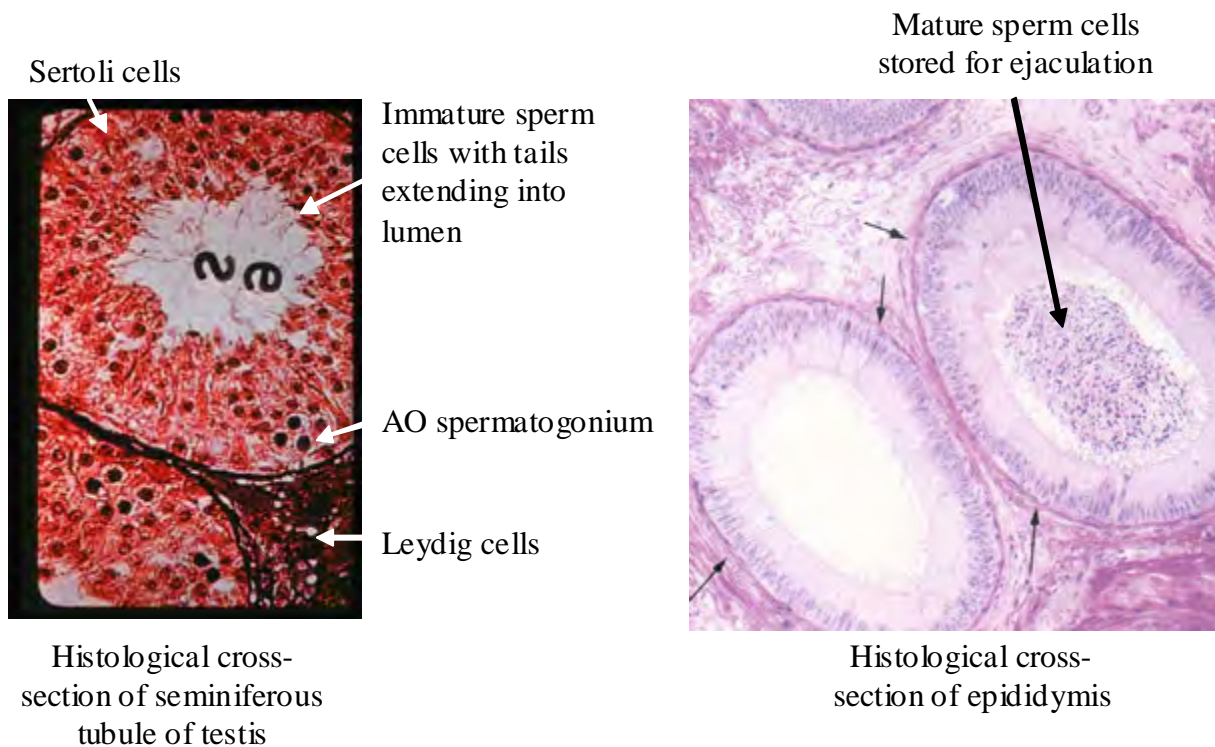


Figure 6. Histological cross-sections of seminiferous tubules (left) in the testes and the tail of the epididymis (right).

development of the acrosomal cap and its contents (Garner and Hafez, 1993). During most of spermiogenesis the sperm cells appear to have their heads imbedded in Sertoli cells. In reality, the membrane of the Sertoli cell actually is wrapped around the sperm head. Communication and exchange of materials between the Sertoli and developing sperm cells occurs via intercellular bridges. The actual release of spermatozoa into the lumen of the seminiferous tubule is called spermiation. The elongated spermatids are gradually extruded or pushed out of the Sertoli cell into

the lumen of the seminiferous tubule until only a small cytoplasmic stalk connects the head of the sperm to the residual body in the Sertoli cell. Breakage of the stalk results in the formation of a cytoplasmic droplet in the neck region of the sperm. These commonly are referred to as proximal cytoplasmic droplets.

Epididymal Maturation - Spermatozoa enter the head of the epididymis incapable of fertilization, however, acquire this ability at some point during their transit to the cauda epididymis. It is believed that epididymal secretions contain maturation factors that stimulate biochemical changes within the sperm cells necessary for fertilization (Garner and Hafez, 1993; Setchell et al., 1993). These changes include development of the potential for progressive forward motility; alteration of metabolic mechanisms; loss of the cytoplasmic droplet; and changes in the plasma membrane, acrosomal cap and nuclear material. It is interesting to note that during storage in the caudal portion of the epididymis, the metabolic activity of mature sperm is actually suppressed by secretion of a "quiescence factor". The entire process of spermatogenesis requires 45 to 55 days in the boar. The majority of this time is spent in the testicle and involves changes associated with both spermatocytogenesis and spermiogenesis. Maturation in the epididymis is thought to require only 10 to 14 days.

Sexual Behavior

Certain aspects of sexual behavior begin as early as 1 month of age in boars. Mounting activity of penmates is observed more frequently for males than females. Consistent mounting activity accompanied by erection occurs around 4 months of age (Hemsworth, 1982). However, most boars are not capable of producing ejaculates with normal quantities of fertile spermatozoa until 6 to 8 months of age (Figure). In general, testosterone is the male hormone that is the most closely linked with sex drive or libido. It is true that castrated males or boars with extremely low testosterone levels exhibit virtually no sexual interest. However, there have been a number of documented cases in which boars with normal levels of testosterone have low libido. Consequently, determining the relative importance of the endocrine system and prior sexual experience in male reproductive behavior is extremely difficult.

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Detailed Description of Sperm Motility/Morphology and Causes of Abnormalities

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Introduction

Semen quality assessment involves two basic aspects: percentage of spermatozoa exhibiting motility and percentage of spermatozoa with normal morphology. Evaluation of motility is the most commonly performed test and often assumed to be directly correlated with semen viability and fertility. Evaluation of morphology of sperm cells is conducted less frequently and often not included in calculating the final number of spermatozoa contained in each dose. Based on what is known about relationships among motility, morphology and fertility, in practice, it is probably safe to say that motility is over-emphasized and morphology is under-emphasized in semen evaluations. Nevertheless, the primary objective of this paper is to review current semen quality evaluation techniques for motility and morphology and discuss their significance in terms of assessing the adequacy of the production environment in which boars are housed.

Motility and Mobility Evaluations

Motility, in a general sense, refers to the percentage of spermatozoa in an ejaculate that show any type of movement. With the development of computer-assisted semen analysis (CASA) systems, it is possible to further subdivide “motile” spermatozoa into groups based on the direction (curvilinear or straight) and speed (velocity) of their forward motion. For the purposes of this paper, “motility” and “motile sperm” will be used to describe the percentage of spermatozoa in an ejaculate that possess any type of movement. “Mobility” will be used to describe the average direction and/or speed of a subset of motile spermatozoa in an ejaculate.

Motility

As mentioned previously, motility usually refers to the proportion of spermatozoa exhibiting any type of motion. The three most common situations in which the motility of a sample is reduced are low viability; storage of semen in hyper-osmotic extenders; and semen more than 3 days old. Low viability is obvious since dead sperm cells are not motile. Hyper-osmotic semen extenders usually suppress motility of spermatozoa. In terms of extending the “shelf-life” of semen, this is desirable. However, it does make it difficult to obtain an accurate assessment of motility. Sometimes, even after samples are warmed prior to microscopic observation, motility of sperm cells stored in hyper-osmotic extenders often appears sluggish. Prudent use of caffeine-coated slides can help negate the suppressive effect of hyper-osmotic extenders on motility.

When semen is stored for extended periods of time at reduced temperatures, biochemical mechanisms associated with motility and metabolism of spermatozoa slow down. This is necessary for maintaining the viability of stored semen. The metabolic state that sperm cells enter during storage at reduced temperatures is similar to that of hibernating animals. When the storage temperature begins to increase, metabolic processes also begin to increase. However, they do not

operate at their normal level immediately. Thus, the motility of spermatozoa warmed up after storage often appears to be slow and sluggish. This period is referred to as "anabiosis". Anabiosis is a metabolic state in which the mechanisms associated with motility are not operating at peak efficiency. During anabiosis, it is not uncommon for spermatozoa to remain in one location and "quiver"; move forward a short distance and then stop; or move slowly in a tight circle. Allowing additional time for the metabolism of sperm cells to return to normal before evaluations are performed is the best way to deal with this anabiosis.

Mobility

The accuracy and cost of computer-assisted motility analysis (CASA) systems have increased and decreased, respectively, to the point where they are becoming more commonplace in boar studs. In its simplest form, a mobility analysis attempts to describe the average path and speed it takes a sperm cell to move between two points. It does this by measuring how far the sperm cell moves forward from its original position, while simultaneously measuring how much the sperm cell deviates to the right or left. This is the direction or path component of the analyses. The diagrams in figure 1 help illustrate the basics of mobility analyses.

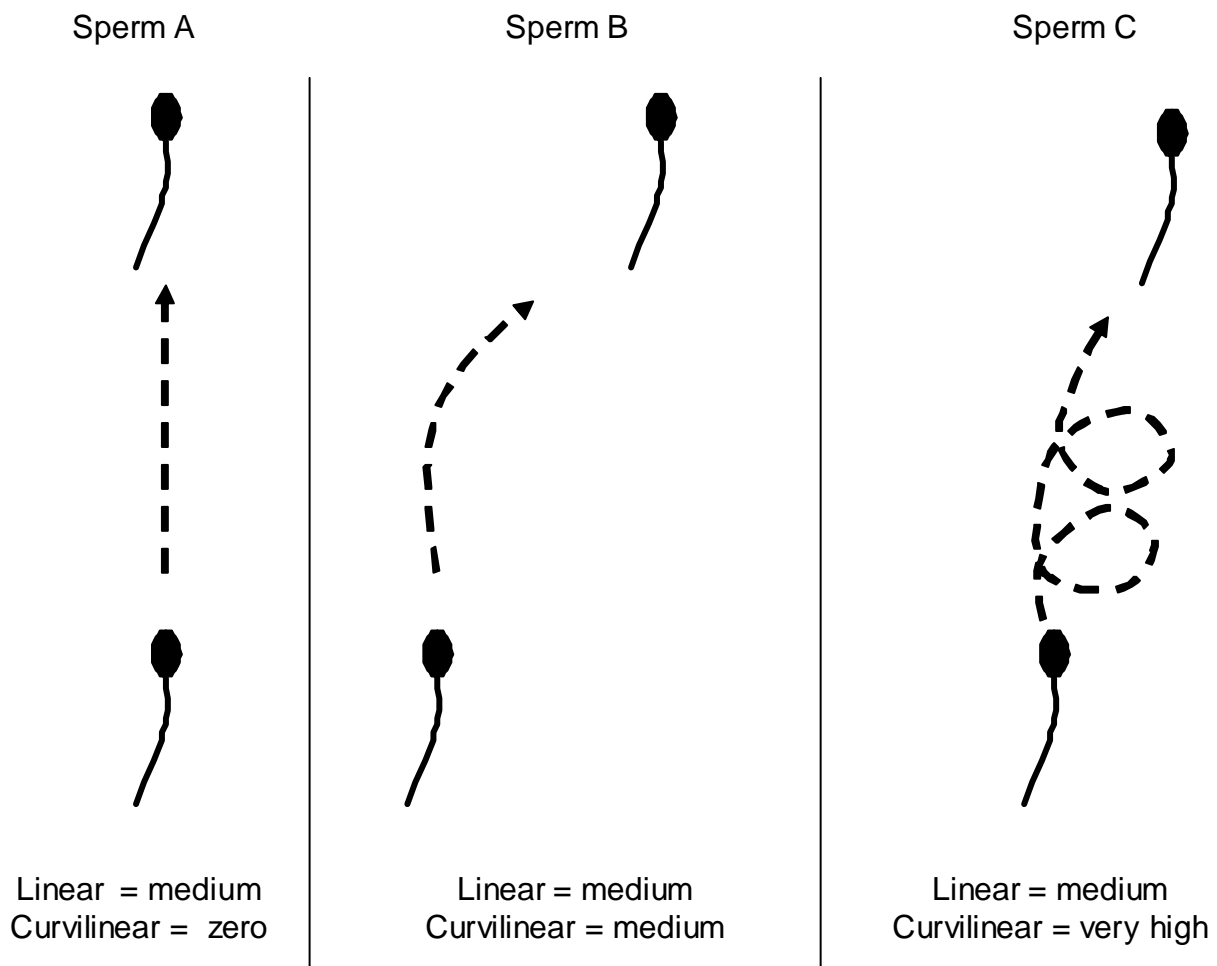


Figure 1. Simple representation of mobility classifications for spermatozoa. Sperm cell A's linear

velocity is medium and its curvilinear velocity is 0. The net result is that sperm cell A travels in a straight line. If the linear velocity remains at a medium speed, but the curvilinear velocity increases, then the path changes from a straight line to a curved line (Sperm cell B) or even a spiral-like path (Sperm cell C).

Unfortunately, there is limited information with regards to the relationships among mobility characteristics, semen quality, and fertility. However, there are a few situations in which mobility characteristics can be useful for identification of potential quality issues. The most common is when the linear velocity is very low and the curvilinear velocity is very high. Spermatozoa with these parameters move in a circle with minimal forward progression. In essence, they appear to be “spinning in place”, so to speak. This pattern of mobility is consistent with spermatozoa that have bent tails or have just begun to escape from anabiosis. The distinguishing characteristic between these two situations is whether the direction of the circular movement changes. Spermatozoa with bent tails spin in the same situation, while their counterparts escaping from anabiosis often spin in one direction, then appear to stop, and resume their circular motion in the opposite direction.

Morphology Evaluations

The three most common types of morphological evaluations conducted on spermatozoa are tail morphology, head morphology, and acrosome morphology. Tail and head morphology typically are conducted simultaneously with a light microscope under 40 to 100x magnification. Background staining is often helpful in visualizing head and tail morphologies. In contrast, acrosome morphology requires a phase contrast microscope or specialized stains and visualization with, at least, a 100x magnification.

Tail Morphology

In most instances, spermatozoa that exhibit tail malformations or an abnormal spatial relationship between the head and tail are both subfertile and non motile. Thus, assessment of motility of a semen sample often includes, usually as a subset, evaluation of normal tail morphology. The only exception to this is the case of translocated cytoplasmic droplets (also referred to as a midpiece lateral reflexion – Figure 2). Translocation of cytoplasmic droplets occurs when the cytoplasmic droplet does not detach from the midpiece and the sperm tail folds or bends back on itself around the droplet forming a 180 degree angle. Most spermatozoa with translocated cytoplasmic droplets still exhibit limited motility. When semen samples are evaluated for motility, it is important to check for the presence of translocated droplets. Inclusion of spermatozoa exhibiting this abnormality in motility calculations results in an overestimation of semen quality.

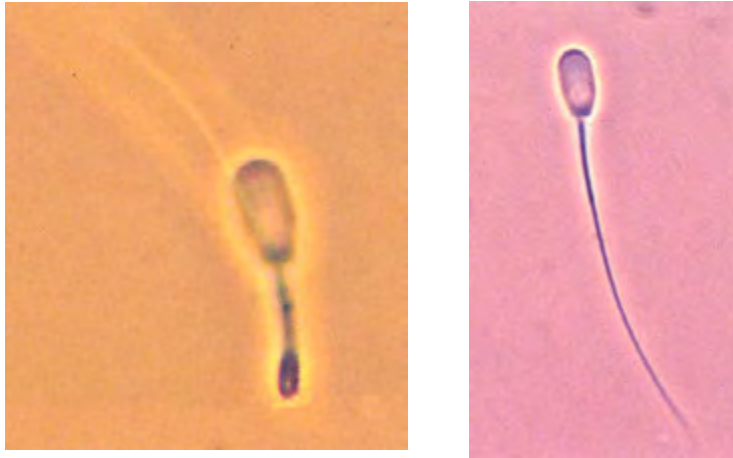


Figure 2. Normal sperm cell (right) and one with a translocated cytoplasmic droplet (left). Translocated cytoplasmic droplet is also called a midpiece lateral reflexion.

The most common types of tail abnormalities are curved or bent tails (Figure 3). Curved or bent tails are common responses of spermatozoa that have been exposed to extreme environmental conditions. These include severe temperature fluctuations, suboptimal changes in pH and/or osmolarity, toxic compounds, ultraviolet radiation, extreme pressure gradients and bacterial contamination (Saacke and White, 1972). There are other types of less common tail abnormalities. The vast majority of these are caused by genetic problems during the development of the tail. Abnormalities in this category include coiled tails, step tails, swollen tails, double tails, and lasso tails (Garner and Hafez, 1980). A general rule of thumb that is common among boar studs is to reject an ejaculation if the percentage of sperm cells with abnormal tail morphology is greater than 20% (< 80% normal).



Figure 3. Normal sperm cell (right); one with a curved tail (left); and one with a bent tail (center). Some classification schemes group curved and bent tails together, while others treat them as separate groups.

Definitive information with regard to maximum percentage of spermatozoa with abnormal cells that can be present in an ejaculate without affecting fertility is lacking. However, some general statements concerning the relationship between tail morphology and fertility can be made. First, in the case of curved tails, it is conceivable that all the spermatozoa in the ejaculate were exposed to the adverse environmental condition responsible for this morphological abnormality. Consequently, if

the environmental stressor also has latent effects on spermatozoa, then spermatozoa with apparently normal morphology at the time of evaluation may in reality be subfertile. There is limited circumstantial evidence that exposure to high ambient temperatures has both latent and acute effects on porcine spermatozoa (Wettemann et al., 1979). As a result, morphological criteria for normal tail morphology should be more stringent than similar criteria for motility. Second, it is true that the viability of stored semen is inversely related to the proportion of dead spermatozoa contained in the insemination dose. This is due to the fact that much of the buffering capacity of extended semen is used to neutralize chemical and physical changes associated with the degradation of decaying sperm cells.

Head Morphology

The size and shape of the sperm head are the primary criteria used to evaluate head morphology. The most common abnormalities are macro (very large) and micro (very small heads). These are illustrated in figure 4. All the most common head abnormalities are genetic defects. Spermatozoa with abnormal heads are believed to be subfertile because they have difficulty in binding to eggs during fertilization. However, spermatozoa with abnormal heads can be motile, so they represent a group of subfertile cells that might not be identified as such with only a motility analysis. Fortunately, boars that produce spermatozoa with abnormal heads tend to be rare.



Figure 4. Normal sperm cell (right); one with a macro head (left); and one with a micro head (center).

Acrosome Morphology

The acrosome is an essential part of the sperm cell because it contains enzymes such as acrosin and hyaluronidase which play a role in the penetration of the egg membranes during fertilization. Consequently, degeneration, malformation or damage of the acrosome is not compatible with normal fertility and the percentage of spermatozoa with a normal acrosome is an important semen quality parameter. The simplest method for acrosomal evaluation is the use of phase contrast microscopy with wet mounts of glutaraldehyde-fixed spermatozoa. With boar

spermatozoa, the apical ridge of the acrosome can be seen easily and categorized into several stages of deterioration - damaged apical ridge; loose acrosomal cap; and missing apical ridge (Pursel et al., 1972; Figure 5).

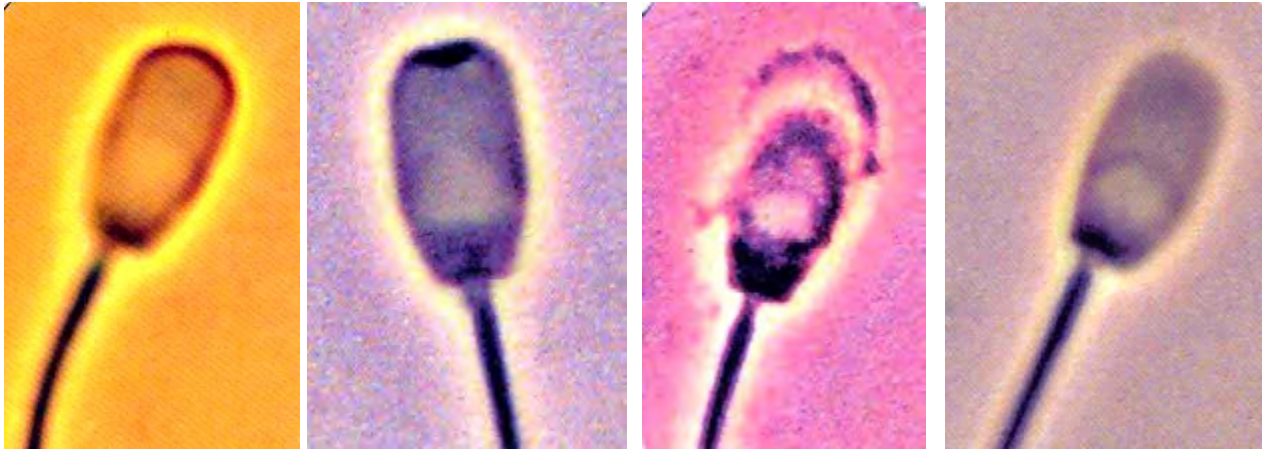


Figure 5. Normal and abnormal acrosomes. A normal acrosome resembles a dark, thin line around the top of the heads of the spermatozoa (far left). This dark, thin line is not present on sperm cells with a missing acrosome (far right). Sperm cells with damaged acrosomes appear to have a thick dark area at the top of their heads that does not cover the entire head (second from left). When the acrosome is loose or detaching, the head of the sperm cell appears rough and not smooth and can take on a variety of shapes depending on how much of the acrosomal membrane has detached (third from left).

The consensus from several different studies examining the relationship between acrosomal integrity and reproductive performance is that ejaculates containing more than 30 - 40% abnormal acrosomes yield reduced fertility (Woelders, 1991). Abnormal acrosomes can be caused by both genetic and environmental conditions. Those caused by genetic conditions usually have abnormal shapes and can be more prone to detachment. Environmental conditions that cause abnormal acrosomes include exposure to elevated temperatures, cold shock, osmotic shock, and exposure to a variety of chemicals. Spermatozoa with abnormal acrosomes can be motile. Consequently, when the fertility of semen is poor even if motility is good, then it is advisable to examine acrosome morphology.

Proximal and Distal Cytoplasmic Droplets

The percentage of spermatozoa with cytoplasmic droplets is also an important criterion for semen evaluation. The presence and location of a cytoplasmic droplet is an indication of the maturity of a sperm cell. During spermiogenesis (maturation of sperm cells) the cytoplasmic droplet migrates down the tail away from the head and eventually "drops off" at the midpiece (Garner and Hafez, 1980). For most boars, spermatozoa acquire fertilizational competence when the cytoplasmic droplet has migrated about one-half the distance of the midpiece. Thus, most spermatozoa with proximal droplets (next to the head) are incapable of fertilization, while most sperm cells with distal droplets are considered to be fertile. However, it is important to note that there have been documented cases in which the cytoplasmic droplet does not migrate off the tail and fertility is apparently normal.

From a practical perspective, ejaculates containing more than 20% proximal droplets should not be used for insemination.

Agglutination

Agglutination or "clumping" is a phenomenon in which the heads of large numbers of spermatozoa appear to be attached to one another when viewed microscopically. Rejection of ejaculates that exhibit a high degree of agglutination (> 30% of spermatozoa) is routinely practiced among boar studs in Europe and the U.S. Whether or not this practice is necessary is often a point of controversy. There are a number of situations in which agglutination of sperm cells can be induced. These include addition of dead, epithelial or sperm cells to an ejaculate; placement of spermatozoa on a glass surface; cooling an ejaculate too quickly after collection; damage to the acrosomal membrane of spermatozoa; and addition of compounds with antigenic properties (Saacke and White, 1972). Some of the causes of agglutination are directly related to reduced quality of an ejaculate (damaged acrosomes, dead epithelial or sperm cells), while others can be attributed to the evaluation process itself (placement of semen on glass, cooling too quickly). As a result, the relationship between agglutination and fertility has not been clearly established for porcine semen. Until this relationship is more clearly defined, use of a maximal level of agglutination at 40% probably is advisable.

Summary

Motility and morphology evaluations are an important part of assessing semen quality. They are most useful in the identification of subfertile or infertile ejaculates. They are less useful as a tool for ranking fertile boars. Unfortunately, changes in motility and morphology are fairly generic and only a very few are exclusively caused by a specific insult. Therefore, when abnormalities are observed, it is not possible to definitively identify the specific cause. Nevertheless, the ability to distinguish between genetically and environmentally-induced defects still can be useful, because there are no practical corrective actions that can be taken for boars that continually produce genetically abnormal spermatozoa.

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Boar Housing and Semen Collection Pen Considerations

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Introduction. The design and management procedures of a boar stud influences boar sexual behavior, efficiency of moving boars, efficiency of collecting semen, production of semen, and safety of workers. The design of a boar stud should consider the safety of employees during movement of boar to a “warm-up” area, during movement of stimulated boar to a semen collection pen, during the semen collection process, during removal of boar from collection pen, and during movement of the boar back to his stall or pen. Collection efficiency (number of boars collected per person per hour) is dependent on duration of: (1) time to move a boar to the “warm-up” area or collection pen, (2) time boar is in “warm-up” area, (3) time to move boar from “warm-up” area to semen collection pen, (4) time in collection pen until boar remains mounted on the dummy and begins ejaculation process, (5) time for ejaculation, (6) time until boar departs semen collection pen after ejaculation is completed, and (7) time to move boar back to his stall or pen. The design of the semen collection pen can influence the duration of time until a boar mounts the dummy and duration of time before the boar departs the collection pen.

Boar stalls. Boars are typically housed in stalls over total slats. Suggested dimensions of boar stalls are indicated in Table 1. Figure 1 shows a side panel of a boar stall. The side panel materials need to be strong enough to prevent the boars from bending the rods or pipe. Placement of the bottom horizontal bar of the stall divider should be at a maximum of 8 inches off the floor. In order to prevent boars from turning around in the alley while being moved, provide vertical head gates instead of slanted head gates. Feeding can be accomplished with either a recessed trough 4 inches below the floor surface or in a raised trough. Shorter stalls will require recessed troughs.

Boar pens. Some boar studs include a few pens to accommodate larger boars or boars that are lame. To prevent boars from climbing up the side of pens, construct pen partitions with vertical pipe or rods (4 to 5 inches on center). To enhance hygiene, either partial or total slatted flooring is recommended. Suggested dimensions for pen sizes are indicated in Table 2.

Alleyways. Design all alleyways to facilitate safe and efficient movement of boars to and from the semen collection area. Narrow alleyways in the front (Figure 2) and rear (Figure 3) will prevent: (1) boars from turning around during movement, and (2) provide a means to lock the rear gate of a stall open or prevent it from swing too far open.

Rear gate. If boar movement is always in the same direction, the rear gate can be designed to be opened from the front alleyway after the boar has exited his stall (Figures 4, 5 and 6). It is

extremely important to make sure the gate latch is designed whereby the boar can not open the rear gate.

Ventilation and cooling. A properly designed and managed ventilation system is critically important in maintaining fertility of boars, especially during extreme weather conditions. The Pork Industry Handbook (PIH-87, Cooling Swine) and the Midwest Plan Service (MWPS-43, Swine Breeding and Gestation Facilities Handbook) publications provide details on the design and management of ventilation, heating and cooling systems.

Some boars show signs of heat-stress at an ambient temperature of 81.5 F. If water is used to cool the boar, make sure the testicles are getting wet and air dried. An Australian study recorded a scrotal temperature of 89.6° F when the ambient temperature was 73.4° F (Stone, 1981). When the boar was heat-stressed at an ambient temperature of 93.2° F the scrotal temperature was 96.8° F (7.2 degrees higher when heat-stressed). Swedish data has clearly shown severe detrimental effects on sperm production of mature boars when their scrotal skin is exposed to temperatures of 93.2° to 98.6° F for 100 hours (Malmgren, 1989). Within the testes, heat-stress has detrimental effects on primary spermatocytes and spermatids.

Lighting. Adequate lighting should be provided throughout the facility for proper observation of the boar's health status and body condition. The recommended level of lighting for animal observation is 20 foot candles (Midwest Plan Service 43). The effect of intensity, duration, or type of lighting on sperm production has received very little scientific study. A general recommendation is to provide 10 to 12 hours of light per day. Additional lighting is required in the semen collection area.

Reicks collection pen. The objectives of the Reicks collection pen design are to improve collection pen efficiency and employee safety on a commercial boar stud (Reicks, 2002). Because all the collection pens in a newly constructed commercial boar stud were the Reicks collection pen design (Figure 7), a direct comparison within the same facility between the new design and the traditional pen design could not be conducted. Except for the collection pen design, the new boar stud was identical to another boar stud. Both boar studs (400 boars per facility) use the same training protocol, collection procedures, genetic composition, and management procedures.

The Reicks collection pen (45 inches wide x 8.5 feet long) is one-half the width of a traditional collection pen (7.5 feet wide x 8.5 feet long). The Reicks collection pen utilizes a solid partition swing gate (45 inches) to make the collection pen smaller and a 24-inch sliding gate within a 48-inch gate through which the semen collection technician can easily grasp the boar's penis. This design allows the semen collection technician to remain outside of the semen collection pen before, during and after collecting semen. The most recent designs of the Reicks collection pen has increases the length of the pen from 8.5 feet to 9 or 9.5 feet. The height of the pen partitions surrounding the Reicks collection pen is 39 inches. In the initial design to enhance the ability of technicians to stimulate boars to mount the dummy in a safe manner, two posts (32 inches high) were used as part of the pen partition in front of the dummy. The most recent designs have replaced the safety posts with a gate. The open area between posts or gate is 8 inches. The

traditional collection pen is surrounded by vertical posts (steel or plastic) and requires the semen collection technician to be inside the collection pen (Figure 8).

Performance data of Reicks collection pen. A data set on sexual behavior traits was collected during the same 5-day period in both boar studs. The number of boars observed was 126 for the traditional collection pen and 99 for the Reicks collection pen. The boars evaluated in both boar studs were 12 to 36 months of age. Data in Table 3 indicate the elapsed time from when a boar entered the collection pen until mounting a dummy sow for the Reicks and traditional collection pens. The boars mounted the dummy sow 26.9 seconds quicker in the Reicks design. The proportion of boars mounting the dummy sow within 60 seconds was 76.6% for the Reicks design and 54.8% for the traditional design (Table 4). The boars exited the collection pen 9.8 seconds quicker with the Reicks design compared with the traditional collection pen design (Table 3). The proportion of boars exiting the collection pen within 20 sec after dismounting was 90.9% for the Reicks design and 67.4% for the traditional design (Table 5).

The use of the Reicks collection pen clearly demonstrates how the design of a semen collection pen can influence sexual behavior of boars. This seemingly small difference in elapsed time to mount a dummy and elapsed time to exit a collection pen accumulates for boar studs with a large number of boars. If a boar stud collects 50 boars per day (260 days per year), the amount of time saved per year with the Reicks collection pen design is 97.1 hours for boars to mount a dummy sow and 35.4 hours for boars to exit the collection pen. In addition to saving time, use of the Reicks collection pen greatly improves the safety of the semen collection technicians. Enhanced safety procedures will reduce injuries to technicians.

Boar movement in Reicks System. The boar is moved down a narrow front alley (Figure 2) to the warm-up stall (Figure 9). The front gates on the boar stalls are solid. The boar has to enter the warm-up stall because the open gate cuts off the alley. After the boar has been sexually stimulated, he is easily moved through a narrow alley (Figure 10) to the semen collection pen. The semen collection pen allows the technician to remain outside of the collection pen (Figure 11). After the boar has been collected, he is easily moved out of the semen collection pen (Figure 12). Because of the narrow rear alleyway, the boar is easily moved back to his home stall (Figure 3).

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Table 1. Recommended dimensions for boar stalls

Boar size/weight	Width, inches	Length, inches	Height, inches
Large (>500 lbs)	28	96	46
Medium (350 – 500 lbs)	24	84	45
Small (<350 lbs)	20	72	44

Table 2. Recommended dimensions for boar pens

Boar size/weight	Width, feet	Length, feet	Height, feet
Large (>500 lbs)	7	10	4
Medium (350 – 500 lbs)	6	8	4
Small (<350 lbs)	5	7	4

Table 3. Elapsed time for a boar to mount a dummy sow and depart semen collection pen after ejaculation (mean ∇ SE)

Item	Traditional design	Reicks design
Elapsed time to mount dummy sow, sec	73.2 ∇ 6.3 (n = 123) ^a	46.3 ∇ 4.8 (n = 90)
Elapsed time to exit collection pen, sec	21.1 ∇ 2.1 (n = 126)	11.3 ∇ 1.9 (n = 99)

^a Number of observations are in parenthesis

Table 4. Percentage of observation by elapsed time to mount a dummy sow

Elapsed time to mount dummy sow, sec	Traditional design (n = 123) ^a	Reicks design (n = 90)
0 to 20	23.4	34.4
21 to 40	16.9	24.4
41 to 60	14.5	17.8
61 to 80	8.9	7.8
81 to 100	7.3	5.6
101 to 120	11.3	1.1
121 +	17.7	8.9

^a Number of observations are in parenthesis

Table 5. Percentage of observation by elapsed time to exit collection pen

Elapsed time to exit collection pen, sec	Traditional design (n = 126) ^a	Reicks design (n = 99)
0 to 10	37.3	72.7
10 to 20	30.1	18.2
20 to 30	12.7	2.0
30 to 40	5.6	3.0
40+	14.3	4.1

^a Number of observations are in parenthesis

Figure 1. Side panel of a boar stall

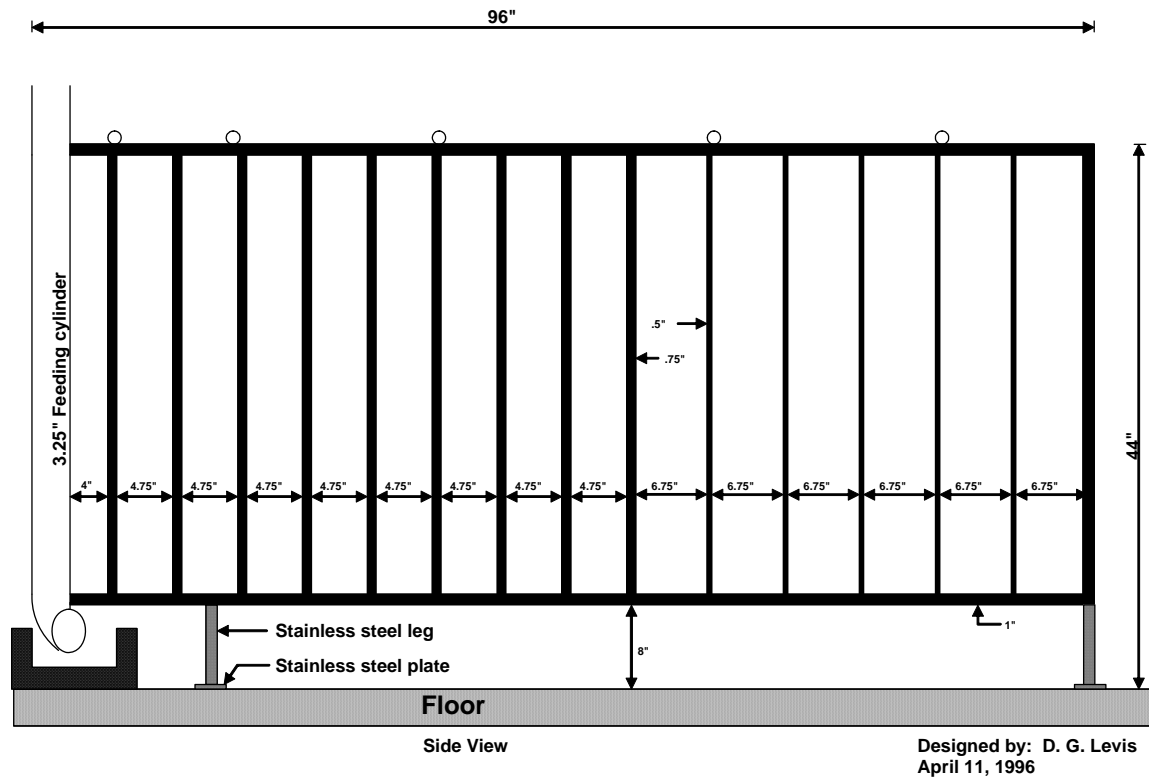


Figure 2. Moving boars in a narrow front alley to a warm-up stall (Reicks System)



Figure 3. Moving boars back to home stall (Reicks System)



Figure 4. Rear gate can be opened from front alleyway with a push-rod mechanism



Figure 5. Plate A shows the full-length of push rod. Plate B shows round pipe (blue arrow) is welded to bottom of U-shaped steel slide and functions as latch; a solid rod is welded to bottom of push rod; a round hole is drilled in bottom of U-shaped slide; solid rod falls into hole when rear gate is closed.

Plate A.



Plate B.



Figure 6. Plate A shows the U-shaped slide for the push rod. Plate B shows Push rod has opened rear gate; thus, handle of rod is next to U clamp (red arrow)

Plate A.



Plate B.



Figure 7. Line drawing of Reicks semen collection pen for boars

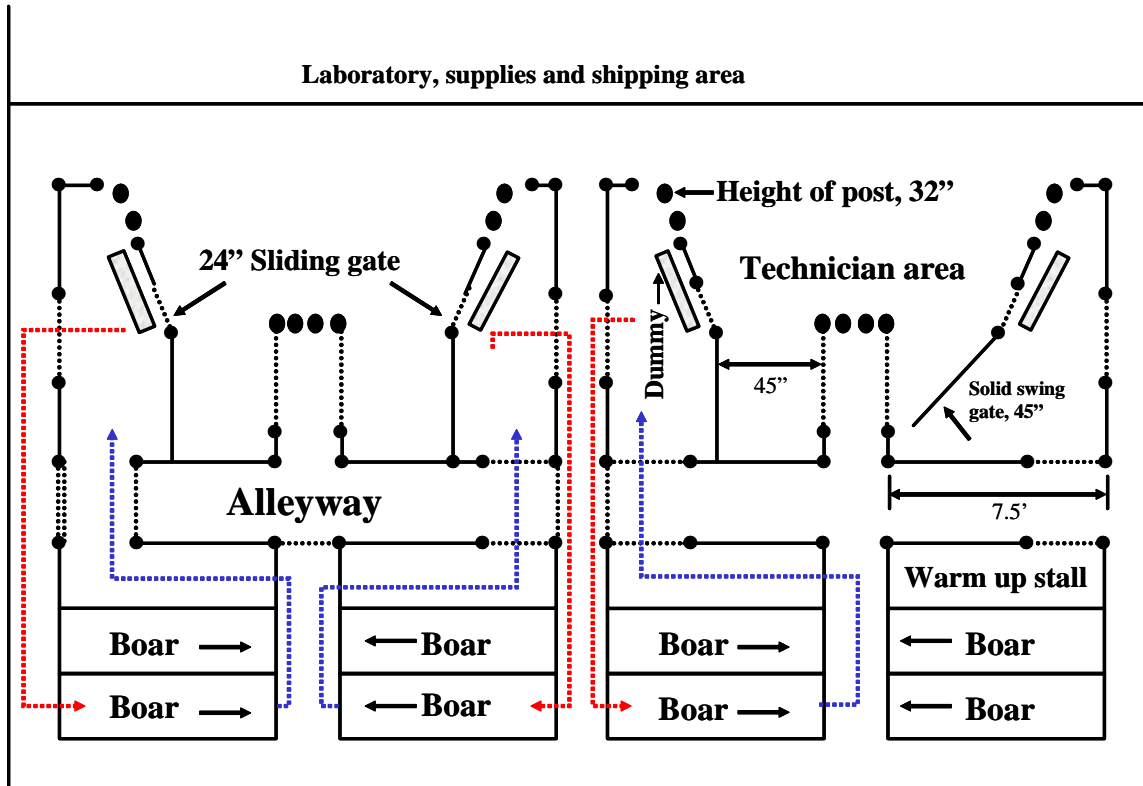


Figure 8. Typical boar semen collection pen with technician inside of pen.



Figure 9. Moving boar into warm-up stall (Reicks System).



Figure 10. Moving boar from warm-up stall to collection pen (Reicks System).



Figure 11. Collecting boar in semen collection pen (Reicks System)



Figure 12. Removing boar from collection pen (Reicks System)



HYGIENE: IN THE BARN AND IN THE LAB

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Background

Bacteria are a 'normal' component of the boar ejaculate (Sone, 1990). Generally, bacteria introduced during mating have little effect on the outcome of natural service (De Winter et al, 1992, 1996). However, bacteria can negatively impact the fertility of stored semen (Althouse et al, 2000). Typical signs of bacterial contamination include macroscopic sperm clumping, decreased longevity of extended semen, increased regular returns to estrus and post-insemination vaginal discharge. Laboratory assessment of contaminated semen may reveal a high incidence of agglutination, poor (5% to 30%) or no motility, and damaged acrosomes (>20%), an acidic pH (5.7 to 6.4). After aerobic culture at a diagnostic laboratory, single or multiple contaminants may be identified of both enteric and non-enteric origin. Traditionally, if extended boar semen was contaminated with a spermicidal organism, microscopic agglutination and reduced motility was usually observed within 36 to 48 hours. However, new patterns of bacterial growth dynamics in extended semen have been recognized as longer storage periods become more common (Pierdon and Althouse, 2004; Althouse and Lu, 2003). It should also be noted that not all agglutination is caused by bacterial contamination; some other causes include exposure to hypertonic liquids, fever, heat stress, and antibodies, etc.

Table 1. Bacterial isolates with known spermicidal activity

Acinetobacter lwoffii	Klebsiella pneumoniae
Aeromonas schubertii	Proteus mirabilis
Alcaligenes xylosoxydans	Pseudomonas fluorescens
Burkholderia cepacia	Ralstonia pickettii
Enterobacter cloacae	Serratia marcescens
Escherichia coli	Stenotrophomonas maltophilia
Flavobacterium (Myroides)	

(Althouse et al, 2000)

The reason bacterial contamination is such an ever-present danger is because semen extenders can easily function as dual culture media. The same attributes that make semen extenders ideal for maintaining sperm viability also allow them to work equally well as bacteria culture media. Although preservative levels of antibiotics are added to most commercial semen extenders, if contamination occurs with resistant bacteria, the result is often uncontrolled growth.

The mechanism of action, or means by which bacteria such as *E. coli* harm boar semen, is generally through a direct spermicidal effect which is largely concentration dependent (Diemer et al, 1996). Bacteria bind to the sperm surface and promote sperm-to-sperm adhesion through damage to the plasma membrane. Although reduced pH often accompanies bacterial overgrowth, this is not seen with all isolates, and reducing pH in the absence of bacteria is not sufficient to re-create the signs of severe agglutination with reduced motility (Althouse et al, 2000). Toxins produced by certain bacteria deserve further study as well, since sufficient evidence exists to suggest that they can play a significant role in damaging sperm cells and reducing sperm viability (Andersson et al, 1998; Reichs, 2003). Performing daily Quality Control (QC) checks (motility) on a sample from each batch of semen throughout its specified shelf-life will ensure that the boar stud is the first to know if a problem arises, and allows the source stud to notify customers before they use sub-standard semen for insemination.

Sources of Bacterial Contaminants

The main sources of bacterial contamination are the boars, the environment, and people. The majority of isolates that enter the semen during collection originate from the fecal material or preputial fluids of the boar. The boar's skin and hair, the collection dummy, and any other surface that comes in contact with the boar should be considered contaminated. Sources for environmental contaminants include organic matter such as feed or bedding, air/ventilation system and water. People can be a source of bacteria as well, but more often are guilty of spreading an organism of animal or environmental origin during normal collection and processing routines (i.e., 'cross contamination'). Some general risk factors for contaminating semen during collection include poor animal or barn hygiene, warm, wet, humid housing environments, solid floors, and poor collection technique.

Anything that enters the processing laboratory from the boar barn (i.e., semen, carrying containers, liners, people, etc.) should be assumed to be contaminated and treated accordingly. Much like all guns should be handled as though they were loaded at all times, barn materials entering that lab should be managed as though they contained a bright red 'biohazard' sticker. This is not to infer that fresh boar semen is a health hazard (although immunocompromised individuals should take extra precautions), but rather to alert everyone to the fact that it is not possible to tell what is contaminated and what isn't with the naked eye. Once an antibiotic resistant spermicidal strain of bacteria gets established in some area(s) of the lab, it can create havoc until it is identified, located, and eliminated.

Control Strategies

There are relatively few interventions that can be considered effective when it comes to bacterial contamination of extended boar semen. One surgical intervention with potential merit is preputial diverticulectomy (Althouse and Evans, 1994). In this procedure, the

preputial diverticulum is removed, thus reducing the amount of contaminating preputial fluids present at the time of collection. This procedure is impractical in most larger boar studs, and is only a partial answer to the problem. A similar approach involves infusing the prepuce with various antiseptic/disinfectant/antibiotic solutions in an attempt to kill the microflora normally found there. This practice is difficult to support, except in extraordinary circumstances as defined by your veterinarian, since re-colonization is inevitable.

In some on-farm collection situations or internal boar studs serving a dedicated system within a limited geographic area, it may be possible to observe a mandatory shelf-life of less than 48 hours for all extended semen. Depending on the bacterial species, original concentration, and extender composition, it generally takes two days or more before detrimental effects on fertility will be observed. Another option would be to cool semen to lower temperatures, or freeze it, during storage. Unfortunately, boar sperm are particularly sensitive to cold shock, and at the present time most commercial semen extender manufacturers do not recommend using their products at temperatures outside a fairly narrowly defined range (Althouse et al, 1998).

One popular control strategy is to add additional antibiotics to the semen extender. This should be considered a short-term intervention, to be performed only under the supervision and direction of your veterinarian, preferably in conjunction with diagnostic results including the identification of the offending organism(s) and antibiotic sensitivity testing. Once the source of the contamination has been found and addressed, the additional antibiotic(s) should be removed. Other special circumstances may trigger the temporary use of another antibiotic, but the goal should be to wean the boar stud from this practice as soon as practical. Boar studs that insist on adding 'extra' antibiotics can find themselves playing a dangerous game of 'antibiotic roulette'. Bacteria isolated from extended boar semen tend to be resistant to multiple antibiotics, and exposing this population to additional forms or classes of antimicrobial agents could result in no effective alternatives when control is needed most. In addition, the cost of continuously adding antibiotics can be prohibitive. Be aware that the extra-label use of antibiotics in food animals falls under the regulatory jurisdiction of the FDA. As such, your veterinarian will need to evaluate justification of such action under the Animal Medicinal Drug Use Clarification Act (AMDUCA) guidelines (Kuster, 2001).

Gentamicin has long been the standard preservative antibiotic included in most commercial extenders, and resistance to this antibiotic has been demonstrated in field isolates of spermicidal bacteria (Kuster and Althouse, 1997). Extender manufacturers have steadily increased the choices of antibiotics and combinations available with their products. While these products have their place in the industry, the choice of preservative antibiotics in the extender should be made in consultation with your veterinarian and/or boar stud consultant to address specific needs or concerns for your operation. The boar housing environment, season of the year, and past culture and sensitivity results are some of the items that should be considered when choosing extender antibiotics. Once again, the cost of utilizing the extender with the same basic composition but more expensive antibiotics needs to be justified.

Minimum Contamination Techniques (MCT)

After discussing the previous control strategies, we are left with the most common-sense approach, which is to minimize contamination during collection and processing. Table 2 offers suggestions on how to reduce the overall load of bacteria introduced into the extended semen. Although they are all important, a few specific points bear reinforcement. Double-gloving may be one of the most effective, or ineffective, strategies on the list. The objective is to use a ‘clean’ hand during the actual collection process. If you contaminate your second glove by leaning on the boar or offering extra stimulation, then you may just as well have only used one glove. Some collectors find it necessary to triple glove, or carry extra clean gloves in their pockets in the event that a boar does not cooperate and extend as they had anticipated. Diverting the pre-sperm fraction of the ejaculate (initial jets of clear fluid) allows you to prevent the fraction with the highest concentration of bacteria from contaminating the rest of the ejaculate (Gall et al, 1998). Additional interventions may be required for specific situations, but Table 2 lists the main recommendations that generally apply to most boar studs. Another useful resource is a publication by the American Association of Swine Veterinarians entitled Health, Hygiene, and Sanitation Guidelines for Boar Studs Providing Semen to the Domestic Market. The Boar Stud Guidelines are available to AASV members, and include a section (Section 1.4) on Hygiene and Sanitation Requirements for Semen Collection, Processing, and Storage (2003).

Table 2. Minimum Contamination Techniques (MCT):
Boar Preparation/Semen Collection (Althouse et al, 2000)

-
- 1) Trim hair around preputial opening
 - 2) Double glove, discarding outer glove after boar prep
 - 3) Use disposable gloves or hand disinfectant between collections
 - 4) Clean preputial area with disposable wipe
 - 5) Manually evacuate preputial fluids
 - 6) Hold penis perpendicular to the boar
 - 7) Divert pre-sperm and gel fractions from cup
 - 8) Dispose of filter prior to passing semen to lab
-

Processing Laboratory

As previously discussed, the main source of bacteria in the lab are items that enter from the barn, including raw semen; however, there are certain other routes that are more specific to the lab environment such as the water used to prepare extender and rinse reusable supplies, forced-air ventilation systems, and people, to name a few. By far the most common problem in the lab is the cross-contamination that takes place during processing. While it may not be possible to completely prevent this from happening, certain precautions should be observed. Frequent and effective hand washing, sanitizing or changing gloves, immediately addressing spills, and thorough clean-up at the end of each processing period are key points. Anything that gets touched by contaminated hands (i.e., pipettors, computer keyboards, door handles, telephones, etc.) can become a

haven for bacteria and allow a cycle of contamination to be sustained not only within a day, but between processing days as well. Table 3 suggests specific procedures to follow in the lab to reduce contamination. Items such as re-usable rags or sponges should be banned from the laboratory due to their propensity to harbor and spread bacteria. Each laboratory is different, and therefore cleaning procedures can and should be tailored to individual circumstances. Written SOP's and check-lists can be helpful to remind existing staff members of how and when specific duties should be performed, but they are even more useful for training new employees and providing a benchmark from which informed decisions can be made regarding the effectiveness of changes and interventions regarding lab sanitation and hygiene.

Table 3. Minimum Contamination Techniques (MCT)
Semen Processing/Laboratory Sanitation (Althouse et al, 2000)

- 1) Utilize disposable products whenever feasible
- 2) Sanitize reusable lab materials properly by heat/gas sterilization, boiling, or 3-step cleaning protocol (residue free detergent, purified water, non-denatured alcohol)
- 3) 'Rinse' reusables with semen extender prior to use
- 4) Disinfect countertops and equipment daily with a residue-free detergent
- 5) Mop the lab floor each day with a disinfectant
- 6) Break down bulk products into smaller, daily quantities
- 7) Consider installing UV lighting as an aid in sanitizing lab surfaces

Risk Levels

It is helpful to recognize three distinct levels of risk when discussing bacterial contamination of extended boar semen. Level III would be considered the highest risk. At Level III, antibiotic resistant bacteria are present and exerting spermicidal effects on the extended semen. These bacteria can be recovered on aerobic cultures from one or more doses of semen. Level II would be considered medium risk. Antibiotic resistant strains of clinically insignificant bacteria are identified by cultures of the extended semen, but shelf-life is unaffected. Not all bacteria are spermicidal, and it is not uncommon to find colony growth on culture plates in the absence of adverse clinical effects. However, the mere presence of bacteria demonstrates a breakdown in barn and/or laboratory hygiene that should be addressed to prevent future problems. Level I is the low risk category, and is defined by no significant growth on aerobic culture after 48 hours of incubation. In order to better serve their customers, all boar studs should strive to achieve Risk Level I.



Figure 1. Mixed bacterial colonies from contaminated extended boar semen

Conclusion

In conclusion, the most important step to improving hygiene in the boar barn and processing laboratory is to follow the Minimum Contamination Techniques and similar guidelines, as outlined above. Resist the temptation to play ‘antibiotic roulette, perform QC checks daily, and verify your Risk Level status by submitting randomly selected doses for culture on a routine basis and whenever shelf-life is reduced. The AASV Boar Stud Guidelines calls for monthly aerobic culturing of 1% of total monthly collections (individual or pooled lots) or four (4) samples per week, whichever is greater. One concluding word of advice; it is always beneficial to bring in an extra set of trained eyes, not only to help resolve existing issues, but more importantly, to help identify critical areas for improvement *before* they become a problem.

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Health and Biosecurity
Midwest Boar Stud Manager's Conference II
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Introduction:

The protection of the health status of today's modern boar stud units has moved into ever sharper focus as PRRS and other pig pathogens continue to cause performance set backs that cost commercial producers a great deal of money. In addition to the threat of pathogens of economic importance present in this country there is the additional threat and need for increased awareness of those pathogens that may be introduced into a boar stud inadvertently or as a result of an act of bioterrorism. Today we use the term "biosecurity" to describe all of the herd health measures that must be considered to protect the safety and economic viability of our pork production systems. Additional biosecurity information for boar studs can be found in the NPB publication: [Biosecurity and Health Assurance at a Boar Stud](#)

Disease control is one of the most challenging areas for boar stud managers and veterinarians. Biosecurity is often perceived as keeping diseases out of a swineherd. However, eliminating disease from a herd is nearly impossible because of the natural presence of pathogens - the endemic pathogen load - in all swine herds. Therefore, the goal of a biosecurity program is to keep out pathogens that the herd has not been exposed to and to minimize the impact of endemic pathogens. With a good biosecurity program, optimal growth can be reached by minimizing the negative effects of subclinical illnesses. High reproductive performance can be attained in the breeding herds supplied by a boar stud by minimizing costly factors such as embryonic loss or preweaning mortality due to disease.

Management practices on swine breeding farms are aimed at securing the health of the pigs on the farm. Artificial Insemination (AI) has been identified as one of the management tools that can be used to aid in preventing the introduction of non-endemic pathogens onto a pig farm. The use of artificial insemination practices allows for increased productivity and production efficiency by decreasing the health risk of introducing new boars on a regular basis and the use of AI facilitates proper isolation practices. For these reasons and many more the application of AI techniques on commercial swine farms will continue to increase.

Proper isolation and Introduction of new boars:

(Additional information can be found in the [AASV Boar Stud Guidelines](#))

Health security measures of a boar stud should include proper isolation and acclimation of all incoming replacement boars. This acclimation and isolation period may last up to 60 days to allow for proper serological monitoring of animals to avoid the introduction of non-endemic pathogens into the boar stud. **A thorough sanitation program is highly recommended to disinfect the isolation premise between groups (a suggested sanitation protocol can be found in Appendix I).**

Genetic selection should be approached with the goal of minimizing the risk of introducing disease into your stud. Modern boar studs must receive new boars periodically to assure genetic progress. All new breeding boars should come from a single source using a genetic pyramid production system. In a pyramid system, the purebred animals at the top of the pyramid (nucleus herd) are the highest level of biosecurity and health status. Commercial production animals are at the bottom of the pyramid with multiplier animals in between. Animals should arrive at your stud from a higher level in the pyramid. The biosecurity for a boar stud is much the same as the biosecurity program of a production unit, including the isolation and acclimation of new boars.

Isolation facilities should be located at least 500 yards from the main herd. Although there may be reasons for longer periods, a minimum of 30 days isolation and 30 days acclimation are necessary for good biosecurity. During isolation, the new animals should be blood tested and observed for any signs of disease. If animals come from out of state, they are required to be tested for pseudorabies (PRV) and brucellosis (the PRV testing requirement may be changing as more states attain PRV eradication stage V-check with your state veterinarian). A suggested isolation protocol may include, but not be limited to the following considerations:

- 1.) Source herd must be Free of Clinical signs of APP, PRRS, SIV and TGE.
- 2.) Source heard must be APP, PRV*, and Brucellosis Free.
- 3.) Source herd must be PRRS negative.
- 4.) Primary Isolation Program (60 days)

The minimum health concern of most boar studs would include: Pseudorabies (PRV), Brucellosis, Porcine Respiratory and Reproductive Syndrome (PRRS), Porcine Respiratory Corona virus (PRCV), Transmissible Gastroenteritis (TGE), Actinobacillus pleuropneumoniae, swine Influenza (SI), and Leptospirosis. An additional disease of concern may include *Mycoplasma hyopneumonia*. The specific tests for a given operation should be determined with the herd veterinarian (a suggested protocol for your consideration is included in fig 1). Be sure to evaluate test results with your veterinarian before moving any animals from isolation. The isolation period protects the receiving farm from any disease agents that may have infected the boars prior to or during transportation.

Acclimation may be done in the same facility as isolation, although only one group of animals at a time. During acclimation, the new animals need to be exposed to the pathogens present in the main herd through the use of manure (biofeedback) or placing cull animals in the same pen with new animals. You should be aware of the current disease profile of your boar stud.

Figure 1.

Isolation & Handling Procedure Considerations for Boar Studs:

A. Blood test:

1. Upon arrival-test for PRV, Brucellosis, App, TGE, SIV and PRRS (ELISA).
2. Retest boars 21 days after arrival for PRV and PRRS (ELISA).
 - a) If PRRS (ELISA) is greater than 0.40 then hold and retest 14 days later.
3. 30 days after arrival send semen to a reputable/independent lab and have the PCR test run.
 - a) Any positive sample will have to be retested 2 weeks later before animal is allowed to enter the stud.
 - b) If sample is positive after 2 weeks the animal should be culled from the isolation facility and the remaining boars should be retested.

B. Treatments

1. Upon arrival: Vaccinate for: PRV*, Parvo/Lepto and administer injectable anthelmintic.
2. 21 days after arrival- Booster with PRV*, and Parvo/Lepto vaccine.

C. Chores are to be done the last thing each day and a shower is required before re-entering the boar stud after having been in the isolation facility.

Note: PRV vaccine is not allowed in the State of Missouri with out prior approval of the MO state veterinarian

Health Monitoring for Boar Studs:

The health status and pathogen profile of a boar stud should be monitored on a weekly basis and if possible a PCR of pooled semen should be conducted weekly. Individual medical records should be maintained on each boar. These medical records should include background from the source farm as well as from the isolation unit. All deaths that occur in isolation or in the stud itself should have a complete written necropsy record with histopathological findings and any other diagnostic investigations. All routine serological, tissue, and fecal records are to be included in the monitoring protocol. A suggested monitoring protocol may include, but not be limited to the following considerations:

- 1) Quarterly vaccinate herd with PRV* and Parvo/Lepto.
- 2) Morphological analysis on semen (5 samples per week) performed by a reputable/independent lab.
- 3) Monthly serological evaluation of 10% of herd for PRV*, PRRS (ELISA), and Brucellosis.
- 4) Perform monthly bacterial cultures on semen (document high health status)

*Note: PRV vaccination is not allowed in the state of Missouri with out the pre-approval of the state veterinarian.

Seminal Transfer of Pathogens:

Individual doses of semen are generally extended with a low inclusion level of antibiotics to limit the spread of bacterial pathogens in the semen. Table 1 identifies the bacteria that have been identified in boar semen. It is important to note that there are some bacterial pathogens commonly found in boar semen.

Table 1

Commonly Found	Infrequently Found
Staphylococcus spp	Corynebacterium spp
Pseudomonas spp	Streptococcus spp
Escherichia spp	Proteus spp
Klebsiella spp	Serratia spp
Citrobacter spp	Bacillus spp
Micrococcus spp	Enterobacter spp
Eubacterium spp	Aerobacter spp
	Bordetella spp
	Mycoplasma spp
	Brucella suis
Spirochete	Actinobacillus
Leptospirosis	Pasteurella spp
	Erysipelothrix rhusiopathiae
	Salmonella spp

In addition to bacterial pathogens some viruses can be transmitted through the semen and some viruses can contaminate a semen sample (Table 2). It is particularly important to recognize that PRRS virus can be transmitted in boar semen. A Polymerase chain reaction (PCR) test has been developed to detect the presence of the RNA material of PRRS in semen in an effort to determine a PRRS “free” status of semen.

PRRS Note: The presence of PRRS virus in boars appears to adversely affect sperm quality especially at high doses. It is also known that PRRS is transmitted in the semen and boars breeding naturally may serve as a source of exposure to naive sows in the breeding herd. For this reason an AI stud that documents all of their monitoring practices can provide assurance that PRRS is not being spread through the semen.

Table 2

Viruses Identified in Boar Semen

Transmitted through Semen

Pseudorabies

PRRS

Porcine Parvo virus

African Swine fever

Semen Contaminant

Adenovirus

Cytomegalovirus

enterovirus

Foot and Mouth Disease

Hog Cholera

Japanese Encephalitis

Reovirus

Swine Influenza

Swine Vesicular Disease

Transmissible Genital Papilloma

It is apparent that there are numerous diseases associated with seminal transfer and these diseases can be a reflection of a stud’s management. For this reason many boar studs conduct a pre-purchase disease profile and a “vet-to-vet” conference before allowing new boars to be delivered to the isolation unit of their boar stud.

PRRS Considerations:

PRRS will be the only specific disease addressed in this presentation as the immunosuppressive affects of this virus and the economic devastation of this virus have been documented. Results from a Pork Check off-sponsored study indicate that PRRS is costing the U.S. pork industry over \$600 million each year (Lawrence J, 2003). The National Pork Board has recognized the need to gain further understanding of PRRS and develop a coordinated effort to control it. This coordinated effort is currently being facilitated by the NPB through the efforts of Dr Eric Neumann. For the year 2004 there will be \$2 million available from the NPB for PRRS specific research and an additional \$4 million from the National Research Institute (NRI).

The interaction of this virus with farm specific pathogens and management factors contribute to the complexities of this viral disease. Dr Scott Dee at the University of Minnesota has demonstrated that after exposure to infected pigs, contaminated boots and coveralls and hands can transmit PRRSV from infected to susceptible pigs (Satoshi & Dee 2002). In this study they also found that washing hands and putting on clean coveralls and boots was as effective in preventing the transfer of PRRS virus as:

- 1) showering in and out with a 12 hour down time
- 2) showering in and out with no down time

Dr. Scott Dee from the University of Minnesota also demonstrated that PRRS virus could be transmitted in a snow ball containing PRRS infected fluid under the wheel-well of his truck. Dr Dee drove about 30 miles to a car wash, where he removed the snow ball. He then washed his truck, stomped on the snowball, and got back into his truck. He drove to a facility, walked into the shower entrance, removed his boots and allowed the snow and ice to melt from his boots onto the floor. While in the production unit he then set up a number of cardboard and Styrofoam boxes in the resulting puddles. This entire process was repeated 10 times. Dr. Dee tested for the presence of PRRS virus particles at each phase of the process (at the carwash, on his boots, on his truck floorboard, on the containers, etc.). In the majority of the times that he performed the above process, he was able to detect PRRS virus particles at each phase. This also included the bottom of the containers that were set in the water puddle created by his boots (Dee SA & Deen J 2002).

Dr Dee and his colleagues also demonstrated that PRRSV could be transmitted from farm to farm in mud contaminated with PRRSV. In this study a vehicle was contaminated with viral infected mud this resulted in contamination of the driver's boots and then the mud from the driver's boots was allowed to drip onto the floor of a farm reception area resulting in contamination of containers of farm supplies. The results of the study indicated that mechanical transmission of PRRSV could occur in warm weather, but it would probably be an uncommon event (Dee SA & Deen J 2003).

Dr. Scott Dee and a student also demonstrated that houseflies could transmit PRRSV. His goal in this case was to determine how long PRRS virus could survive in housefly ingesta and on the body of the fly itself. He exposed houseflies to PRRS positive pigs and tested them for the existence of PRRS virus at 0, 6, and 12 hours. PRRS virus was detected both inside and outside of the houseflies post exposure (0 hour). His results indicated that PRRS virus can survive inside the fly for 12 hours, but not on the exterior of the flies. This study supports the possibility that multiple species of biting insects could spread PRRS between pigs (Boorman JA, Dee SA 2004).

It would seem that the PRRS virus can be tracked mechanically from farm to farm, virtually at any time of the year, from winter through summer. These studies also identify new areas of risk, such as the cab of a vehicle, the farm office/entry room and delivered packages. However, it would appear that moisture is required to preserve the PRRS virus outside of the pig host. Every effort should be made to prevent damp or wet materials from entering into a boar stud or production facility.

Conclusions:

The use of Artificial Insemination in swine production continues to expand as this technique allows breeding managers to improve the biosecurity of their herds and utilize existing facilities in a manner that will reduce the fixed costs per pig and allow for genetic improvement that will improve the profit potential of the farm. As the use of AI in swine production continues to increase there is an ever-increasing responsibility for boar stud managers to assure the health status and biosecurity of the boars in their studs.

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Appendix I Disinfection Plan

This disinfection plan requires a minimum of three weeks “down time”. This down time has been proven to be beneficial in reducing pathogen survivability.

Week 1-Three step wash and sanitize

Before beginning sanitation/disinfection process all equipment must be removed and all damaged curtains must be replaced.

Cold Water wash 1200psi (day 1)

Hot water wash (day 2)

Scrub any remaining residue or organic material (day 3)

Week 2-Three step disinfection process

Bleach wash, followed 1 hour later with cold water rinse (day 1)

Phenol wash, followed 1 hour later with cold water rinse (day 2)

Vercon[®] in hot fogger, followed 1 hour later with cold water rinse (day 3)

Week 3-Further Maintenance

Paint any exposed wood (2 coats of paint)

Seal or paint all concrete flooring and surfaces

Biosecurity and Health Assurance at a Boar Stud

An Outline of Questions to Ask Your Semen Supplier

Introduction

Preventing the introduction of disease agents is a continuous challenge for pork producers and veterinarians. When a farm or site is affected by disease, the impact can be devastating to the health of the swine and the producer's bottom line. If a foreign animal disease were to overcome the biosecurity safeguards in place on our farms and our country, it would have a devastating effect on all pork producers.

One route of disease entry to a farm is through introduction of genetic material. Introduction of live animals offers the greatest risk of disease transmission. Artificial insemination can lessen this risk; however, biosecurity still is very important because bacteria and viruses can spread from infected boars to females through semen. Consequently, it is recommended that producers and veterinarians develop farm-specific biosecurity protocols for purchased or delivered semen.

Bacteria Found in Boar Semen*

Common	Infrequent
Staphylococcus spp.	Corynebacterium spp.
Pseudomonas spp.	Streptococcus spp.
Escherichia spp.	Proteus spp.
Klebsiella spp.	Bacillus spp.
Citrobacter spp.	Enterobacter spp.
Micrococcus spp.	Aerobacter spp.
Eubacterium spp.	Bordetella spp.
	Mycoplasma spp.

Viruses Found in Boar Semen*

Common	Infrequent
Adenovirus	Pseudorabies virus**
African swine fever**	Porcine parvovirus**
Classical swine fever virus**	Porcine reproductive respiratory syndrome virus**
Cytomegalovirus	Reovirus
Enteroviruses	Swine vesicular disease virus
Foot-and-mouth disease virus	Transmissible genital papilloma virus
Japanese encephalitis virus	

**Known to be transmissible through semen

* Source: The Swine AI Book: Second Edition, Chapter 3; Publisher: Dr. Morgan Morrow, NCSU



Detection of bacteria and viruses in semen does not necessarily correlate with transmission of those agents through semen. In fact, most bacterial and at least some viruses present in semen can be the result of contamination during collection and processing and not actual shedding by the boars.

Biosecurity Considerations for the Stud Facility

The following questions can be used as a framework to assist pork producers and their veterinarians in assessing the biosecurity risk associated with a potential new semen supplier for their herd or to evaluate the biosecurity of their current semen supplier. More detailed, farm-specific questions may evolve from these questions through active participation by your veterinarian. As you work through this exercise, keep the following questions in mind:

1. Has the semen supplier been able to answer your questions?
2. Are you satisfied with the answers you received?

Figure 1 is designed to assist readers in understanding some of the terminology used in the suggested questions that follow.

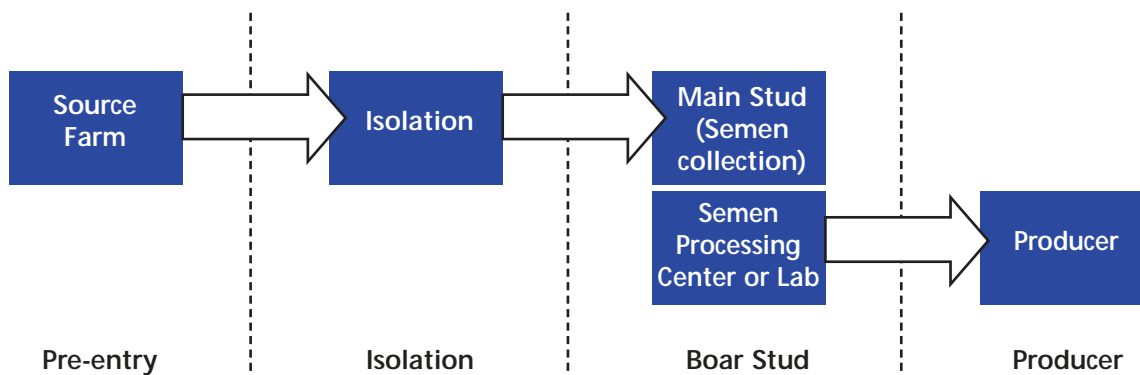


Figure 1. Schematic Production Flow

Fresh semen cannot be "isolated" as you would live animals. Good biosecurity at the stud is your only means for minimizing the disease risks that come with using semen from an outside supplier. However, even when your semen supplier does everything correctly, the biosecurity risk is never zero.

General Inquiries for Boar Stud:

This section is designed to establish the general health status and biosecurity practices of the boar stud.

What is the number of source herd(s) from which the current boar population at the stud originated?

What is the number of source herd(s) that have contributed to the population at the boar stud since its original stocking?

Does the boar stud utilize an isolation facility for replacement boars?

How far is the boar stud facility from other swine? From a major highway?

Are biosecurity procedures for the boar stud in written format and available for review?

Do you have a written visitor policy that is available for review?

Is the boar stud a shower-in, shower-out facility?

Is downtime from pig contact required before people can enter the facility? If yes, what is the length of the downtime required?

Are employees allowed to raise pigs on their home farm?

Please provide documentation to indicate the status of the boar stud for the following diseases: porcine reproductive and respiratory syndrome (PRRSV), pseudorabies (PRV), brucellosis, and leptospirosis.

Have there been any clinical signs of disease within the boar stud in the last 12 months? If yes, please provide diagnostic information and the actions taken.

Is semen ever collected from boars that have been allowed to serve naturally?

Has the boar stud ever been depopulated? If yes, for what reason?

Does semen shipped from the processing center originate from a single stud or multiple studs?

Where is feed for the boar stud produced? Are biosecurity protocols in place at the mill?

Are animal by-products allowed as a feed ingredient?

Is the feed delivered to the stud in meal form or is it pelleted?

Pre-entry or Source Herd Inquiries:

Are there any specific health procedures and requirements of the source farm(s) prior to shipment of individual animals to the boar stud?

Does the source herd(s) have a written herd health assurance program(s) that is available for review?

Does the source herd(s) have a designated herd veterinarian? Does the herd veterinarian make regular visits to observe the animals?

How frequent are the visits? Please provide the contact information in the event my veterinarian wishes to initiate a vet-to-vet health communication.

Describe the current health status of each source herd(s).

Are biosecurity procedures to prevent disease introduction, including isolation protocols, available from the source herd(s) in a written format?

Please identify any vaccines used in the past 24 months. What is the current vaccination protocol at the source herd(s)?

Is any diagnostic testing performed on a routine basis? If yes, what tests are performed?

Does a veterinarian interpret all diagnostic test results?

How frequently does communication occur between the source herd veterinarian and the boar stud veterinarian?

What transportation biosecurity protocols are used when delivering boars to the boar stud?

Isolation Procedures:

Isolation allows time to observe new boars for signs of disease before entry to the stud. Isolation also provides the opportunity to test animals for exposure to certain diseases and to acclimate or vaccinate animals. Continuous pig flow through an isolation facility cannot be considered proper isolation. Failure to isolate new boars offers the greatest risk of disease introduction into the boar stud, and subsequently into your herd.

Does the boar stud utilize isolation procedures?

Is pig flow through isolation managed in an all-in, all-out manner?

Is the isolation building cleaned and disinfected between groups of boars?

Are boars in the isolation unit exposed to the outdoors or totally enclosed?

Is the isolation facility on-site or off-site?

How far is the isolation facility from other swine, including the main stud?

What is the length of the isolation period?

Does the isolation facility serve more than one boar stud or swine farm?

What vaccination and parasite control protocols are used during isolation?

Are the boars in isolation routinely monitored for signs of clinical disease? If yes, how often and by whom?

Are boars in isolation routinely monitored for seroconversion to specific pathogens?

If yes, which pathogens?

Please describe the timing and frequency of diagnostic testing in isolation as it relates to boar entry dates and vaccinations.

Serological testing at the time of entry may provide a source herd baseline for interpreting results and can indicate exposure to diseases in the past. Testing two to three weeks after entry into isolation gives the boar's immune system time to produce the antibodies that are detected by the test. Contamination during transportation may not become serologically evident until two to three weeks into isolation. It requires ten days to three weeks after exposure before a boar will test serologically positive to most diseases.

If routine serological testing is performed in isolation, is this testing performed on the entire population or on a subset of the entire population?

If a subset (percentage) of the boars is tested, how is the number of boars to be tested determined?

Does a veterinarian review and interpret all test results?

Are any boars ever moved to the main stud before diagnostic results are received and interpreted?

What is the policy if a boar in isolation tests positive for a pathogen on a diagnostic test?

- Is the sample rerun utilizing the same test?
- Are other tests for the same pathogen run?
- Is the boar retested?
- Are any of the other boars in isolation retested? If yes, how many and how long after the positive result?
- If the positive boar continues to test positive, then what is the protocol?
 - Is the boar removed from isolation?
 - Does a veterinarian perform a post-mortem on the boar?
 - Is a complete diagnostic work-up performed with samples submitted to an accredited diagnostic lab?
 - What health assurance measures are taken on the remaining boars?

What is the protocol if a boar dies in isolation?

- Does a veterinarian perform a post-mortem on the boar?
- Is a complete diagnostic work-up performed with samples submitted to an accredited diagnostic lab?

What transportation biosecurity protocols are used when delivering boars from isolation to the boar stud?

Health Assurance of the Main Stud:

Disease monitoring is often a routine part of health maintenance at a boar stud. Testing of boars and semen can be useful in the detection of disease. In addition to concern about new diseases entering the stud, attention must be paid to the overall well-being of individual boars and their freedom from common diseases and injuries. These questions will define the normal standard of care for boars once they have entered the main stud.

How often are boars entered into the stud?

Does a formal and written health assurance plan exist for the main stud?

Are boars routinely monitored for specific pathogens through serological testing or other diagnostic procedures? If yes, describe which pathogens and the method, timing, and frequency of the diagnostic testing.

If serological testing is used, is it performed on the entire population or on a subset of the entire population?

If a subset (percentage) of boars is tested, how is the number of boars to be tested determined?

What percentage of the boar stud population is tested...

- on a monthly basis?
- on an annual basis?
- other?

Are diagnostic tests performed on semen? If yes, which tests and how often?

Has the boar stud ever been determined to be positive for Porcine Reproductive and Respiratory (PRRS) virus? If yes, please describe the status today.

Does a veterinarian review and interpret all test results?

Please identify any vaccines used in the past 24 months. What is the current vaccination protocol for the boar stud?

Is a new needle used for each boar that is vaccinated or treated?

What is the response protocol if a boar in the main stud tests positive for a pathogen on a diagnostic test?

- Is the sample rerun utilizing the same test? Are other tests for the same pathogen run?
- Is the boar retested?
- Are any of the other boars in the main stud retested? If yes, how many and how long after the positive result?
- If the positive boar continues to test positive, then what is the protocol?
 - Is the boar removed from the main stud?
 - Does a veterinarian perform a post-mortem on the boar?
 - Is a complete diagnostic work-up performed with samples submitted to an accredited diagnostic lab?
 - What health assurance measures are taken on the remaining boars?

What is the protocol if a semen sample tests positive for a pathogen on a diagnostic test?

What is the protocol if a boar dies in the main stud?

- Does a veterinarian perform a post-mortem on the boar?
- Is a complete diagnostic work-up performed with samples submitted to an accredited diagnostic lab?

Herd Closure:

Herd closure occurs when a confirmed or suspected disease situation occurs at a boar stud that requires the termination of all semen deliveries from the stud. Customers should be aware of the criteria that would initiate a herd closure event, understand how and when they would be contacted by the semen supplier, and have plans for alternative sources of semen before they enter into any arrangement with a single boar stud.

What constitutes closure of the boar stud for semen shipments? Is this protocol formal and written? If so, please provide a copy of this protocol.

Who decides the stud should close for shipments...

- herd veterinarian?
- manager?
- genetic supplier?
- other?

Is there a written communication plan to quickly notify customers in the event of a closure? Please explain the procedure.

Is there a back-up plan to supply semen from an alternative source in the event that the boar stud is closed for health or any other reason? Is this plan formal and written? If so, please provide a copy of that plan.

If the back-up plan involves another stud or semen supplier, is that alternative source compatible in the areas of health status and quality assurance?

Semen Processing Center or Lab:

The semen laboratory processes are critical to successful implementation of an artificial insemination program. Semen quality from even the healthiest boars can be compromised if proper technique is not followed in the laboratory.

Please describe the minimum standards for a dose of semen in regards to concentration (number of sperm per dose), motility, and morphology.

Is there a designated clean area and clean sterile equipment for semen, collection, processing, and storage?

Is there a written protocol available to determine if a boar is eligible or ineligible for collection?

Does the stud have written procedures available for semen collection, processing and storage?

Does the semen processing area have written sanitation protocols available?

Is there a written protocol for monitoring the quality and bacterial contamination levels of semen samples? If yes, please provide.



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BOAR STUD GUIDELINES

Health, Hygiene, and Sanitation Guidelines for Boar Studs Providing Semen to the Domestic Market

Standing Committee: Gary C. Althouse (Chair), Darwin Reicks, Gordon D. Spronk, Timothy P. Trayer
Ex-officio: Thomas J. Burkgren (AASV Executive Director), John T. Waddell (AASV President-Elect)

Article 1. Domestic (USA) Requirements

Section 1.1 Pre-entry (Herd of Origin) Health Requirements of Semen Donor Boars

1.1.1 All pre-entry qualifying procedures performed on the farm of origin are to be performed by or under the supervision of a United States Department of Agriculture (USDA) accredited veterinarian or, if the farm of origin is located in Canada, by or under the supervision of a Canadian Food Inspection Agency (CFIA) accredited veterinarian.

1.1.2 The herd of origin must be inspected by a USDA accredited veterinarian (or, when appropriate, by a CFIA accredited veterinarian) and found free from clinical evidence of infectious or communicable diseases and insofar as can be determined, from any history of infectious or communicable diseases during the preceding 30 days.

1.1.3 The herd of origin must be free from clinical evidence of infectious or communicable diseases of swine, and be considered a negative herd for brucellosis and pseudorabies (Aujeszky's) within 30 days prior to animal dispatch from the herd of origin to isolation at the designated AI stud facility.

1.1.4 All potential semen donor boars must be examined individually by a USDA accredited veterinarian (or, when appropriate, by a CFIA accredited veterinarian) within 30 days of farm-of-origin dispatch and any evidence of heritable physical defects is to be documented. Boars exhibiting any heritable physical defects should not be used as donor semen boars.

1.1.5 A Certificate of Veterinary Inspection is to be completed by a USDA accredited veterinarian (or, when appropriate, by a CFIA accredited veterinarian) and a copy of this certificate must accompany the animal(s) to the AI stud center isolation facility.

1.1.6 The entry of visitors to the pre-entry site should be controlled. Personnel allowed access to the pre-entry site should be technically competent and observe high standards of personal hygiene to preclude the introduction of pathogenic organisms. Protective clothing and footwear for use only on the pre-entry site should be provided.

1.1.7 Animals shall not have been fed garbage, food byproducts, or meat/bone meal products in diet.

Section 1.2 Isolation Health Requirements of Semen Donor Boars

1.2.1 All procedures associated with the assessment of the isolation health status are to be performed by or under the supervision of a USDA accredited veterinarian.

1.2.2 Only animals which have a completed Certificate of Veterinary Inspection and have followed the pre-entry requirements outlined in Section 1.1 can enter into an AI stud center's isolation site.

1.2.3 Isolation in this section is defined as a self-contained facility physically separated from swine and other animals. The isolation facility is maintained exclusively for the purpose of isolating incoming boars for observation. Movement out of isolation will be all-out, with the start of isolation commencing after introduction of the last boar into the self-contained facility.

1.2.4 All boars presented for entry as additions to the resident stud of a semen production center must undergo a minimum 15-day isolation to allow completion of the necessary tests as outlined in Section 1.2.6.

1.2.5 All animals in isolation will be observed for clinical signs of disease on a daily basis. If clinical signs such as excessive coughing, sneezing, changes in consistency or amount of manure, decreased appetite or water consumption, skin lesions, lameness, or lethargy are observed, the attending veterinarian must be contacted to determine if the animal(s) should be removed from the group for further diagnosis and/or therapeutic management. An examination and necropsy shall be performed by a veterinarian on any animal which succumbs to an unexplained death.

1.2.6 All animals in isolation shall be serologically tested through an accredited diagnostic laboratory with negative results for brucellosis and pseudorabies (Aujeszky's). At the attending veterinarian's discretion, tests for the following pathogens and disease conditions may be performed: influenza, leptospirosis, mycoplasmosis, *Actinobacillus pleuropneumoniae*, porcine reproductive and respiratory syndrome virus (PRRSV), tuberculosis, and others as deemed necessary.

1.2.7 Removal or release of animals from isolation must be done only with the permission of the attending veterinarian.



1.2.8 The entry of personnel to the center's isolation facility should be controlled. Personnel allowed access to the isolation facility should be technically competent and observe high standards of personal hygiene to preclude the introduction of pathogenic organisms. Protective clothing, footwear, and all husbandry equipment must be provided for use only in the isolation facility.

1.2.9 Animals shall not be fed garbage, food byproducts, or meat/bone meal products in diet.

Section 1.3 Health Requirements for the Resident AI Stud Herd

1.3.1 Resident AI Stud facility requirements include:

1.3.1.1 Protective clothing and footwear specific for stud.

1.3.1.2 Constructed as a bird-proof facility.

1.3.1.3 Rodent control in place.

1.3.1.4 Insect control in place.

1.3.1.5 Physically separated from other swine and preclude direct contact with other livestock.

1.3.1.6 Entry of visitors to the resident AI stud should be controlled. Personnel allowed access to the resident AI stud should be technically competent and observe high standards of personal hygiene to preclude the introduction of pathogenic organisms. Protective clothing, footwear, and all husbandry equipment must be provided for use only on the resident stud site.

1.3.1.7 Feed and other supplies must originate from a premise free of livestock and be delivered directly to the stud from the source.

1.3.1.8 Loading and unloading areas for boars and supplies must be kept clean and free of organic material.

1.3.1.9 Animals shall not be fed garbage, food byproducts, or meat/bone meal products in diet.

1.3.2 Once a boar has completed the pre-entry and isolation requirements, and is officially released by the attending veterinarian as outlined in Section 1.1 and 1.2, he may enter the resident AI stud where he shall continue to be tested in accordance with the testing procedures listed below so long as he remains in the stud.

1.3.3 The resident AI stud should be maintained as a Validated Brucellosis-free and Qualified Pseudorabies (Aujesky's) Negative Herd.

1.3.4 At the attending veterinarian's discretion, tests for the following pathogens may be performed: influenza, leptospirosis, mycoplasmosis, *A. pleuropneumonia*, PRRSV, tuberculosis, and others as deemed necessary.

1.3.5 If on any given day greater than four percent (>4%) of the boars standing at the resident AI stud facility exhibit similar

clinical signs which could be associated with an infectious disease, a USDA accredited veterinarian must immediately assess the resident AI herd, and will be required to determine if sufficient risk warrants closure of the herd to further shipments of donor semen. Closed herds can be released by the USDA accredited veterinarian after he/she determines there is minimal risk in the transmission of disease via semen.

Section 1.4 Hygiene and Sanitation Requirements for Semen Collection, Processing, and Storage

1.4.1 General Requirements

1.4.1.1 Semen may only be collected, processed, and stored from boars that fulfill the requirements set forth in Sections 1.1, 1.2, and 1.3 of this document.

1.4.1.2 Only semen originating from resident boars may be analyzed, processed, and stored at the resident stud.

1.4.1.3 Semen collection, processing, and storage takes place only on the premises set aside for this purpose and under conditions of the strictest hygiene.

1.4.1.4 All implements which come into contact with the semen or the donor animal during semen collection and processing are single-use, disposable materials or, if re-usable, are properly disinfected or sterilized between uses.

1.4.2 Semen Collection

1.4.2.1 Semen may only be collected from boars which show no clinical signs of infectious disease on the day the semen is collected.

1.4.2.2 Each collection of semen, whether or not it is separated into individual doses, is clearly marked in such a way that the identification of the donor animal(s) is evident.

1.4.2.3 Each collection of semen is obtained using prudent minimum contamination protocol practices, which include:

1.4.2.3.1 Use of a collection pen which is cleaned after each daily use following proper sanitary techniques.

1.4.2.3.2 Use of double gloves of a non-spermicidal nature, with the outer glove discarded after preparation and stimulation of the boar, allowing for a clean gloved hand for direct grasping of the penis.

1.4.2.3.3 Clipping of preputial hair surrounding preputial opening.

1.4.2.3.4 Cleaning of the preputial opening and surrounding area (if needed) with a single-use disposable wipe.

1.4.2.3.5 Evacuation of preputial fluids prior to grasping of the penis for semen collection.





1.4.2.3.6 Holding of the penis perpendicular to the boar to minimize the contamination of the semen with preputial fluids.

1.4.3 Semen Processing

1.4.3.1 The entry of personnel to the semen processing site should be controlled. Personnel allowed access to the semen processing site should be technically competent and observe high standards of personal hygiene to preclude the introduction of pathogenic organisms. Protective clothing and footwear for use only at the semen processing site should be provided.

1.4.3.2 Only single-use disposable products or sterilized reusable products should come into contact with semen in order to prevent cross-contamination of ejaculates or pooled semen during processing.

1.4.3.3 Semen extenders or diluents:

1.4.3.3.1 Whenever any animal protein is used as part of a semen diluent, the product must be free of pathogens and sterilized.

1.4.3.3.2 An effective preservative antibiotic or antibiotic combination using chemicals of U.S.P. grade must be present in the extender or diluent which is to be used to expand the volume of boar semen. Preservative antibiotic or antibiotic combination choices with minimal active concentrations at final dilution are as follows:

1.4.3.3.2.1 500 IU penicillin/500 mg streptomycin per mL final dilution.

1.4.3.3.2.2 150 µg lincomycin/300 µg spectinomycin per mL final dilution.

1.4.3.3.2.3 250 µg gentamicin sulfate/250 µg neomycin sulfate per mL final dilution.

1.4.3.3.2.4 200 µg gentamicin sulfate per mL final dilution.

1.4.3.3.2.5 50 µg ceftiofur sodium per mL final dilution.

1.4.3.4 Each dose of diluted semen must be clearly marked in such a way that, at a minimum, the date of semen collection and appropriate identification of the donor animal(s) are evident. If donor identification is coded, the semen processing center must keep on file for no less than 4 months a record of donor animal(s) which contributed to the coded doses.

1.4.3.5 Each extended/diluted semen dose shall have a unique origin/laboratory identity clearly marked on it. Semen originating from any other laboratory shall not have the same identity.

1.4.4 Extended/Diluted Semen Storage

1.4.4.1 Only extended/diluted semen doses that originate from the resident AI boars which have fulfilled the requirements set forth in Sections 1.1, 1.2, and 1.3, and have been collected and processed as set forth in Section 1.4, may be stored in individual semen containers and storage areas at the stud.

1.4.4.2 Extended/diluted bulk and packaged semen is to be stored only in individual semen containers and storage areas which are capable of being disinfected.

1.4.5 Disease Control of Extended/Diluted Semen

1.4.5.1 Monthly aerobic bacteriological culturing is to be performed on randomly selected individual or pooled semen lots which are at least 48 hours of age post-processing, with the number sampled representing 1% of total monthly collections or four (4) samples/week, whichever is greater. Identification of samples positive for significant bacterial contamination will be followed up with a review of stud hygiene and sanitation by a veterinarian.

1.4.5.2 An established monitoring program which minimizes the risk of PRRSV transmission in the extended semen product is to be in place.



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Doing in-house research and product/technique comparisons

by

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Research can be a powerful tool to develop innovative products and to understand fundamental principles of biological systems. For this reason millions of dollars are invested annually by companies, foundations and governmental agencies into agricultural research. Data are typically collected under relatively controlled conditions, for reasons that may be clearer after reading this paper. Not every experiment successfully answers the question it is set out to. This can be because of unknown factors that complicate the experiment or poor experimental design.

In addition to the scientific research mentioned, tremendous effort and expense is invested into field trials by companies or producers. Entire semester courses are offered in experimental design in order to train future scientists in designing their studies in ways most likely to answer the questions of interest. Field trials are less often supervised or designed by people with formal statistical training and have a higher frequency of inadequate design. This paper will attempt to help the reader understand some common experimental design flaws seen in field trials. Statistical analyses are beyond the scope of this paper, and for assistance there the reader is encouraged to contact one of the course organizers.

Textbooks on experimental design are not light reading. Some of the jargon, however, will be useful to the reader. Think of an experiment as being comprised of three components. The first is the **treatment**, or what we want to measure the effect of. Treatments may include feed additives, different semen extenders, photoperiod, etc. The second component is the **observation**, or what we expect the treatments might influence. This could be ejaculate volume, total sperm numbers, farrowing rate of mated sows, etc. **Experimental units** are the third component. They are what the treatments are applied to. The boar or the ejaculate are the most likely experimental units, but depending on the design of the experiment the units may be room within a stud or may be entire studs. Technically the experimental unit is the “smallest division of the experimental material such that any two units may receive different treatments in the actual experiment” (Cox, 1958). In other words, to compare two extenders, the ejaculate would be the experimental unit if each ejaculate were assigned to a treatment, or the dose of semen could be the experimental unit if ejaculates were split and extended in multiple products. For a feed additive the individual boar would be the smallest possible experimental unit, but if the experiment were inefficiently designed it might be the row or the room or the stud.

The objective of most field trials is to compare among alternatives. It is common to maintain a portion of the experimental units under the status quo to serve as controls. In this way changes that result due to non-experimental reasons (e.g. new corn, the fan goes out) are not inadvertently credited to the treatment, because comparison is to the control rather than historical performance.

Cox (1958) listed five characteristics of a good experimental design, and they will be paraphrased here for boar studs.

- 1) The first requirement is that the experiment be free from systematic error. In other words, there is not a bias in the design that might be expected to influence results of the experiment. Let us assume for example that the goal is to compare fertility of semen diluted with two separate extenders. The stud has two collectors, say Wayne and Don, and Wayne is assigned to extend in extender "A" and Don in extender "B". If differences exist in fertility of mated sows it will be unclear whether they exist because of the extender used or the person collecting and extending. A better design would be to have Don and Wayne each alternate which extender they use. Let us assume that instead the stud manager, Rob, decides to oversee this experiment. He decides to split each ejaculate and extend half in "A" and half in "B". If Rob allows the ejaculate to sit on the counter while temperatures equilibrate and always extends the first half of the vessel in "A", it may be expected that semen in extender "B" will have a higher sperm concentration due to settling of cells. This may be either beneficial or detrimental, but clearly would not result in a fair comparison of extenders. He could instead either be sure to gently mix the semen before extending it or alternate mixing first in "A" and then "B."

Perhaps the comparison is among two feeding programs. If the stud has two rooms it is tempting to split feeding programs by room. Again a systematic bias exists if the ventilation system is more efficient in one room (or any other differences exist between rooms). Even if rows within a room are used to divide treatments there are potential complications to data interpretation. Boars may be assigned to row by age or line, air quality may differ between rows, etc. Because of the feed delivery system it may be decided that treatments will be divided by row. In this case row is the experimental unit instead of the boar, and that has serious implications for the power to detect differences (discussed later). The best option would be to either randomly assign each boar to one or the other feeding program, or to alternate treatments by crate or pen.

- 2) Comparisons must be made with sufficient precision. Heritability is a term used to describe the amount of observed variation within a population that is due to additive genetic effects. For most reproductive traits this value is low, 10-15%. Most of the remainder of the variation is environmental. The implication is that in order to detect treatment effects requires relatively large numbers of observations. Sloppiness or inefficient techniques in measuring the observations adds to the "noise" and increases the required number of experimental units to

detect differences if they do exist. If we attempt to measure semen volume by weighing on a bathroom scale, for example, treatment differences would need to be very large in order to be detected. Other experimental variation comes from the inherent variability in the observed traits, the design of the experiment and the number of experimental units. There is little that can be done to reduce inherent variation. By addition of experimental units, however, we can make dramatic reductions in the experimental error. The benefit of additional experimental units decreases, such that adding five experimental units to each treatment more dramatically reduces experimental error if it allows us to go from five to ten than if it allows us to go from ten to fifteen. Determining the appropriate number of experimental units will be discussed in more detail later in this paper.

- 3) A third requirement is that the results be broadly applicable. Let us use the semen extender comparison again. If we determine that we want to evaluate 50 ejaculates per extender, we can do this in six months by collecting two boars twice weekly. The advantage to this is that we make comparisons over multiple seasons, take little risk in lost reproductive performance, and could in fact afford to discard the ejaculates. On the other hand, these two boars could be peculiar, and the same effects might not be observed in the entire population. A more representative comparison would be to include a greater number of different boars, either in a shorter time or over the same time period.

As another example, assume we wish to compare providing three extra hours of light to boars housed in double curtain sided barns. One set of barns receives the supplemental light while the other does not. Barn is technically the experimental unit, photoperiod is the treatment and we will assume average sperm output is the observation we are interested in comparing. If an effect is detected, would it be expected to be the same in March/April as in August/September? Data from gilts shows that supplemental light during periods of decreasing day length (fall) can reduce age at puberty. The same amount of supplemental light when day length is increasing (spring) has no effect. It is important that we not extrapolate beyond the range of the data, or spurious conclusions may be reached.

- 4) Another requirement of good experimental design is that it be simple. The appropriate design is the simplest one which allows the question to be answered efficiently. As experimental design becomes more complicated so does interpretation of the results. This is especially obvious when the results are not what was expected and it is necessary to explain why.

Simplicity in methods is as important as simplicity in design. Most field trials are conducted within commercial systems, and thought must be given to overall productivity and potential negative effects of experimental treatments. An additional benefit of simple methods is that they are more likely to be applied correctly. It is common that people responsible for applying treatments and recording observations are asked to do so in addition to their normal

responsibilities. A desirable characteristic is to have treatment and observation accomplished without knowledge of treatments by those applying them.

- 5) The final element is the ability to calculate uncertainty. This is the only one of the five characteristics that is purely statistical, and will largely fall into place if the other conditions have been met. This means that we are able to calculate the “uncertainty in the estimates of the treatment differences.” The normal procedure is to calculate the standard error, and allows calculation of statistical significance of differences among treatments. This is critical if we desire to compare treatments statistically, which allows us to measure the certainty we would have in the repeatability of the results. In general terms this means that a good design results in all errors being random in nature and not attributable to treatment effects.

Randomization

For most field trials, random assignment of experimental units to treatments is desirable because it avoids systematic bias (discussed above) and bias of the experimenter. An example of bias of the experimenter could be in a comparison of a topdressing alleged to increase libido. The treatment is the topdressing, the experimental unit is the boar and the observation may be the time taken to mount the dummy. If personnel in the stud are allowed to assign treatments in any fashion besides random, experimenter bias is likely. Boars with a history of low libido or from whom more ejaculates per week are desired are more likely to be placed on the experimental compound, because the experimenter would then benefit immediately if the compound worked.

Randomization is usually achieved by computer generated random numbers or by tables of random digits in the back of all statistics textbooks. Less glamorous methods are also effective, such as flipping a coin or rolling dice.

Determining Experiment Size

The ideal number of experimental units to use is the exact number needed to detect real treatment differences of a magnitude important to you. If not enough units are used we risk failure to detect a real difference. If too many units are used we have wasted the expense and effort of applying treatments and recording observations beyond the level needed to show a difference.

The size of the experiment should be determined prior to application of the first treatment. Except in extreme cases, the experiment should be completed regardless of observations in the early phases. Methods to determine experimental size when some previous knowledge exists are outlined below. Without such knowledge it is primarily guesswork. It is possible to guess at the numbers used to calculate size of experiments, but more often it will be useful to collect preliminary data.

To calculate experimental size mathematically requires some knowledge of four parameters. The first is an estimate of the magnitude of difference we wish to detect. Is

a treatment difference of one billion sperm cells per ejaculate meaningful? This value will be referred to as δ (**delta**), and will depend on the cost of the treatment and the value of a unit difference in the response. The producer/stud will have to determine this value.

The second number is an estimate of the variance of the response traits, or σ^2 (**sigma squared**). This is a statistical term. It may be possible to obtain estimates from the scientific literature, or it can be determined from the error mean square from previous experiments. At least to start with it may be helpful to consult someone with statistical training.

The third and fourth values are closely related. They are the power of test, **P'** and probability level, **α (alpha)**. **P'** is the likelihood of detecting a difference at least as big as δ if one exists, and .80 or .90 are commonly used. This means there is an 80% or 90% chance of detecting the treatment differences at the level of α specified. The value of α can be thought of as the probability that a difference detected in the experiment is actually due to chance, and not treatment effects. Values of .05 or .10 are likely appropriate for field tests, and indicate a 5% or 10% chance of finding a treatment effect in error. We would expect, for instance, one in 20 comparisons to show an effect at the .05 level even if one did not exist. If these four values can be estimated, the following equation is helpful:

(Equation 1) **number of experimental units per treatment = $2X \sigma^2 / \delta^2$**
 where X is obtained from the following table.

Table 1. Values for X to use in calculation of necessary experimental units using equation 1.

	Two-tailed tests			One-tailed tests		
	α			α		
	<u>.01</u>	<u>.05</u>	<u>.10</u>	<u>.01</u>	<u>.05</u>	<u>.10</u>
<u>P'</u>						
.80	11.7	7.9	6.2	10.0	6.2	4.5
.90	14.9	10.5	8.6	13.0	8.6	6.6
.95	17.8	13.0	10.8	15.8	10.8	8.6

An example taken from Dr. Lamberson's graduate statistics course will be helpful to those who want a better understanding of these principles. A compound is hypothesized to increase litter size when used as a feed additive. The cost of the compound is such that an increase of 0.8 pigs in litter size would offset the cost of feeding it. Thus δ is set at 0.8 pigs. The standard deviation of litter size (σ , the square root of the variance) is about 2.5 pigs. The investigator is confident of the compound's effectiveness, and so sets **P'** and α

at .95 and, .05, respectively. A one-tailed test is used since the investigator is only interested if the compound will increase litter size giving an X of 10.8 (from the table). The number of experimental units needed per treatment is then:

$$n = 2 (10.8) 6.25 / .64 = 211 \text{ litters}$$

If only one hundred litters can be allocated to the experiment what effect of the compound could reasonably be expected to be found statistically significant?

(Equation 2)
$$\delta^2 = 2 X \sigma^2 / n$$

The investigator could have 95% confidence of finding statistical significance if the compound had a real effect of increasing litter size by 1.65 pigs. An Excel spreadsheet ([experimentsize.xls](#)) has been prepared to help with these calculations. By filling in cells B2, C2 and D2 the number of experimental units needed will be provided in A2. By filling in cells A2, B2 and C2 the size of difference detectable is calculated in D2.

Tables 2 through 4 provide estimates of experimental units (litters) needed to detect treatment effects of various magnitudes on litter size from 0.5 pigs to 2.0 pigs. Since in most field trials we will only be interested if a treatment either increases or decreases a trait, and we have an expectation, we will only concern ourselves with one-tailed tests. By studying these tables it is clear that because of the inherent variation in this trait a large number of litters per treatment are needed in order to detect treatment effects. Estimates of the variance were obtained from literature reports, and increased precision in estimating necessary experimental units could be obtained if estimates are available for the system in which data is to be collected.

Table 2. Approximate numbers of litters needed per treatment to detect a one-half pig difference at various powers of test and significance levels.

	One-tailed tests		
	α		
	.01	.05	.10
<u>P'</u>			
.80	500	310	225
.90	650	430	330
.95	790	540	430

Assumes a standard deviation in litter size of 2.5 pigs

Table 3. Approximate numbers of litters needed per treatment to detect a one pig difference at various Powers of test and significance levels.

<u>P'</u>	One-tailed tests		
	α		
	.01	.05	.10
.80	125	78	56
.90	163	108	83
.95	198	135	108

Assumes a standard deviation in litter size of 2.5 pigs

Table 4. Approximate numbers of litters needed per treatment to detect a two pig difference at various Powers of test and significance levels.

<u>P'</u>	One-tailed tests		
	α		
	.01	.05	.10
.80	31	19	14
.90	41	27	21
.95	49	34	27

Assumes a standard deviation in litter size of 2.5 pigs

If we follow a similar line of thinking and calculations, it is possible to calculate these numbers for other traits. For most applications, P' of .90 and α of .05 will give results in which the investigator can have reasonable confidence, and these values are used for the remaining examples. The numbers of boars needed to detect differences in number of sperm cells ejaculated of two billion, five billion and ten billion cells would be 1101, 176 and 44 boars, respectively.

Farrowing rate is a peculiar trait, but one that might be of interest to boar studs. There is not a commonly accepted variance, and estimates from literature are difficult to use because they will vary with number of experimental units (sows) and with mean farrowing rate. A more complicated procedure was used to calculate approximate numbers of sows mated per treatment to detect treatment differences of 1%, 2%, 5%, and 10% in farrowing rate for mean farrowing rates of 70%, 80% and 90% (Table 5). The detection of large effects clearly requires fewer sows. This is even more true with higher mean farrowing rate because there is a reduction in the variance.

Table 5. Approximate numbers of sows needed per treatment to detect differences in farrowing rate at various mean farrowing rates.

Mean Farrow rate	Treatment Effect on Farrowing Rate			
	1%	2%	5%	10%
	number of experimental units (sows) per treatment			
70%	190	95	40	20
80%	170	85	35	20
90%	125	65	25	15

Conducting experiments can require a serious commitment of time and money. There is no other way, however, to answer how factors affect a given operation. The cost and effort that go into conducting a well designed, appropriate experiment are rarely greater than required for a poor experiment. Randomly assigning treatments to the appropriate number of experimental units in the simplest design helps to increase the chance of a successful experiment. These comments are provided knowing that studs will conduct experiments, and are intended to help make such tests as informative and reliable as possible. The reader is encouraged to contact one of the organizers for more assistance in designing trials or conducting data analyses.

References:

Cox, D.R. 1958. Planning of Experiments. John Wiley and Sons, New York.



Boar Feeding and Nutrition

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Introduction

When compared to other classes of swine, nutritional research focusing on the breeding boar has historically been rather limited. Reasons for this relative lack of attention include the fact that mature boars did, and still do, comprise a relatively small part of the entire swine population. Additionally, long ago it was determined that a typical boar ejaculate contains many more sperm cells than are necessary to impregnate a single sow. Because natural mating systems dominated the industry, there was little incentive for investigating nutritional approaches for increasing the average number of sperm cells produced in an ejaculate from say 50 billion to 75 billion. It was common for swine producers to feed boars a gestating sow diet and assume that male reproductive efficiency would not be seriously impacted. Today, however, artificial insemination is the most common mating system in the swine industry and each additional dose of semen processed from an ejaculate has monetary value.

Another factor that may have limited research in this area is the large variation displayed among boars with regard to reproductive characteristics such as semen volume, sperm concentration, sperm motility or measures of sexual behavior. To conduct meaningful research, detect statistically significant treatment differences, and draw sound conclusions, large numbers of experimental boars are generally needed which sometimes presents logistical problems for researchers. That spermatogenesis in boars requires 6 to 7 weeks is another consideration. Experiments investigating the effects of various nutritional regimens on sperm production need a preliminary period of at least this long before actual effects of treatment can be critically evaluated.

Finally, when examining the effects of graded levels of nutrients on reproduction in the boar, semen and libido characteristics may not be particularly sensitive measures. This may be in contrast to other nutritional research where a relatively small change in a specific nutrient results in easily demonstrated changes in performance. For example, Figure 1 shows the response in gain/day and lean gain/day to increasing dietary protein in gilts. Such a well-defined response curve seems much more difficult to produce if response criteria involve semen characteristics or libido.

The objective of this paper is to review some of the practical research that has been conducted to examine the effects of feeding and nutrition on reproduction in the adult boar, paying particularly close attention to more recent findings. When older research is cited, the reader is reminded of the genetic changes that have occurred in the swine industry in the past 20 years. Thus, past nutritional recommendations may or may not be completely applicable to all modern genotypes (e.g., extreme lean, Meishan cross,

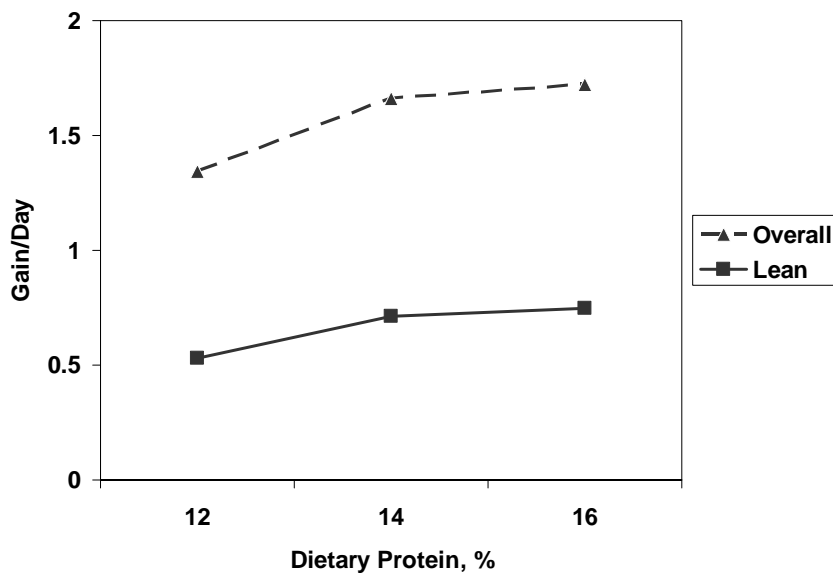


Figure 1. Effect of dietary crude protein intake on overall and lean gain/day in growing-finishing gilts (from Cromwell et al., 1993)

etc.). Moreover, nutritional requirements of boars may be impacted by factors such as health status, ambient temperature and the frequency of semen collection.

Nutrient Requirements of Sexually Active Boars

In 1998, the National Research Council (NRC) published the most recent Nutrient Requirements of Swine. Contained within this document are nutrient requirements for sexually active boars. As noted above, research focusing on the nutrition of the boar has been limited, necessitating the use of many older studies, and in some cases, conjecture, in determining NRC recommendations. Thus, the requirements put forth may or may not be applicable to all modern genotypes. Indeed, it is common for boars housed at many commercial studs to be fed rations that contain specific nutrient levels exceeding NRC recommendations. Nevertheless, contained in Table 1 are the NRC requirements for selected nutrients. The table can be used to put into context, the results of experiments described below.

Effects of Protein and Energy Intake on Reproductive Characteristics

According to the NRC, sexually active boars require 6.530 Mcal of metabolizable energy, 260 g of total protein, and 12 g of lysine per day. Daily energy requirements can be partitioned for three energy-demanding processes: maintenance, growth and

Table 1. Selected energy and essential nutrient requirements of sexually active boars (90% dry matter) (from NRC, 1998).

Feed intake	4.4 lbs/day
ME intake	6.530 Mcal/day
Crude protein	260 g (13.0 % of diet)
<hr/>	
Required amount/day	
Lysine	12.0 g (0.60 % of diet)
Selenium	0.3 mg
Vitamin A	8,000 IU
Vitamin D ₃	400 IU
Vitamin E	88 IU
Vitamin K (menadione)	1.0 mg
Biotin	0.4 mg
Choline	2.5 mg
Folacin	2.6 mg
Niacin	20.0 mg
Pantothenic Acid	24.0 mg
Riboflavin	7.5 mg
Thiamin	2.0 mg
Vitamin B ₆	2.0 mg
Vitamin B ₁₂	0.03 mg
Linolenic Acid	2.0 g (0.1 % of diet)

reproductive functions. Maintenance requirements are greater for larger boars and increase in colder environments. Boars may enter studs 9 months of age or less and in an actively growing state. The ideal rate of growth for boars housed in studs, however, is the subject of considerable debate and research is needed to characterize semen production and libido in boars fed to grow at different rates. Finally, the energy costs for mounting an artificial sow and ejaculating once or twice weekly are negligible compared with the energy costs of maintenance and growth.

Based on a review of the scientific literature, Kemp (1991) and Kemp and Verstegen (1991) concluded that a prolonged period of protein and energy restriction decreases the production of sperm cells. It appears, however, that the deleterious effects of under-nutrition are more pronounced when protein, rather than energy, is limited.

Research conducted by Louis et al. (1994a, b) focused on the effects of protein and energy intake on semen characteristics and libido in boars. In the first experiment (Louis et al., 1994b), 20 sexually mature, Landrace x Large White boars were fed either high protein (324 g crude protein and 16.6 g lysine per day) or low protein (146 g crude protein and 6.2 g of lysine per day) diets for 23 weeks. Boars on both diets received 6.82 Mcal of metabolizable energy per day.

During the first seven weeks of the study, there was a trend for boars fed the low protein diet to take longer to mount an artificial sow and begin ejaculating. There were no effects of treatment on semen characteristics (volume, sperm concentration, sperm motility, etc.).

From Week 8 to the conclusion of the study, however, boars fed the low protein diet required more time to mount the artificial sow and start ejaculating, had shorter duration of ejaculations, and ejaculated less semen than did boars fed the high protein diet. Total sperm output and sperm motility were similar between treatment groups.

Alterations in blood concentrations of reproductive hormones may at least partially explain these results. Several hormones, including luteinizing hormone (LH) and follicle-stimulating hormone (FSH), are released into the blood stream from the pituitary gland, a garden pea-sized organ that is located just below the brain.

Secretion of LH and FSH stimulates spermatogenesis and the testicular secretion of testosterone and estradiol, two steroid hormones that together are responsible for maintenance of libido. Blood levels of estradiol increase with age in boars (Estienne et al., 2000) and are inversely related to the time required to mount and begin ejaculation once boars are in the presence of an artificial sow (Louis et al., 1994b). Estradiol concentrations were higher in boars that readily mounted an artificial sow than in boars that refused to do so.

In the experiment of Louis et al. (1994b), from Week 8 to the conclusion of the study, blood concentrations of LH and testosterone were similar between treatment groups. The concentration of estradiol, however, was greater for boars fed the high protein diet than for boars fed the low protein diet.

In the second experiment (Louis et al., 1994a), 24 sexually mature, crossbred boars (Landrace x Large White) received one of three diets (8 boars per treatment): 1) low-energy and low-protein, 2) low-energy and high-protein, or 3) high-energy and high-protein. The low-energy and high-energy feeds provided 6.1 and 7.7 Mcal of metabolizable energy per day, respectively. The low-protein diet provided 7.7 g of lysine per day while the high-protein diet provided 18.1 g of lysine per day. Each boar was allowed a total of 4 to 5 pounds of feed daily.

Semen was collected twice weekly for 27 weeks. During the course of the experiment, boars consuming the high-energy and high-protein diet gained more weight than did boars in the other treatment groups. Average daily gain during the experiment for boars eating the high-energy and high-protein feed was 0.83 pounds. Boars consuming the low-energy and high-protein diet gained more weight than did boars eating the low-energy and low-protein feed (0.37 pounds and 0.20 pounds per day, respectively).

Boars consuming high-protein and either high- or low-energy diets had similar semen and ejaculation characteristics during Weeks 8 through 27 of the study. However,

animals in these treatment groups produced 60% more semen and 33% longer durations of ejaculations than did boars consuming the low-energy and low-protein feed.

Libido was significantly affected by treatment. Five of eight boars consuming the low-energy and low-protein diet consistently refused to mount the artificial sow. In contrast, only two of eight boars consuming the high-protein and low-energy diet, and zero of eight boars consuming the high-protein and high-energy ration failed to mount the artificial sow.

Several important conclusions can be drawn from these experiments. First, if protein, or both energy and protein intake are reduced, libido and semen quality in boars are adversely affected. However, energy intake of adult breeding boars can perhaps be reduced to control their weight gains without seriously compromising reproductive performance. Secondly, reduced libido (e.g., time necessary to mount an artificial sow and begin ejaculation) preceded altered semen characteristics in boars that were chronically protein restricted. Thus, a reduction in sexual aggressiveness may be considered an early “caution flag” that boars are perhaps being nutritionally challenged. Finally, decreased libido may be a consequence of suppressed testicular secretion of estradiol.

Effects of Vitamin Intake on Reproductive Characteristics

Few experiments have been conducted in boars to assess the effects of vitamins on reproductive function and most of the existing studies have focused on young developing boars. The following is a summary of pertinent work.

Recently, Audet et al. (2004) conducted an experiment during which the effects of dietary supplements of vitamins on semen characteristics and libido were determined. Duroc, Landrace or Yorkshire boars that ranged in age from 6 to 10 months received one of four daily diets: Basal diet supplemented with “industry levels” of vitamins (n = 9), Basal diet supplemented with 1000 mg Vitamin C (n = 11), Basal diet supplemented with fat soluble vitamins (100,000 IU Vitamin A; 10,000 IU Vitamin D₃; 600 IU Vitamin E; and 10 mg Menadione [Vitamin K]) (n = 9), and basal diet supplemented with water soluble vitamins (4000 mg choline; 400 mg Pantothenic Acid; 100 mg Riboflavin; 40 mg folic acid; 500 mg Niacin; 20 mg Thiamin; 60 mg Pyridoxine; 0.4 mg Vitamin B₁₂; and 5 mg Biotin) (n = 11). All boars received 6.6 pounds of feed daily containing 8.3 Mcal of metabolizable energy, 15.3% crude protein and 1.06% lysine. The vitamin premixes were given as a top dressing of 50 g.

Diets were fed during a one month acclimation period, a three month period during which boars were trained to mount an artificial sow and allow semen collection, a five-week, regular collection period during which boars were collected three times every two weeks (8 ejaculates), a two-week intensive collection period during which boars were collected daily, and a 10-week recovery period during which boars were collected three times every two weeks (15 ejaculates).

Throughout the experiment measures of libido (interval between entering collection area and start of ejaculation and duration of ejaculation) and blood concentrations of estradiol were similar among treatments. Moreover, there were no treatment effects on the number of sperm cells per ejaculate or the percentage of motile sperm cells during the regular collection period.

During the intensive collection period, there was a tendency for the number of sperm cells per ejaculate to be greater in fat soluble vitamin- (25.92 billion) and water soluble vitamin- (26.67 billion) supplemented boars compared with controls (24.12 billion). Although these differences were relatively small, they approached statistical significance.

During the recovery period, the number of sperm cells per ejaculate was similar between groups. However, the percentage of motile sperm cells for boars given supplemental fat soluble vitamins (88.8%) and for boars given supplemental water soluble vitamins (89.1%) tended to be greater than the percentage of motile sperm cells for controls (87.0%). The biological significance of these small differences in the percentage of motile sperm cells is questionable. Finally the percentage of sperm cells with abnormal morphology was similar among groups during the recovery period. Audet et al. (2004) concluded that supplementation of boar diets with high levels of Vitamin C, fat soluble vitamins or water soluble vitamins had no appreciable effects on semen or libido characteristics in boars.

Marin-Guzman et al. (1997) studied the effects of vitamin E and selenium supplementation to boar diets. From weaning to 9 months of age, and through a 16-week experimental period, boars were fed a basal diet, the basal diet supplemented with selenium (0.23 mg/pound of diet), the basal diet supplemented with Vitamin E (100 IU/pound of diet), or the basal diet supplemented with both selenium (0.23 mg/pound of diet) and Vitamin E (100 IU/pound of diet). Diets were consumed on an ad libitum basis from weaning to approximately 319 pounds of body weight and thereafter were limit fed to individual boars at a rate of 4.4 pounds per day. During the experimental period semen was collected three times weekly. Boars fed the basal diet displayed decreased sperm motility and an increase in the percentage of sperm cells with abnormal morphology compared with the supplemented groups. The effects of added selenium on semen characteristics were more pronounced than the effects of added Vitamin E, and selenium supplementation resulted in greater fertilization rates when gilts were bred with semen from the experimental boars. It should be noted that current U.S. Food and Drug Administration (FDA) regulations allow up to 0.136 mg of added selenium/pound of diet for all pigs (NRC, 1998).

Effects of Fatty Acids on Reproductive Characteristics

Linoleic acid (an omega-6 fatty acid) is the only fatty acid for which NRC has established requirements for sexually active boars (0.1% of diet). The effect of dietary supplementation of various fatty acids, particularly the omega-3 fatty acids, on semen and

libido characteristics in boars, however, has received increasing interest by swine researchers. The omega-3 fatty acids are linolenic, eicosapentaenoic (EPA) and docosahexaenoic (DHA).

Rooke et al. (2001) conducted an experiment during which boars (age range from 395 to 761 days) were fed daily 5.5 pounds of either a control diet (n = 5) or the control diet supplemented with tuna oil (13.6 g/pound of diet) (n = 5). Tuna oil is a rich source of omega-3 fatty acids. Boars in both groups were fed Vitamin E (134 mg/pound of diet) to serve as an antioxidant. An antioxidant is necessary to prevent oxygen from altering the biological activity of omega-3 fatty acids.

Semen was collected twice weekly at 3, 5, and 6 weeks of feeding the experimental diets. Supplementing the diet of the boars with tuna oil increased the proportion of viable sperm cells and the percentages of sperm cells with progressive motility, normal acrosome morphology, and normal morphology.

PROSPERM (Minitube America, Inc., Minneapolis, MN) is a commercially available product that contains DHA, Vitamin E and selenium. In a commercial field trial (Sperminotes, Volume V, Issue 1- Spring 2001, pages 4-5) thirty-five boars were reportedly fed diets with or without PROSPERM for 16 weeks. Sperm concentration (502 million for control, 584 million for supplemented), number of sperm/ejaculate (74.1 billion for control, 83.4 billion for supplemented), and sperm motility score (3.9 for control, 4.5 for supplemented) were increased by PROSPERM. Four hundred, seventy-eight gilts were mated via artificial insemination to boars that received the supplement or those that did not. Significant improvements were demonstrated for conception rate (83% for control, 90% for supplemented) and number of pigs born alive (10.2 for control, 10.6 for supplemented). Remaining to be determined is the relative contribution of each of the components of PROSPERM (DHA, Vitamin E and selenium) toward the overall positive effect on reproduction.

Effects of L-Carnitine on Reproductive Characteristics

L-carnitine is a vitamin-like compound synthesized in the liver, kidney, and brain that is involved in energy metabolism by sperm cells. There have been reports that supplementation of diets with L-carnitine increase sperm production and enhances sperm motility in several species. For example, feeding L-carnitine at a rate of 227 mg/pound of diet increased sperm concentrations in roosters (Neuman et al., 2002).

At Virginia Tech's Tidewater Agricultural Research and Extension Center in Suffolk, VA we recently conducted two experiments to assess the effects of dietary L-carnitine (Carniking; Lonza, Inc., Fairlawn, NJ) supplementation on semen characteristics in boars (Kozink et al., 2004). In Experiment 1, young, postpubertal boars that were 258 days of age were used. Boars were fed daily 4.4 pounds of a control diet (n = 9) or the control diet plus 500 mg L-Carnitine (n = 9). Semen was collected weekly from Week 0 to 15 and on 4 consecutive days during Week 16. Experiment 2 was similar

to Experiment 1 except boars (n = 10 per treatment) were 504 days of age. For the weekly and intensive collections in both experiments there were no positive effects of L-carnitine on sperm cells/ejaculate or on sperm motility.

In contrast to our results, results of a commercial field trial (Akey Swine Newsletter, August 2000, page 1) suggested that dietary supplementation with L-carnitine enhanced boar performance. One hundred, eighty boars (high lean growth genotype) received a control diet or a diet supplemented with a “low” or “high” level of Carniking for 16 weeks. Feeding high levels of L-carnitine reportedly increased semen volume and the number of viable sperm cells produced.

Summary

Although research focusing on the nutrition of the sexually active boar is limited, some general conclusions can be drawn. A prolonged period of restricted protein, or both energy and protein, adversely affects libido and semen quality in boars. Reduced libido, perhaps due to decreased estradiol concentrations, precedes altered semen characteristics in boars that are chronically protein restricted. Recent data suggest that there are no exceptional positive effects of supplementing large levels of Vitamin C, fat soluble vitamins, or water soluble vitamins on boar semen or libido characteristics. With regard to reproductive performance, however, there are data to support the addition of selenium and vitamin E to boar diets. Recent evidence also supports the notion that dietary supplementation with omega-3 fatty acids improves semen characteristics. Finally, results from studies investigating the effects of supplemental L-carnitine on reproduction in boars are equivocal and will require additional study.

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Certification Programs

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Introduction

There really is no organized certification program for boar studs in the USA. The bull stud industry organized itself several decades ago to start a uniform program, but efforts in the swine industry have been lacking.

Part of the problem today is that a large portion of the industry is integrated. So the appeal of a certification program is less. The reality is that the majority of semen distributed in the US is by company owned studs. For the company owned stud, there is little need to differentiate or become part of a certification program.

As a result, this talk will cover the basics of an ISO 9001 type certification program, the value of third party audits, and the potential for a new audit certified program through the American Association of Swine Veterinarians (AASV).

Certification Programs overview

Certification programs are intended to provide benefit to both the organization seeking certification and to the customer. It can be a way to distinguish one from competitors in the marketplace. Certification programs tend to keep things under “control”. A system that is under control has predictable outcomes.

In the case of a boar stud, there could be a certification program that has specifics as to how boars are released from isolation and moved into the main stud population. This would be valuable so that all staff know exactly who makes the decision to release the boars from isolation, what document provides proof that the boars were released from isolation, and who is responsible that the document is in hand before the boars are actually moved. If all these things are in place and being followed, the isolation procedure would be viewed as being “under control”.

Specific certification programs that apply to boar studs

ISO 9000

The most well known and popular certification program worldwide is ISO 9000. It stands for the International Standards Organization and was started in 1947 primarily for engineers. ISO 9000 deals with quality management. Quality management refers to what the organization does to ensure that its products or services satisfy the customer's quality requirements and comply with any regulations applicable to those products or

services. ISO's purpose is to facilitate international trade by providing a single set of standards that people everywhere would recognize and respect. The management system (boar stud manager / owners) sets up the requirements for what the organization must do to manage processes influencing quality. ISO basically provides the framework. 610,000 organizations in 160 countries have adapted the ISO 9000 system. Previously, there were various certification programs within ISO depending on the type of business (ISO 9001, 9002, and 9003). As of the year 2000 update, there is now just one, called ISO 9001:2000. The basic idea is: Say what you are going to do, then prove it with objective evidence. Since the 2000 update, there is now much more focus on continuous improvement as well. The nuts and bolts of this system are¹:

1. Establish a quality system – have written procedures that make sense and focus on producing a quality product.
2. Document a quality system – be able to prove through documentation that things are being done the way they are supposed to be done.
3. Support quality – have a good training program in place that helps ensure quality product goes out every day.
4. Satisfy your customers – part of this involves doing a customer survey and responding to customer needs or complaints.
5. Establish a quality policy – Defines the goals for the boar stud. An example might be to have >90% of deliveries on time.
6. Carry out quality planning – set objectives and check if they are being followed through.
7. Control the quality system – delegates who is responsible for what.
8. Perform management reviews – formal meeting usually 2-4 times a year to make sure things are being done and to brainstorm for opportunities for improvement.
9. Provide quality resources, personnel, infrastructure, and environment – ensures that there is a system in place so goals/objectives can be met. For example, if one objective is to sell an additional 1000 doses per week, about 50 boars would need to be in place to get that done. Additional labor may be needed and another collector trained. The ISO system helps to train management into thinking ahead and planning these types of things.
10. Review customer requirements and communicate with customers – this means having a form for orders and a system to deal with order changes.
11. Control purchasing – this is an area most would not be doing. It involves having a formal way to approve of suppliers or subcontractors. For example, they may have to sign a statement saying they have read and agree to follow the studs biosecurity policies.
12. Control operational activities – this is what most studs would call a procedure manual. For example, it would say under what circumstances semen would be discarded rather than sold.
13. Control monitoring devices – this relates to calibration of equipment. For example, scales should be calibrated with a standard weight to an acceptable range at a pre-determined frequency.
14. Monitor and measure quality – this amounts to having audits done. Most would do quarterly audits by someone not directly involved with the production. For example, a veterinarian or consultant. This is called an internal audit. Then, an

- external audit is done 1-2 times a year by a certified professional auditor. This person usually has little knowledge of the particular facility or business. Their job is to look for objective evidence. In the example of isolation entry procedures, the auditor would look for the document signed by the person designated to be able to give approval to release a group of boars from isolation.
15. Control non-conforming product – if an ejaculate is discarded, it should be clearly marked and separated to ensure it doesn't end up in a pool of semen going out to sow farms.
 16. Analyze quality information and make quality improvements – normally this is done with charts and graphs. For example, a chart showing % of deliveries on time to the farm by month should show improvement over time if that is an objective.

PQA Level III

This is the Pork Quality Assurance program that has been around for many years. The primary target is to minimize the risk of meat residues. This program has less application than the SWAP program for boar studs.

SWAP

The Swine Welfare Assurance Program was created by the National Pork Board with Pork Checkoff dollars. In some ways, it is an extension of the Pork Quality Assurance Program (PQA) which is required by most packers and was set up to reduce residues in the meat. SWAP consists of nine Care and Well-being Principles (CWP's):

1. Herd Health and Nutrition
2. Caretaker Training
3. Animal Observation
4. Body Condition Score
5. Euthanasia
6. Handling and Movement
7. Facilities
8. Emergency Support
9. Continuing Assessment and Education

The nine principals are based from the US Pork Producer Code of Practice:

- Provide facilities to shelter pigs from weather extremes
- Provide well-kept facilities to allow safe and humane animal movement
- Provide personnel with training on proper animal handling
- Provide access to good water and feed quality
- Observe pigs to make sure basic feed and water needs are being met
- Develop herd health program with veterinarian
- Provide prompt veterinary care
- Use humane methods to euthanize sick or injured animals
- Maintain appropriate biosecurity to protect herd health
- Provide transport that minimizes stress

Most boar studs do a good job in all of these areas, and should be SWAP certified.

Health, Hygiene and Sanitation Guidelines for Boar Stud Providing Semen to the Domestic Market

This is a document produced by the American Association of Swine Veterinarians in 2003². As the title indicates, and as you may predict coming from veterinarians, it primarily deals with disease prevention issues. It does not cover procedures or processes in the boar stud. It is a list of guidelines that may be the basis for a later certification program. All boar stud managers should be familiar with this document and work toward compliance. It may also be adopted at the federal level as has happened in some other countries. Government agencies prefer self-regulation as opposed to handing down rules, so it is fortunate to have this document as a base to work from in the future.

PAACO

A new organization has recently been formed to deal with auditing in animal agriculture. Professional Animal Auditor Certification Organization, Inc. (PAACO, Inc.) is a non-profit organization. The intention will be to train and certify animal agriculture auditors. It is made up of the Federation of Animal Science Societies (FASS), the American Registry of Professional Animal Scientists (ARPAS), the American Association of Bovine Practitioners (AABP), and the American Association of Swine Veterinarians (AASV). The organization was formed in a proactive manner and in response to auditing being done at the packing plant level that will likely trickle down to the farm level in regards to animal welfare. That has been driven by an auditing agency derived by the Food Marketing Institute and the National Council of Chain Restaurants. The four founders of PAACO will help to bring a scientific approach to auditor training and common sense approach due to their familiarity with the animal agriculture industry.

A realistic scenario is that a boar stud certification program could evolve out of the AASV and that auditors would be trained and certified by PAACO to do the audits. The emphasis of this certification program would likely mirror the Health, Sanitation, and Hygiene Guidelines to start with.

Summary

We are at the founding level for a certification program for boar studs in the USA. Using the Boar Stud Health and Sanitation Guidelines as a base, the industry can build a auditable certification program with scientific merit and credibility. Boar studs should also pursue PQA and SWAP certification. Finally, ISO can provide benefits as a quality management system for any business including boar studs.

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Data on Various Extenders: Viability over Time

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Introduction

Preservation of boar semen in the liquid state is a vital component of achieving acceptable fertility with A.I. The single most important factor that influences the success of maintaining the viability of fresh semen probably is the extender in which semen is extended. Consequently, "which semen extender maintains viability best over time" is a common and important question that is often asked. Unfortunately, the answer depends on a number of factors that are likely to vary among different farms and within the same farm over time. The primary purpose of this paper is to review the "generic composition" of semen extenders and discuss several factors that affect the viability of extended semen over time.

Generic Composition of Semen Extenders

Extenders used in preservation of liquid semen must perform five basic functions: 1) provide nutrients for sperm metabolism; 2) neutralize metabolic waste products; 3) stabilize sperm membranes and prevent capacitation; 4) maintain an osmotic equilibrium; and 5) retard bacterial growth during storage. In general, commercially available semen extenders are classified as short-term, medium-term, and long-term. However, a more informative description would be 3-day, 5-day, and 7-day extenders, based on the length of time that they maintain sperm viability. For the most part the energy sources and electrolytes that are used in semen extenders tend to be fairly universal. However, the buffering systems, which remove metabolic wastes, and the compounds that are added to stabilize sperm membranes are the components that differ and are likely the primary reason why sperm cells live longer in some extenders versus others (Table 1).

Common ingredients used in extenders to perform the five required functions are as follows. Simple sugars such as glucose and fructose are added as energy substrates for spermatozoa. Buffering systems consisting of an acid and its conjugate base are the primary means by which metabolic wastes are neutralized and pH is maintained. Examples include sodium bicarbonate, phosphate buffers and organic zwitterionic molecules such as hydroxyethylpiperazineethanesulfonic acid (HEPES). Macromolecules and chelating agents help promote membrane stability and prevent capacitation. Sodium citrate, ethylenediaminetetraacetic acid (EDTA) and tris(hydroxymethyl)aminomethane (TRIS) are common extender ingredients used to bind free calcium, whereas egg yolk, milk proteins and albumins, in some animals, are added because they have been shown to improve semen viability, presumably due to their ability to bind to and stabilize sperm membranes. Finally, neomycin sulfate, gentamycin, pencillin, and polymixin B sulfate are antibiotics that are effective in preventing the growth of bacteria commonly found in semen without affecting sperm viability. In theory, any antibiotic can be used with any semen extender provided the pH and the osmolarity of the final solution is balanced.

Table 1. Composition of Selected Porcine Semen Extenders¹

Ingredient	BTS	Kiev	Modena	Zorlesco	Androhep
<u>Energy Substrates</u>					
glucose (anhydrous), g/l	37.00	66.00	27.50	11.70	----
glucose (monohydrate), g/l	----	----	----	----	26.00
<u>Buffering Systems</u>					
sodium citrate ² , g/l	6.00	3.75	6.90	11.70	8.00
sodium bicarbonate, g/l	1.25	1.25	1.00	1.80	1.20
EDTA (disodium), g/l	1.25	3.70	2.35	2.10	2.40
potassium chloride, g/l	0.75	----	----	----	----
citric acid, g/l	----	----	2.90	3.80	----
Tris buffer (base), g/l	----	----	5.65	6.50	----
HEPES, g/l	----	----	----	----	----
<u>Membrane Stabilization</u>					
cysteine, g/l	----	----	----	0.10	----
BSA (fraction V)	----	----	----	----	2.50
<u>Antibiotics³</u>					
neomycin sulfate, g/l	----	----	----	1.00	----
penicillin G (Na), g/l	0.60	0.60	0.60	----	0.60
dihydrostreptomycin, g/l	1.00	1.00	1.00	----	1.00

¹ semen extender recipes were obtained from original information published in journal articles

² EDTA, sodium citrate and other chelating agents also assist with membrane stabilization

³ type and amount of antibiotics added are often adjusted for individual situations

Factors Affecting Viability of Extended Semen

It is often stated that "semen begins to die once it is collected and semen extenders basically slow down the process". From a physiological perspective this is true. In the tail of the epididymis, compounds are produced that keep mature spermatozoa in a quiescent state. Once ejaculation occurs, spermatozoa leave the epididymis and these compounds are mixed with secretions from the secondary sex glands. The seminal vesicles contain compounds that facilitate capacitation and increase the metabolism of spermatozoa. In essence, spermatozoa are being activated or primed for fertilization by the process of ejaculation. The role of semen extenders is to counteract or, at least, slow down these processes. How effectively they accomplish this can be influenced by a number of factors including individual boar characteristics, number of sperm cells and volume of the insemination dose, and season of the year.

Divergent Changes in Viability and Fertility of Extended Semen

When comparisons are made among various types of semen extenders, motility is typically used as a measure of viability. In doing this, it is generally assumed that as motility decreases over time, then so does the viability and fertility of semen. In other words, the assumption is made that within boars, semen with a motility of 60% at the time of collection will have the same fertility as aged semen with a motility of 60%. Unfortunately, there are data to suggest that this assumption probably is not true (Figure 1).

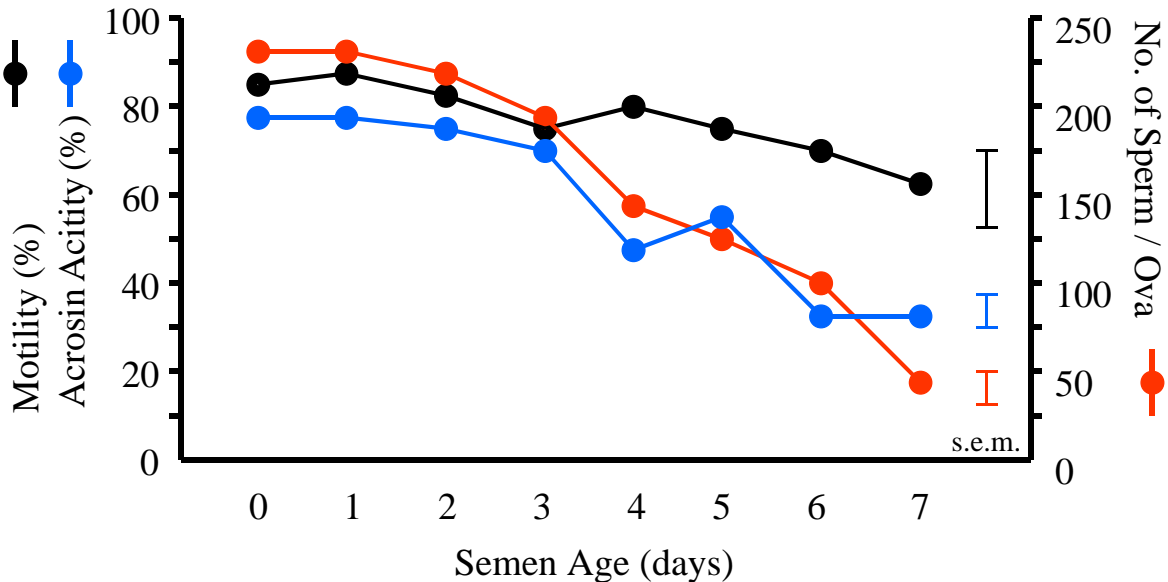


Figure 1. Changes in motility, acrosin activity, and number of spermatozoa binding ova over time for boar semen extended with a 7-day extender.

Data presented in figure 1 is from a study in which changes in motility and several indices of the fertilizing potential of spermatozoa over time were compared. These data are from semen extended in a 7-day extender. It is interesting to note that the motility of the ejaculate at the time of collection (day 0) was 82%. On days 4 and 5 after collection, the motility of the ejaculate was still about 82% (black line). In contrast, the percentage of spermatozoa exhibiting acrosin activity, an enzyme necessary for fertilization, and the average number of spermatozoa binding to ova both decrease by almost 50% over the same time period (blue and red lines, respectively). Basically, these data show that, for this particular boar, the ability of semen to bind ova during fertilization that is 4 to 5 days is considerably less than semen at the time of collection even though its motility has not changed. This is due to the fact that some aspects of the fertilizational competence of spermatozoa, such as acrosin activity, begin to be compromised sooner than others, such as motility. This divergence between the viability and fertility of spermatozoa probably occurs in all types of extended semen. Consequently, this presents a large and, as yet, unresolved hurdle when viability measures are used to compare semen extenders.

Individual Boar Differences

Semen is a complex biological suspension that contains living cells (spermatozoa), proteins, sugars, minerals, and other organic and inorganic compounds. By comparison, semen

extenders are relatively simple solutions. However, they also can contain a variety of different compounds. Occasionally, when semen is mixed with extenders reactions among the compounds in each take place that have a detrimental effect on spermatozoa. Although it appears to be rare, there is anecdotal evidence that semen from some lines of boars or individual animals are not compatible with certain types of extenders. Examples are individual boar differences are shown in figure 2. At the present time, reasons for these interactions are not known. However, when they do occur, use of another extender often corrects the problem.

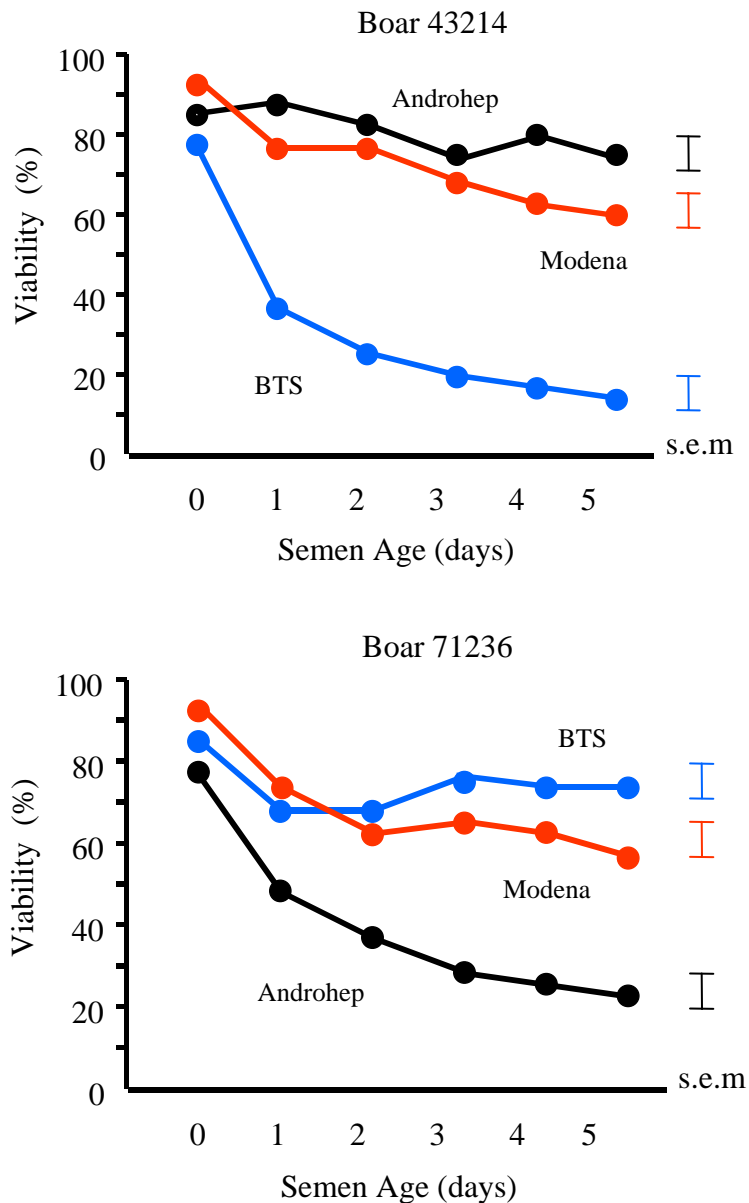


Figure 2. Interactions among individual boars (43214 and 71236) and semen extenders (BTS, Modena, and Androhep).

Interactions between Season and Fertility of Semen in Different Extenders

While it is important to test semen extenders in attempts to identify the ones that produce superior farrowing rates and litter sizes, conducting such an evaluation in a truly objective manner, in reality, is very difficult. In order to be scientifically accurate, a single ejaculate should be partitioned and an equal portion extended with extenders to be evaluated. In addition, an equal number of these insemination doses should be used for breeding sows on at least two different farms. Finally, breeding technicians and semen age at the time of insemination should also be balanced across extender types at each location. These steps are necessary to insure that the true effect of the extender is evaluated and the results are not confounded with other factors known to influence fertility. Even if these precautions are taken and a superior extender is identified, then there is no guarantee that the conditions under which this effect occurred will remain constant in a herd over an extended period of time. In fact, data from field observations indicate that the advantage of one extender over another may change over time (Table 2).

Table 2. Seasonal Fluctuations in Fertility with Different Semen Extenders¹

Time Period	Semen Extender	Farrowing Rate (%)	Litter Size
Jan., 1998 - June, 1998	Extender A	86 ± 2 ^x	11.7 ± 0.3 ^x
	Extender B	83 ± 3 ^x	11.5 ± 0.2 ^x
	Extender C	75 ± 3 ^y	10.5 ± 0.4 ^y
July, 1998 - Dec., 1998	Extender A	80 ± 3 ^x	11.1 ± 0.3 ^x
	Extender B	88 ± 2 ^y	11.5 ± 0.3 ^x
	Extender C	78 ± 3 ^x	10.9 ± 0.3 ^y
Jan., 1999 - June, 1999	Extender A	82 ± 3 ^x	11.3 ± 0.3 ^x
	Extender B	85 ± 2 ^x	11.4 ± 0.2 ^x
	Extender C	82 ± 3 ^x	11.1 ± 0.3 ^x

¹ adapted from Flowers, 2001; means ± s.e. are based on about 1000 matings for each extender for each time period.

^{x,y} extender means with different superscripts within the same time period differ ($p < .05$)

Summary

From a management perspective, the most practical guide for the selection of an extender probably should be the average age of the semen at the time the majority of sows are bred within a herd. For example, if the majority of sows on a farm are bred with semen that is 2 days old, then, on the average, the influence of the semen extender of fertility would probably be minimal compared to other factors. In contrast, if the age of semen was 4 days, then it is reasonable to speculate that fertility would be better if 5-day or 7-day extenders were used compared with the use of their 3-day counterparts.

When determining the average age of semen at the time of insemination, it is important to remember to include the age of the insemination doses that are used for the second and third inseminations, when appropriate. A common mistake is to use only the first insemination. This causes problems since there, currently, is no accurate way to know from which insemination fertilization results. For example, if the semen dose used for the first insemination is 2 days old, then the age of the doses used for subsequent matings, if they came from the same batch, would be between 3 and 4 days old, depending on the breeding regimen. In this situation, if a 3-day extender was used and only the first mating was used to calculate semen age, then one could come to the conclusion that the extender was matched correctly with the average age of semen at insemination. However, in reality, the second and third inseminations, which probably are involved in the fertilization process of a significant number of females, are actually performed with aged semen based on the extender. If this occurred on a regular basis, then fertility of these insemination doses would likely be suboptimal.

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Prostaglandins and Boars

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Introduction

The effective operation of a commercial stud requires that young boars be easily trained to mount an artificial sow and allow semen collection. Once trained, it is essential that boars consistently mount in an expeditious manner. Indeed, the efficiency of a stud is compromised when boars display a reluctance or refusal to mount an artificial sow.

On many swine operations, commercially-available prostaglandin products are used in attempts to expedite mounting behavior, as well as restore libido in boars displaying decreased sex drive. The objective of this paper is to provide a brief review of research that has focused on the effects of exogenously administered prostaglandins on sexual behavior in boars.

General Comments about Prostaglandins

Prostaglandins were first discovered in mammalian seminal plasma and it was believed that the compounds originated from the prostate gland. Thus, the substances were named “prostaglandins”. Today, however, it is known that prostaglandins are produced by practically all tissues in the body.

Arachidonic acid is the fatty acid precursor molecule for synthesis of prostaglandins. There are at least six types of prostaglandins and these compounds have numerous physiological functions. For example, prostaglandin-E₂ (PGE) lowers blood pressure. In contrast, prostaglandin-F₂α (PGF) increases blood pressure. Prostaglandins stimulate smooth muscle contractions, are involved in lipid metabolism, and modulate inflammatory responses.

The prostaglandins also participate in a variety of reproductive processes. For example, PGF causes luteolysis, which is the destruction of corpora lutea. Corpora lutea are ovarian structures that secrete progesterone, a steroid hormone essential for the maintenance of pregnancy. In gestating sows, an injection of PGF causes luteolysis, which results in a decrease in blood levels of progesterone, pre-partum behavioral changes and ultimately, induced farrowing. In fact, the use of PGF for induced farrowing is the only use of the compound in swine actually approved by the U.S. Food and Drug Administration (FDA). The use of PGF for stimulating sexual behavior in boars is technically considered an “extra label” use and should only be done after consultation with a licensed veterinarian.

There are several commercially-available PGF products including dinoprost tromethamine (Lutalyse; Pfizer Animal Health), cloprostenol sodium (Estrumate; Schering-Plough Animal Health) and fenprostalene (Bovilene; Syntex Animal Health). Once in the blood, prostaglandins have a very short half-life and are rapidly degraded during passage through the lungs.

Prostaglandin-Induced Sexual Behavior in Boars: Mechanism of Action

Shown in Figure 1 is the hormonal control of reproduction in boars. In swine, gonadotropin-releasing hormone (GnRH) is released from an area of the brain called the hypothalamus. GnRH travels to the pituitary gland and there stimulates the release of luteinizing hormone (LH) and follicle stimulating hormone (FSH). In boars, LH and FSH stimulate spermatogenesis and the secretion of testosterone and estradiol, two steroid hormones that together are responsible for maintenance of libido. Castration of adult, sexually experienced boars decreased sexual behavior within 30 to 60 days, an effect reversed by testosterone and estradiol therapy (Levis and Ford, 1989). Blood levels of estradiol increase with age in boars (Estienne et al., 2000) and is inversely related to the time required to mount and begin ejaculation once boars are in the presence of an artificial sow (Louis et al., 1994). Estradiol concentrations were higher in boars that readily mounted an artificial sow than in boars that refused to do so.

The mechanism by which prostaglandins may enhance libido in boars is not clear. One plausible hypothesis is that prostaglandins stimulate the testicles to release steroid hormones. In an experiment conducted by Fonda et al. (1981), however, testosterone secretion was not affected by prostaglandin treatment in boars. In that study, catheters were placed in the jugular vein of six, 8 to 9 month-old boars. Blood samples were collected at 30-minute intervals for 12 hours. After collection of the second blood sample, boars were injected i.m. with 20 mg PGF (n = 3) or saline (n = 3). Blood levels of LH and testosterone were similar for PGF-treated boars and controls throughout the sampling period. In contrast, PGF treatment resulted in robust increases in blood concentrations of prolactin and cortisol. The role, if any, of prolactin, a hormone produced by the pituitary gland, and cortisol, a hormone secreted from the adrenal gland, in controlling sexual behavior in boars has not been established.

Enhanced sexual behavior as a result of PGF treatment almost surely involves a direct or indirect stimulation of one or more areas of the brain. Although data in the boar are lacking, numerous areas of the brain are activated after i.m. treatment of sows with PGF. When cells are stimulated, there is an increase in FOS protein, the translated product of c-fos mRNA. Burne et al. (2002) conducted an experiment during which sows were treated i.m. with PGF (n = 6) or saline (n = 5). Sixty-five minutes after treatment, sows were killed and various regions of the brain were analyzed for c-fos mRNA. Compared with control sows, PGF-treated sows had significantly higher levels of c-fos mRNA expression in the cerebellum and several areas of the hypothalamus.

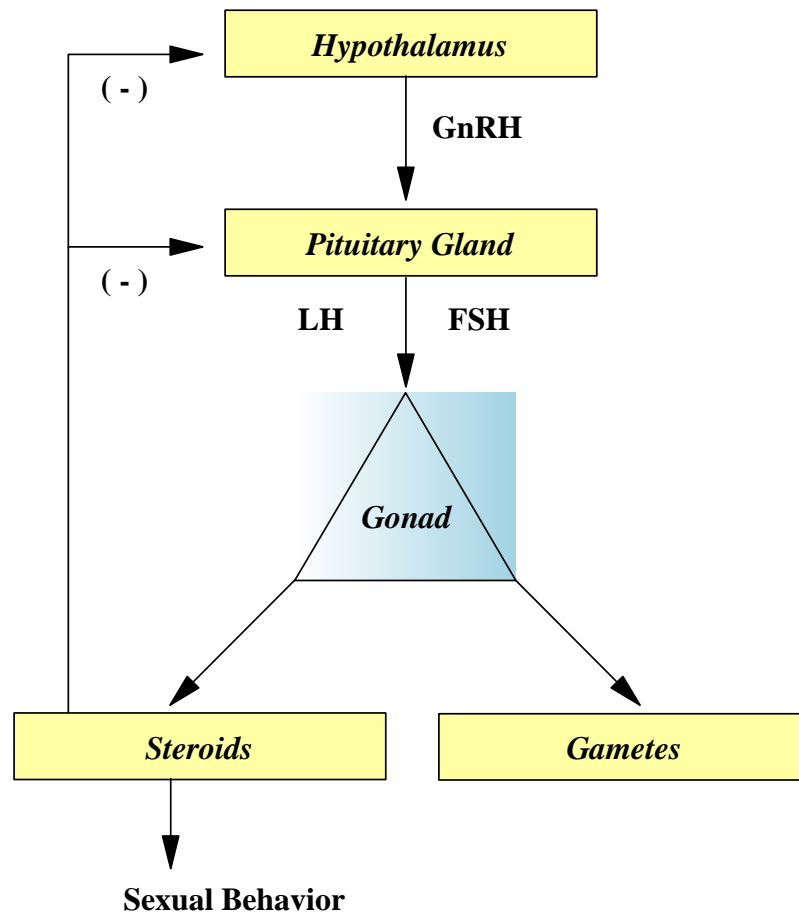


Figure 1. Hormonal control of reproduction in boars.

Sexual Behavior after Prostaglandin Treatment in Boars

For the purposes of this section, the effects of prostaglandin treatment on sexual behavior will be summarized for three different “classes” of boars: Sexually inexperienced boars, sexually experienced boars, and sexually experienced boars displaying decreased sex drive.

Sexually inexperienced boars. Equivocal data exists regarding the use of prostaglandins as a tool to stimulate libido in young, sexually inexperienced boars (Szurop et al., 1985; Wettemann et al., 1992; Estienne et al., 2001; Kozink et al., 2002). Differences in the results among studies could be related to genetics, age or weight of experimental boars, different prostaglandin therapies employed, or undetermined management factors.

Szurop et al. (1985) conducted a clinical trial investigating the effects of a PGF analog (cloprostenol sodium; Enzaprost-F; Chinoin) on the training of boars for semen

collection. Dutch and Belgian Landrace, Large White and Duroc boars ($n = 156$), 7 to 7.5 months of age and weighing 242 pounds, were employed. Boars were housed at 30 studs under similar management conditions.

Boars were injected with PGF (25 mg) 30 minutes before being exposed to the artificial sow. A “success” was defined as a reaction time of 5 to 7 minutes or less, combined with erection and collection of semen. Over 90% of the boars were successfully collected during the first training session and 95% of the boars were collected during the second training session. Control boars were not included, but previous experiences at the studs revealed a minimum of 4 to 5 training sessions with reaction times varying from 20 to 30 minutes and an overall success rate of 70%.

Estienne et al. (2001) conducted an experiment utilizing six Landrace x Yorkshire boars, 9.6 months of age and weighing 423 pounds. Boars were moved to a semen collection pen twice weekly for 4.5 weeks (a total of 9 training sessions). None of the boars mounted the artificial sow during this preliminary period. Immediately before entering the collection pen for the tenth training session, each boar received an i.m. injection of 10 mg PGF (Lutalyse). All boars mounted the artificial sow and allowed semen collection. During the eleventh training session, all boars were successfully collected without first receiving an injection of PGF.

In contrast to studies demonstrating positive effects, Wettemann et al. (1992) reported that PGF treatment did not enhance sexual behavior in boars identified as lacking libido. In that study, Hampshire boars (6 months of age; $n = 10$) that consistently failed to mount an estrous gilt were utilized. Boars were given i.m. injections of saline, 10 mg PGF (Lutalyse) at one minute before exposure to an estrous gilt, or 25 mg PGF at 30 minutes before exposure to an estrous gilt. There were no effects of treatment on anogenital sniffs, nose to nose contact, nosing the flank, proper mounts or completed matings.

Finally, Kozink et al. (2002) conducted an investigation during which Lean-type, terminal-line boars (National Pig Development, Roanoke Rapids, NC), 5.9 months of age and weighing 248 pounds, were used. Boars were moved twice weekly for 6 weeks to a semen collection room. Upon entering, boars received i.m. injection of either deionized water ($n = 10$) or PGF (Lutalyse) at doses of 5 mg ($n = 10$), 10 mg ($n = 10$) or 20 mg ($n = 10$). Boars received a libido score of 1 to 5: 1 = boars showed no interest in artificial sow, 2 = slight interest in artificial sow but did not attempt to mount, 3 = mounted artificial sow but did not display an erection, 4 = mounted the artificial sow and displayed an erection, but did not allow semen collection, or 5 = mounted the artificial sow and allowed semen collection. Average libido score for boars receiving 10 mg PGF (2.35) was significantly greater than for controls (2.14). The percentages of boars successfully trained for semen collection, however, was similar among treatments.

The researchers noted that PGF-treated boars exhibited several behaviors not associated with libido that were dependant on the dose of the substance administered. Mild and transient scratching of the face and neck with the hind legs was observed in

boars treated with 5 or 10 mg PGF. Boars receiving 20 mg PGF responded with intense scratching of the face and neck with hind legs followed by a transient state of immobilization while standing. One boar vomited within 5 min of each injection of 20 mg PGF. Thus, it is doubtful that a higher dose of PGF (greater than 20 mg) would have increased the number of boars successfully trained for semen collection.

Sexually experienced boars. The effects of PGF treatment on the training of sexually active boars (i.e., boars experienced with natural mating) to mount an artificial sow and allow semen collection was investigated by Estienne and Harper (2000). Purebred Hampshire, Landrace and Yorkshire boars ranging in age from 1 to 4 years were used. Boars were moved to a semen collection pen twice weekly for 4 weeks (8 training sessions). Immediately after entering the collection pen, boars received i.m. treatment with 10 mg PGF (Lutalyse) (n = 7) or deionized water (n = 7). Eighty-six % of the PGF-treated boars mounted and allowed semen collection during the first exposure to the artificial sow and 100% of the PGF-treated boars were trained for semen collection by the end of the fourth training session. In contrast, only 29% of control boars were collected during the first training session and by the end of the fourth session only 57% of the controls had been trained. At the conclusion of the eighth training session, the three remaining untrained controls were administered PGF. Two of these boars subsequently mounted the artificial sow and allowed semen collection.

During the course of the experiment, reaction time, defined as the elapsed time between entering the collection pen and the start of ejaculation was greater for controls (628.4 seconds) compared with PGF-treated boars (267.4 seconds). Moreover, the number of false mounts, defined as mounting the artificial sow but not ejaculating, was greater for controls (3.9/session) compared with PGF-treated boars (0.6/session). There was no difference between treatments for the duration of ejaculation.

Estienne and Harper (2000) suggested that the use of PGF has potential for expediting the training of sexually active boars to mount an artificial sow for semen collection. Use of the substance could be advantageous for producers switching to artificial insemination and needing to train a battery of boars that were previously used for natural mating.

Sexually experienced boars displaying decreased sex drive. Szurop et al. (1985) reported that treatment with a PGF analog (Enzaprost) restored sexual behavior in older boars exhibiting low sex drive. Purebred Dutch and Belgian Landrace, Large White, and Duroc boars (n = 120) that were 3 years old and weighed 440 pounds were studied. Boars were classified as showing signs of reduced libido and received 25 mg PGF 30 minutes before collection time. Treatment with PGF restored libido and normalized reaction time in 95% of the boars.

Although hormone profiles were not determined in the study of Szurop et al. (1985), decreased sex drive may have been associated with low testosterone and estradiol secretion and despite a deficiency in endogenous testicular hormone release, PGF increased sexual behavior. Estienne et al. (2004) tested this hypothesis and determined

the effects of PGF on sexual behavior in boars with suppressed blood concentrations of testosterone and estradiol.

Lean-type, terminal-line boars (National Pig Development), 2.3 years of age and subjected to a once weekly semen collection regimen, were utilized. On the day after semen collection at week 0, boars received a s.c. implant of a GnRH agonist (Ovuplant; 2.1 mg Deslorelin; Fort Dodge Animal Health, Fort Dodge, IA) or were sham-implanted. In male animals, continuous exposure to potent GnRH agonists has been shown to decrease LH secretion because the binding sites for GnRH on the pituitary gland become over-stimulated. Subsequently, testosterone and estradiol secretion is decreased (Vickery, 1986).

Beginning at week 1, boars implanted with the GnRH agonist received an i.m. injection of 10 mg PGF (Lutalyse) (n = 5) or saline (n = 5) upon entering the collection room. Sham-implanted boars received an i.m. injection of saline (n = 5). Blood was sampled and sexual behavior assessed at week 0 and week 5.

As expected, blood concentrations of testosterone and estradiol were decreased by the GnRH agonist. However, the number of boars ejaculating, time from entering the collection room to the first attempt to mount the artificial sow, time from entering to the start of ejaculation, and duration of ejaculation did not differ among groups. The number of false mounts (mounting artificial sow but dismounting prior to semen collection) was increased by the GnRH agonist, an effect reversed by PGF. The number of false mounts for each treatment group was as follows: Sham-implanted boars receiving saline, 1.0; GnRH agonist-treated boars receiving saline, 4.2; GnRH agonist-treated boars receiving PGF, 0.2.

Estienne et al. (2004) concluded that acutely suppressing concentrations of testosterone and estradiol will not abolish sexual behavior in boars, but leads to an increase in the number of unsuccessful mounts of an artificial sow. The number of false mounts can be decreased by treatment with PGF.

Effects of Prostaglandins on Semen Characteristics

Little research has been conducted to determine the effects of treatment with prostaglandins on semen characteristics in boars. Hemsworth et al. (1977), Hashizume and Niwa (1984), and Estienne and Harper (2000) reported that sperm concentration and total number of sperm cells tended to increase after i.m. treatment of boars with PGF. In contrast, Kozink et al. (2002) found no effect of PGF treatment on various semen characteristics. These studies were all limited by low numbers of experimental boars from which semen was collected.

Given that prostaglandins are used commercially to enhance sexual behavior, we thought it important to determine if there were consequences of repeated treatment with PGF on boar semen characteristics. Thus, we conducted an experiment, the objective of

which was to determine the effects of repeated injections of PGF on semen and libido characteristics in boars (Estienne and Harper, 2004).

Lean-type, terminal-line boars (National Pig Development), that were 1.5 years of age and trained to mount an artificial sow and allow semen collection were used. Semen was collected once weekly from week 0 to 15 and on four consecutive days during week 16. Boars received an i.m. injection of 10 mg PGF (Lutalyse) (n = 11) or vehicle (n = 11) immediately before entering the collection room. For the weekly collections, there was no effect of treatment on semen volume, gel weight, sperm concentration, total sperm cells, the percentages of motile or morphologically normal sperm cells, sperm velocity, or the period from injection to the start of ejaculation. Treatment with PGF increased the duration of ejaculation (472.0 seconds and 280.4 seconds, for PGF-treated and control boars, respectively).

During the intensive collection period (week 16), semen volume, gel weight, sperm concentration, total sperm cells, the percentage of motile sperm cells and sperm velocity were similar between treatments. The interval from injection to the start of ejaculation tended to decrease (by 44%) during the intensive collection period in PGF-treated boars, but not in controls. Treatment with PGF increased the duration of ejaculation (459.1 seconds and 303.1 seconds, for PGF-treated and control boars, respectively). Thus, overall there were no exceptional positive or negative effects of long-term treatment with PGF on indicators of semen quality and libido in boars.

Summary

In some research studies, exogenous administration of prostaglandins has been demonstrated to enhance libido in sexually inexperienced boars, sexually experienced boars accustomed to natural mating, and in sexually experienced boars exhibiting a loss of sex drive that was perhaps due to decreased blood concentrations of testosterone and estradiol. In other experiments, however, prostaglandin therapy has proven ineffectual in stimulating libido. Differences in the effectiveness of prostaglandin therapy to stimulate sexual behavior among studies could be related to genetics, age or weight of boars, different products or doses of products employed, or some undetermined management practices. Given the variability in the results, we suggest that the compounds should not be used routinely, but rather judiciously as a potential tool for enhancing libido in certain situations such as the training of boars to mount an artificial sow for semen collection. The physiological mechanism by which exogenously-administered prostaglandins stimulate sex drive remains undetermined but probably involves a stimulation of areas of the brain involved in reproductive behavior. Finally, available data suggests that there are no dramatic effects of exogenous prostaglandin administration on semen characteristics in boars.

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SPERM COUNTING METHODS AND INSTRUMENTS^A

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One of the most important measurements taken on an ejaculate is sperm concentration. An accurate estimate of sperm concentration to a large degree is pivotal in determining both the reproductive success of the AI program and the efficiency of operation of the stud. The goal is to extend semen with precisely the desired number of morphologically normal, motile sperm per dose, which will result in optimum reproductive performance under a given set of conditions (specific extender, storage time, and individual boar differences).

Techniques most commonly used for routine boar semen processing will be reviewed and discussed. When one considers that a typical ejaculate may contain from less than 10 to over 100 billion sperm cells it should be apparent that all techniques provide only an estimate of the actual number of sperm. Therefore, regardless of the method used, it is important to fully understand the basis for the technique, and to gain an appreciation of factors which can result in inaccurate estimates.

Over estimating actual sperm concentration will lead to a reduced number of sperm in the insemination dose, while under estimating it will lead to sperm wastage and decrease semen production efficiency in the stud.

Methods

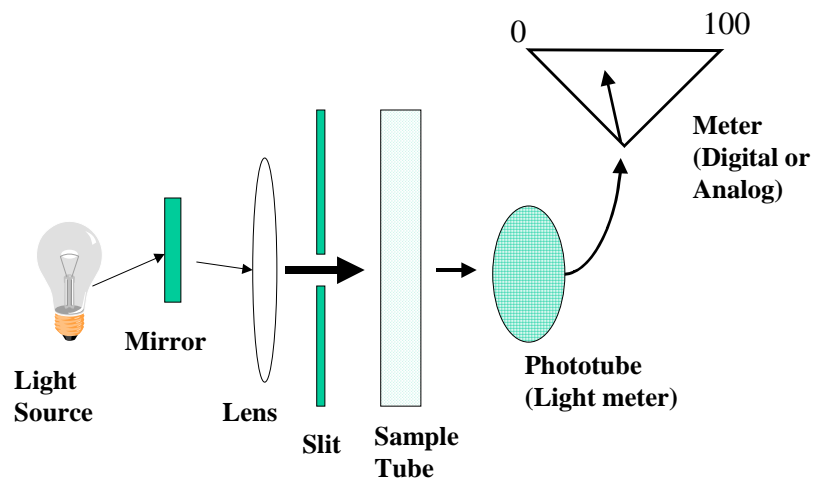
Photometric

The most common method of estimating sperm concentration is by using one of the photometric instruments that are widely available from most of the AI equipment suppliers.

^AAdapted from: Estimating sperm concentration. 1998. Leman Conference

Reference to products in this publication is not intended to be an endorsement to the exclusion of others, which may be similar. Persons using such products assume responsibility for the use in accordance with current directions of the manufacturer. The information represented here in is believed to be accurate but is in no way guaranteed.

Figure 1



Although there are some differences between individual devices the principle of operation of the photometric technique is shown in figure 1.

A beam of light is passed through the sample and the amount of light transmitted through the sample is detected and measured by a phototube, which in turn is displayed on a meter (either analog or digital). The amount of light transmitted through the sample is inversely correlated with sperm concentration in the sample.

Meter readings (Optical Density or % Transmittance) are converted to a chart with a corresponding sperm cell concentration. In the case of the SpermaCue, and some other spectrometers, the instrument itself further converts this meter reading directly to sperm/ ml.

Calibration of Conventional Photometers (Excluding SpermaCue)

A variety of makes and models of photometers are widely used in research and industrial laboratories. In many assays the intensity of a color change due to a chemical reaction is related to the concentration of the compound. With certain biological tests and sperm concentration in particular, the turbidity or opaqueness is related to cell content.

Standard laboratory photometers purchased direct from the manufacturer are not supplied with a calibration curve. Each individual assay requires its own unique method of calibration. Before purchasing a unit direct from the manufacturer or wholesale supply firm, be sure that either you have in-house expertise or someone identified to assist with calibrating it for sperm concentration determinations.

In order for the photometer to provide accurate estimates of sperm concentration they must be properly calibrated, operated, and maintained. Most instruments available from swine AI equipment suppliers have been pre-calibrated, and are accompanied by a

chart, which converts Optical Density or % Transmittance to the number of sperm per ml.

There are several accepted methods for calibrating photometric units; these include correlations with hemocytometer counts and correlations with various concentrations of latex or polymer beads. These techniques are published elsewhere, but the following are important points to consider.

1. Each photometric unit must be calibrated as an individual unit. Each unit is slightly different and requires its own calibration and conversion chart. Units should be calibrated such that most sperm concentrations result in a reading of about 40 - 60% T.
2. Because there is the potential for dust accumulation, slight changes in the light source intensity, and other functional changes over- time each unit should be checked for accuracy (calibration) on a regular basis.
3. Calibration should always be checked when the light source is changed and if a sample is accidentally spilled in the chamber

Suggestions for Daily Operating Procedures

1. Read the manual and understand how the unit operates.
2. Read and understand the techniques for preparing samples, and operating the unit. The AI equipment supplier will provide this.
3. Provide a separate 110-volt circuit for the unit.
4. Use the unit as specified by the supplier
 - Set the wavelength as specified(usually 550)
 - Use same diluent (usually 2.32% sodium citrate)
 - Dilute semen as specified. Dilutions of 1:20, 1:25, and 1:40 are commonly used. Each calibration curve is based upon a specific dilution rate. Do not use a conversion chart that was developed for another instrument.
 - Prior to use each day, turn on the unit and allow it to warm up for the specified length of time (usually about 10 minutes)
5. Read the scale the same way every time.
6. Keep the unit clean and covered when not in use.
7. Gently mix the neat ejaculate prior to sampling so that a representative sample is obtained.
8. Prepare and follow a written protocol for the specific instrument.

Potential For Errors

1. If properly calibrated, and the correct dilution rate is used, most ejaculates should result in readings between 40 -60% T. This is typically the most accurate range (sweet spot). If properly calibrated, readings between 20 and 80% should be acceptable. If a sample results in a reading of less than 20%T (very concentrated) double the dilution rate, and correct the chart reading accordingly. If readings are over 80%T, dilute the semen sample by only one-half, and correct the chart reading. If a boar semen laboratory routinely collects for processing only the sperm rich fraction, one would expect lower %T readings (more sperm / ml, and less light) as compared to the situation where the sperm rich plus post sperm fractions are collected where one would expect the readings to be higher (fewer sperm/ ml and more light). If one of these methods is routine for the laboratory, then a dilution/ calibration curve developed specifically for that range of cell concentrations would likely yield more accurate estimates.
2. Improper pipetting technique will lead to inaccurate dilution rates. Read and follow pipetting and dilution procedures supplied with the calibration information. For example, one procedure calls for a 1:40 dilution rate. This would be equal to 0.2 ml semen and 7.8 ml of diluent. Just a slight error in pipetting the 0.2 ml of semen would result in a large error in %T, and sperm concentration.
3. Use clean, sample tubes. Smudges, fingerprints, slight differences in tube diameter or wall thickness may alter the light transmission.
4. Mix the diluted sample, and read it immediately. Cap the sample tube with parafilm, and invert it 4 or 5 times. DO NOT SHAKE. Handle it only between the thumb, and middle finger at the top and bottom. Wipe the tube with a soft tissue, place in the chamber, close the cover, and let it sit for about 10 seconds before reading. Remove the tube, invert it, and then read it again. The readings should be within 1%T of each other.
5. Make certain that the photometric wavelength is set in accordance with the instructions supplied with the instrument.
6. Remember that these units are designed to measure the amount of light, which passes through the diluted sample. In addition to sperm cells, debris such as clumping, gel particles, dirt, blood or a high level of bacteria can absorb light, which leads to an inaccurate estimate of the number of sperm cells. Differences in the opaqueness of seminal plasma may also result in erroneous estimates. Reduce the estimated sperm number accordingly if such samples are to be processed.

SPERMACUE™

The SpermaCue is a specialized photometric that is widely used in boar semen laboratories. It measures the sample turbidity in a manner similar to the standard units previously discussed. However, because of some unique features the calibration and operation techniques are quite different.

Comments

This unit is calibrated for sperm concentration prior to delivery. Each unit is supplied with its own unique "standard" cuvette. This standard cuvette is read on a routine basis and the reading on the digital read out of the SpermaCue should be within +/- 5 of the value supplied with the standard cuvette. If the reading is outside of this range contact the supplier for specific instructions on how to disassemble the unit and to adjust the calibration mechanism.

Additional electronic mechanisms convert the light transmission through a relatively thin sample of semen directly to a digital readout to the number of cells x 10^6 per ml.

According to the manufacturer this unit is most accurate in the range of 150 to 450×10^6 sperm per ml. If a majority of samples fall within this range, no dilution of the neat semen is necessary. Most concentrations of the entire ejaculate would fall within this range. If only the sperm rich fraction is collected, samples will likely be above the 450×10^6 range and must be diluted 1:1 with 2.9% sodium citrate prior to reading. The reading displayed must then be multiplied by 2 (the dilution factor) to obtain the correct number of sperm per ml of semen.

Suggestions for Daily Operating Procedures

1. Read and fully understand the operating instructions supplied with the unit.
2. Check the calibration with the calibration cuvette before each use.
3. Keep the slide mechanism clean.
4. Obtain representative sample. Gently mix semen by sampling.

Potential For Errors

1. Use of a dirty cuvette or one that has a fingerprint might lead to an over estimate of sperm concentration. If the cuvettes are to be reused, carefully follow the manufactures procedures for cleaning them.
2. Fill chamber carefully. If the chamber overfills and semen contaminates the outside of the cuvette, discard and prepare a new one. Avoid air bubbles.
3. As with the other photometer devices, dirt, blood, sperm cell clumping and other debris can lead to an overestimate of sperm cell concentration.

Hemocytometer

The hemocytometer or counting chamber is a direct method of counting sperm cells. However it is an impractical and time-consuming method for use in routine semen laboratory operations. Most hemocytometers available from AI supply firms are accompanied by specific instructions. Read the instructions, and fully understand proper techniques of preparing the diluted sample and counting the sperm in the grid area. These systems are usually accompanied by a Unopette diluting system which when properly used, allows one to accurately dilute the neat semen sample for counting in the hemocytometer chamber.

Suggestions for daily Operation Procedures

1. Gently mix the neat ejaculate so that a representative sample is obtained.
2. Use only cover slips specifically designed for hemocytometer chambers. They are slightly thicker than regular disposable cover slips and they are perfectly flat.
3. Carefully clean and dry the chamber and cover slip after each use. Avoid scratching them.
4. Fill and count the sperm in both chambers. Use the average number of the two for your calculations. If the numbers obtained vary by more than 10%, prepare another diluted sample and repeat the counting procedure.

Potential for Errors

1. There are 2 Unopette systems. One provides for a dilution rate of 1:100 and the other 1:200. When ordering a supply of Unopettes be sure to purchase the correct one.
2. Slight errors in preparing the diluted sample can result in large errors in sperm concentration estimates. The small capillary tube holds only 0.01 ml or 1 μ l. It must be completely filled or the estimate will be lower than the actual number. Be sure to wipe the film of semen from the capillary tube after it is filled. If these extra cells are introduced into the dilution fluid reservoir the number of sperm will be over estimated.
3. Develop a standard method of counting cells within the chambers. For example, count only the sperm heads and ignore the tails. Count cells inside the triple lines and those touching the top and left lines and ignore those touching the bottom and right lines.
4. Depending upon the microscope and personal preference, the counts are usually made at either 40 or 100X. Assure that all cells are counted by making the proper light adjustments and by continuous refocusing up and down.
5. Do not over fill the counting chamber.
6. If the cells are clumped, prepare another sample.

Computer Assisted Semen Analysis

At least 3 systems are currently available for determining sperm concentration of both neat and extended semen. Two of these instruments incorporate a video and software system along with a microscope and computer that identifies and counts each cell in a field of a disposable chamber with a given size and depth. Although these systems require a higher investment than those previously described, they are designed to operate at line speed and they can remove some of the error between technicians. Additionally, these systems are capable of accessing sperm motility and morphology and the data can be incorporated into the total semen processing procedure. As with other methods, accurate dilutions and operation of these systems are important.

A third system incorporates a fluorescence staining technique that identifies both viable and non viable cells.

Summary

When used properly all of the above methods can provide satisfactory estimates of sperm concentration. As indicated, all of them are subject to errors. For the most reliable and accurate estimates, the laboratory personnel must be well trained to operate and maintain the devices on a daily basis and to be aware of the common sources of errors, which can be associated with each technique.

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Data: what do you record and how is it used?

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Introduction

Data is generated in large numbers in a boar stud. Most boar studs would record the data on each individual ejaculate. These numbers are used to calculate how many doses can be made and how much extender should be added to make those doses. The purpose of the paper is to discuss what items of data are important to manage the boar stud efficiently and result in the best production possible for the end user – the sow farm.

Basic data to record

The basic data that is recorded to make a dose of semen to a set sperm per dose is:

- Boar ID – seems obvious but accuracy is quite important for the customer, especially for a nucleus or multiplier sow farm
- Volume of ejaculate – usually determined by weight (1 gram = 1 ml)
- Concentration – determined with one of the following
 - Visual guess
 - Hemocytometer
 - Spectrophotometer
 - CASA machine
 - Flow cytometer

That is the fundamental of what is done in a boar stud. Most of the studs I work with also record:

- Contamination/agglutination score or comment
- Morphology count of
 - Tail abnormalities
 - Proximal droplets
 - Distal droplets
 - Other (detached heads, etc)
- Motility – after extension and each day as long as it will be used on farm
- % Normal Acrosomes - done on boars who were discarded and young boars
- Discarded ejaculates
- Pooling Data - tracking of which boars are in a pool
 - I discourage “continuous pool” processing
- How many doses of each pool went to each farm
 - This gives traceability back to the boar
 - Referred to as semen distribution

Recording of these data items can be done manually, but is more conveniently done using boar stud specific software (for example, PRISM).

Stud Management Data

Other pieces of data help to keep things under control on a day to day basis at a boar stud. A stud “under control” has a predictable quality product going out day after day.

Collection schedule

This can be done by hand with a boar collection card or tracked through the computer software. For smaller studs, it is best done with a paper collection card hung above each boar.

There are two ways to manage the collection schedule:

1. Based on days rest: this is a revolving door or scrolling type schedule where you work down a list and keep going until the orders are filled.
 - a. The advantage is it’s simple and doesn’t require much calculating or planning.
 - b. The disadvantage with this schedule is that if there is a drop in production due to heat stress, disease, etc. The schedule spins faster and faster and can quickly get out of control.
2. Each boar on a set schedule: with this system, needs are calculated for each day and boars are scheduled to meet the need. Normally, 10-15% excess is scheduled for each day.
 - a. The advantage is the barn staff knows how many boars it will be collecting each day. Also, changes in sperm output do not change the day for staff or boars. Also, there is typically some extra semen collected which can be used to fill emergency orders in between collection days.
 - b. The disadvantage is that normally more boars are collected than are needed, so labor cost is higher and also extender is wasted.

The collection schedule also can be used to make sure that all boars are collected. Without a collection schedule, the easiest collecting and best producing boars tend to get used the most, rather than the most valuable boars to the customer.

Collector Data

For larger studs, it is useful to track information on each individual collector. The two main things to look at are:

1. Total Sperm per dose by collector
 - This is usually looked at by number of doses average by collector, but it is best to break it down into volume and concentration. This helps to see that proper collection technique is being done by everyone, and who needs improvement. For example, one collector may have a lower volume than the others which may be a sign that they are not allowing the boar to finish completely.
2. Collections per hour

- This is an efficiency measure, which is again more important for a larger boar stud. Most studs have a goal for each collector to collect 4-5 collections per hour.

EBV (Estimated Breeding Value) Management

It is important that accurate EBV information is recorded for each boar and that it is updated. That allows the boar stud to deliver the best genetics to the customer.

Normally, boars with the lowest EBV are put into a “reserve” status and then culled.

The other way to manage this is to just always cull the oldest boars and use the youngest boars first. This is based on the assumption that the genetic supplier is always making genetic progress, thus the younger boars are more valuable than the older boars.

Generally, this is true, but managing each boar based on the EBV is a much better way to make progress.

The poorest way to decide which boars to collect (for the customer) is to just collect the best producing boars, or the boars who jump the dummy the quickest.

Young boars semen quality

For most of the studs I work with, the first 10 ejaculates (after training) are looked at closely for motility, morphology, and acrosome integrity. If more than half of the ejaculates for a boar have <70% normal for these three criteria, the boar should be culled.

Semen availability

This is most valuable for a stud operating on a set collection schedule rather than a days rest collection schedule. It tells the manager whether the stud can handle more sales and how many of what line. Simply it is doses collected minus doses sold.

Boar Location

The larger the stud, the more useful it is, for obvious reasons. Knowing for sure which boar is in which stall does take some work, but saves a lot of footsteps when you need to find a certain boar.

Lab Technician Data

This is quite useful if there is more than one person in the lab. Especially useful is the comparison of concentration values by technician. The measurement of concentration is by far the data point most prone to error in a boar stud. Looking at technician data helps to make sure all technicians are on the same page with technique.

Quality Management System Data

These would be things to help to ensure that procedures are being done the way they are supposed to be done. These data items also help to catch errors before the semen goes out to the customer.

Problems, Errors, and Customer Complaints

Recording these things and reviewing them helps to identify where opportunities for improvement exist. For example, if there have been 500 customer complaints about leaking semen doses at the farm in the last 3 months, someone better fix the packaging machine! These types of things typically are kept in a mangers diary, or more formally, in a ISO 9001 type of process.

Supplier and Subcontractor approval

The primary use for this is in regards to biosecurity. People doing work at a boar stud should have read the biosecurity procedures and sign off that they agree to follow those procedures.

Inspection of incoming product or boars

Make sure that you got what you ordered.

Calibration Records of equipment

Scales, thermometers, controllers, spectrophotometers, etc. should be calibrated monthly.

Training Records

Record the date you showed someone how to do a procedure and when they are approved to do that procedure. This is quite useful at employee review time.

Order Fulfillment Records

Shows what the customer ordered and what you sent them. Many sow farms have a standing order or fax orders.

Treatment Records

Important for PQA Level III Training and also for SWAP certification.

Semen Cooling Records

Semen temperature is recorded to make sure semen is fully cooled prior to packaging or bundling.

Delivery records

It is important to record temperatures of semen during transport and delivery time. This helps ensure quality is maintained after semen leaves the boar stud.

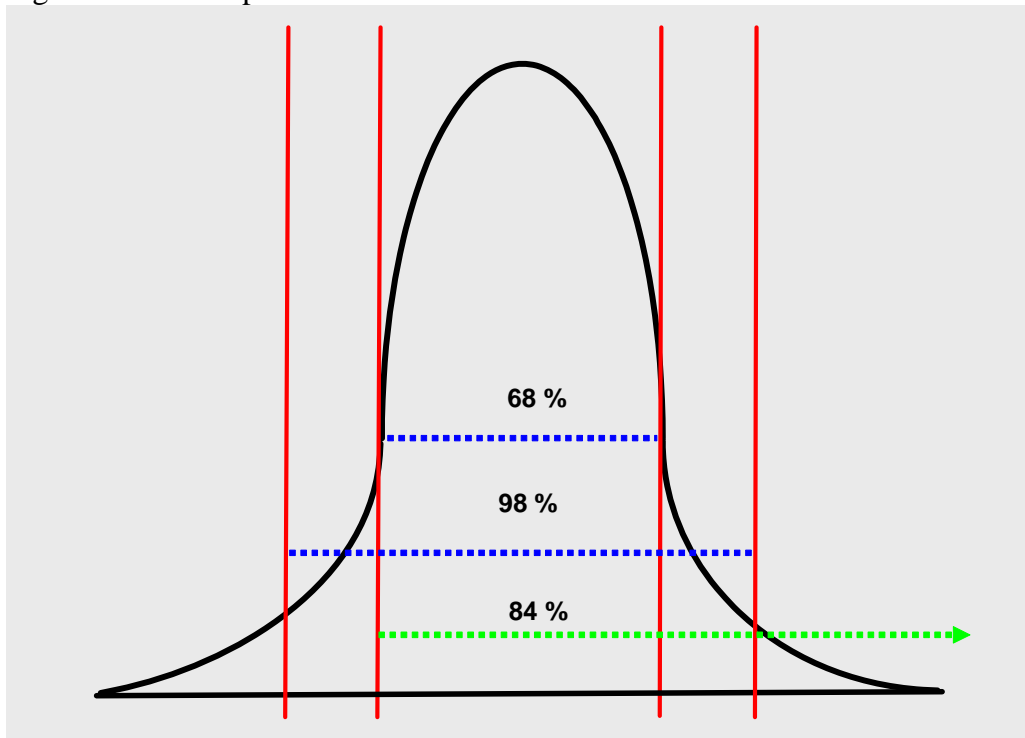
Third Party Quality Control Checks

For our clients, this has involved sperm counts and bacteria monitoring of extended semen doses.

Sperm counts

We count sperm doses each collection day and monitor sperm per dose and standard deviation. These numbers are used to calculate “Ave – 1 Std. Dev.”. This gives a number, for example 2.8 billion. In this example 68% of the doses would be above 2.8 billion sperm per dose as shown in the following diagram.

Figure 1: Bell shaped curve



If we calculate this number, it tells us that for that set of data (doses submitted for that day or week), 84% of the doses could be expected to be above this number. This is illustrated by the green dashed line in Figure 1. For example, if the average sperm per dose was 3.5 billion with a standard deviation of 0.5, one could expect 84% of the doses to be >3.0 billion total sperm per dose. If the average for the stud on those samples was 90% viable sperm, then you could say 84% of the doses had >2.7 viable sperm per dose. It gives us a point of reference over time. I tend to look at this number in 4 week chunks, and recommend adjustments to the boar stud regarding adjusting their calculated sperm per dose to achieve their goal on doses going out the door.

A variety of examples will be presented showing how this information can be utilized to minimize variation of sperm per dose in the final product.

Bacteria

The boar studs I work with culture 4 extended semen doses each collection day. This data is tracked so we can see when a boar stud is starting to have a problem. Adjustments can then be made with procedures, certain cleaning recommendations can be made, or an adjustment can be made with the extender to fix the problem.

Table 2: Bacterial growth by quarter July 2000 – June 2004

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Total
Doses Cultured	1167	1228	1095	1222	4712
Doses with Growth	363	174	255	329	1121
% with Growth	31%	14%	23%	27%	24%

Table 3: Bacteria Isolated from Extended Semen at Swine Vet Center (4725 doses cultured)

Isolated	Count
Corynebacterium	142
Staphylococcus sp.	121
Streptococcus	110
Pseudomonas sp.	104
Stenotrophomonas maltophilia	84
Alcaligenes	79
Providencia	72
Enterococcus sp,	59
Burkholderia	48
OTHER/MISC	42
Ralstonia pickettii	39
Bacillus sp.	33
Proteus sp	27
E. coli	21
Flavobacterium	21
Serratia sp.	20
Micrococcus sp,	17
Aeromonas	16
Yeast sp.	14
Enterbacter	12
Actinobacter lwoffii	8
Klebsiella	8
Arcanobacterium pyogenes	6
Chryseobacterium	5
Agrobacterium sp	4
TOTAL	1112

Summary

Data is important for a boar stud to manage in order to make continuous improvement, maintain control of quality, and continue to strive for exceptional customer performance.

Intrauterine Body and Deep Intrauterine Horn Insemination

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***Summary.** The results from various published studies that evaluated the effect of inseminating sows with an intrauterine catheter on reproductive performance are contradictory. Some studies reported a positive benefit for using the intrauterine catheter whereas other studies found detrimental effects when using an intrauterine catheter. Although values for farrowing rate and litter size are routinely reported, a fecundity index value (farrowing rate x litter size) provides a more reliable estimate for determining the value of an intrauterine insemination procedure. A computer spreadsheet has been developed to evaluate the economics surrounding the use of intrauterine insemination. Currently, the deep intrauterine horn insemination catheter is under development and not commercially available in the United States.*

Introduction. The current protocol for inseminating pigs is to: (1) check for estrus once or twice per day, (2) inseminate females two to three times during estrus, (3) inseminate 2.5 to 5.0 billion sperm cells per dose, (4) use a total volume of 70 to 100 mL, and (5) deposit the semen into the caudal to middle segment of the cervix with a disposable catheter. The site of semen deposition, number of sperm cells per dose, volume per dose of semen inseminated, time of ovulation and number of inseminations per estrus are the main factors that influence the current protocol for inseminating pigs with liquid-extended semen. To increase the efficient use of spermatozoa from a single ejaculate of boar semen, “new protocols” for using liquid-extended semen will utilize a smaller volume, a reduction in number of spermatozoa per dose and change the site of semen deposition. One proposed method to enhance the number of female pigs that can be inseminated by each ejaculate of boar semen is to use intrauterine insemination. There are basically three procedures for artificially depositing spermatozoa into the uterus: First, non-surgically deposit semen into the uterine body (Levis et al., 2002; Watson and Behan, 2002); Second, non-surgically deposit semen “deep” into the uterine horn (Martinez et al, 2001a, 2002); and Third, surgically deposit spermatozoa approximately 5 cm (~2 inches) from the uterotubal junction (Krueger et al., 1999; Krueger, 2000; Krueger and Rath, 2000; Rath, 2002; Rath et al., 2000).

Suggested benefits of intrauterine insemination. For new technology to be adopted by the pork industry there has to be a true beneficial effect on productivity and economics. Some of the claims stated as advantages for the intrauterine insemination procedure are: (1) less back-flow will occur during and after insemination, (2) fewer sperm cells per dose are needed, (3) a smaller volume of semen is needed, (4) less time is needed to infuse semen after placing the catheter into the uterine body, (5) paternal genetic cost will be lower per dose because less sperm cells are inseminated, and (6) as a result of less sperm cells per dose fewer boars will be needed to produce superior semen.

Back-flow. There is no doubt that back-flow is frequently observed during and after cervical insemination (Table 1). Although the causes of back-flow between sows are still poorly understood, many times the back-flow problem is due to the skill level and patience of the inseminator (technician). The volume of back-flow that occurs during the process of insemination is quite variable (Table 2).

An important question is: Does back-flow affect farrowing rate and litter size born alive? For back-flow to have a significant effect on farrowing rate and litter size, there has to be a loss of sperm cells in the volume of back-flow. The percentage of spermatozoa lost in back-flow from an experiment in The Netherlands is indicated in Table 3. There was a high linear correlation between volume of “fluid” lost and number of spermatozoa (During insemination, $r = .97$; 0 to .5 hours after insemination, $r = .73$; and .5 to 2.5 hours after insemination, $r = .81$). Matthijs et al. (2000) found that 45% of the spermatozoa inseminated (80 mL dose) were recovered in back-flow fluids collected in a stoma bag attached around the vulva.

The experiment by Steverink et al. (1998) did not allow the sows to farrow; thus, farrowing rate could not be calculated. The experiment did evaluate the effect of backflow on fertilization rate of oocytes. Although the number of observations for the high amount of sperm loss category was very small, a negative effect was found with a high amount of back-flow during insemination on the percentage normal embryos when 1 billion spermatozoa were inseminated (Table 4). The percentage of normal embryos was reduced ($P < .05$) regardless of the interval from time of insemination to ovulation. There are not an adequate number of observations to evaluate whether the interval of time from insemination to ovulation has an effect on percentage of normal embryos. Numerically, the percentage of normal embryos was 22 percentage points higher for sows inseminated within 0 to 24 hours of ovulation with 1 billion sperm cells compared with sows insemination 24 to 48 prior to ovulation with 1 billion sperm cells (68% vs 46%). The amount of back-flow after insemination did not affect the percentage of normal embryos in any of the three insemination dosages.

Sperm cells per dose. Traditionally, estrous gilts or sows are inseminated two or three times during estrus with 2.5 to 4 billion sperm cells per dose. Thus, 5 to 12 billion sperm cells are used for one pregnancy. The minimum number of sperm cells per dose, that will result in a high fecundity index for number of piglets born, is influenced by: (a) overall quality of semen at time of ejaculation, (b) quality control of semen processing procedures, (c) the management of sperm cells during storage, (d) age of sperm cells at time of use, (e) type of semen extender, and (f) inseminator skills.

The number of spermatozoa reaching the oviduct is greatly diminished during the “transport phase” through the uterine horns. Although billions of spermatozoa are inseminated, only thousands are found in the oviduct (Viring, 1980; Mburu et al., 1996). Sperm losses in the uterine horns are caused by adhesion of sperm to ciliary epithelial cells of the uterus and migration into uterine glands

When evaluating the influence of number of sperm cells per dose, it needs to be clearly understood how the experiment was “exactly” conducted. Without knowing anything other than the following statement, the statement can be misinterpreted - *Depositing a dose of semen*

directly into the uterus would allow a dramatic reduction in number of sperm cells per dose and total volume without lowering the fecundity index. Because of the “new” word, intrauterine insemination, most pork producers are immediately thinking that the semen is deposited in the uterine body. In reality, most of the research data on low volume and low sperm numbers per dose is related to surgically placing spermatozoa as close as possible to the uterotubal junction after hormone injection (Kruger, 2000; Rath et al., 2000). Research is underway to develop a non-surgical procedure (flexible fiberscope) for placing spermatozoa close to the uterotubal junction without sedation of the female (Vazquez et al., 2000).

Recently, France and Korea reported the results about the influence of reducing the number of sperm cells per dose on reproductive performance when using the traditional intra-cervical insemination procedure. The French work did not find a significant difference in farrowing rate or litter size when sows were inseminated with either 1.8 or 2.4 viable sperm cells (Table 5). ***However, it needs to be clearly understood that each sow was inseminated on average $2.7 \pm .03$ times during an estrous period.*** Although the main effect of number of sperm per dose did not affect farrowing rate or litter size, there was a significant interaction between age of sperm cells and number of sperm cells per dose. Farrowing rate decreased 8.2 percentage points from Day 1 to Day 4 for sow inseminated with 2.4 billion sperm cells and 3.6 percentage points for sow inseminated with 1.8 billion sperm cells. The difference in fecundity index between Day 1 and Day 4 for sows inseminated with 2.4 billion sperm cells was 135 piglets. The difference in fecundity index between Day 1 and Day 4 for sows inseminated with 1.8 billion sperm cells was 77 piglets. The Korean data did not find a significant affect of number of sperm per dose inseminated (1.5, 2.0, 2.5, or 3.0 billion) on farrowing rate or litter size (Table 6). Once again, it needs to be clearly understood that inseminations were performed twice per day with an interval of 12 hours.

Volume of semen per dose. Research conducted in 1968 suggested that gilts inseminated with 100 mL of semen (5 billion sperm cells) had a significantly higher proportion of oocytes fertilized and more sperm attached to the zona pellucida than gilts inseminated with 20 or 200 mL of semen (Baker et al., 1968). The current recommendation is to insemination 80 to 100 mL per dose into the cervix whereby it flows into the uterine horn. Why is the volume of semen per dose important? Does volume of semen per dose enhance the transport of sperm cells through: (a) the cervix, (b) the uterine body, (c) the uterine horns, or (d) the cervix, uterine body and uterine horns? The 6 to 10 inch long cervix is a highly muscular structure that is tightly constricted during diestrus and pregnancy; however, during estrus the cervix is open and edematous under the influence of estrogen. Thus, a minimum volume of semen is required to ensure that an adequate “flow of semen” moves the sperm cells through the cervix and into the body of the uterus. Before spermatozoa reach the uterine horns, they have to move through the 1.5 to 2.0 inch uterine body. The uterine body is a single structure that “feeds” the two uterine horns with sperm cells. Thus, a specific volume of semen is needed to ensure spermatozoa enter each uterine horn.

Although the volume of inseminate is important to get the sperms cells to the uterine horn, the myometrial contractions (waves) of the uterine horn are the major transport method for moving spermatozoa towards the utero-tubal junction. Viable spermatozoa arrive at the oviduct from 15 minutes to 2 hours after insemination (First et al., 1968; Viring and Einarsson, 1981).

The volume of fluid in the uterine horns is greatly reduced at 30 minutes after a natural mating; plus, only foamy moisture is found in the tip of the uterine horn at approximately two hours after a natural mating (Lovell and Getty, 1968). Because the volume of an inseminate is mainly composed of fluids instead of sperm cells, the main purpose of a specific volume of semen is most likely to “indirectly” stimulate sperm transport. The seminal plasma component of boar semen contains many different substances, such as, hormones (estrogens, testosterone), lipids, and proteins. It has been demonstrated that seminal plasma estrogens increase contraction frequency of the uterine horns by causing an endometrial release of prostaglandin $F_{2\alpha}$ (Claus et al., 1990). The physical insertion of a catheter into the cervix (mechanical stimulation) has been shown to enhance contraction frequency of the uterus when infusing 100 mL of saline.

Phagocytosis. Rapid transport of the spermatozoa through the uterine horn is important because: (a) polymorphonuclear leukocytes start attacking sperm cells in the uterus within 30 minutes after insemination, and (b) polymorphonuclear leukocytes are in the uterus for 9 to 10 hours after insemination (Hadjisavas et al., 1994).

Woelders and Matthijs (2001) have reviewed the scientific literature on phagocytosis of boar spermatozoa *in vitro* and *in vivo*. Uterine clearance of “foreign” material is a normal physiological process that serves to prepare the uterus for the reception of embryos. The clearance of spermatozoa (phagocytosis) from the reproductive tract by PMNs is not a specific immune response; otherwise, insemination would lead to the development of a sterilizing anti-sperm immunity reaction.

Insemination of pigs triggers a massive influx of PMNs into the lumen of the uterus. Large numbers of PMNs have been found at 30 minutes (Lovell and Getty, 1968), 2 hours (Pursel et al., 1978), and 3 hours (Kohsaka et al., 2000) after insemination. Rozeboom et al. (1999) found greater numbers of PMNs from 12 to 36 hours after sows were inseminated with 5 billion sperm cells compared to sows inseminated with 100 mL of seminal plasma or phosphate buffered saline. Because phagocytosis in the uterus kills sperm cells, it is extremely important that sperm cells travel to the oviduct as quickly as possible. Although the sperm cells do not travel through the folds of the cervix with IUBI, they do have to travel through the long, convoluted structure of the uterine horns. Once spermatozoa reach the oviduct they are protected from immunological reactions. Capacitated spermatozoa fertilize the oocytes in the ampulla of the oviduct.

Suggested disadvantages of intrauterine insemination. Some of the disadvantages for implementing the use of intra-uterine insemination are: (a) cost per insemination catheter is increased, (b) time has to be spent to train people on how to effectively use the new style of catheter, (c) the catheter is not recommended for use with gilts and some Parity 1 females, (d) it takes more time to carefully insert the catheter, (e) there is an increase in risk of injuring the cervix and uterine body, and (f) a higher level of catheter sanitation is required because the inner cannula is placed into the uterine body.

Intrauterine body insemination (IUBI). The uterine body of the pig, approximately two inches long, is located between the cervix and bifurcation of the two uterine horns. When using IUBI, semen is deposited about 20 cm (8”) farther into the female pig’s reproductive tract compared to

traditional cervical AI (Figure 1). The use of IUBI does not overcome the “biological” factor of losing sperm cells during the transportation process from the uterine body (site of semen deposition) to the oviduct (site of fertilization). Sperm cells are primarily lost by back-flow of semen during the first two hours after AI and phagocytosis by polymorphonuclear (PMN) leucocytes. Although approximately 90% of the spermatozoa cannot be recovered from the uterus within 2 hours after a natural mating (Viring, 1980), a sufficient number of sperm cells (100 to 200 million) reach the uterotubal junction and the adjacent first isthmic segment of the oviduct (sperm reservoir) within 15 to 20 minutes after a natural mating (Hunter, 1990). Because a substantially lesser number of motile sperm cells are deposited in the female reproductive tract with AI (2.5 to 3.0 billion) compared with a natural mating (47.9 ± 13.6 billion; ejaculation interval of 3 to 4 days), it is extremely important to minimize the number of spermatozoa lost during the transport of spermatozoa from the site of semen deposition to site of fertilization after AI.

The first, large-scale, scientifically controlled study on the commercial use of intrauterine insemination of pigs was reported by Watson et al. (2001). The complete results of the experiment were published by Watson and Behan (2002). The objective of the United Kingdom research was to investigate the effect of depositing semen directly into the uterine body on reproductive performance. A new IMV International Corporation inseminating catheter, called the DeepGoldenpig (intrauterine insemination), was compared to the standard IMV Goldenpig (intra-cervical insemination) when inseminating sows with an 80 mL doses of semen containing either 1, 2 or 3 billion total spermatozoa. Ejaculate quality was controlled to minimize variation due to spermatozoa (at least 80% motile spermatozoa; no more than 20% abnormal spermatozoa; no more than three agglutination points per field at 400x). A split-ejaculate principle was used; thus, all treatments were represented in all ejaculate. More than 10 technicians were trained to inseminate with the DeepGoldenpig and Goldenpig. Although five farms were involved with the research project, three farms had not previously used artificial insemination. Twenty-two boars from two sire lines contributed semen but the majority of the inseminations were with semen from 13 boars. Starting in January 2000 the inseminations were carried out in the United Kingdom over 27 weeks (120 sows per week). Two inseminations at 24-hour intervals were performed during a single estrus in sows (Parity 2+) with a weaning-to-estrus interval of 4 to 6 days (day of weaning is Day 1). Each sow received a single treatment with semen from the same boar at each insemination. The 3,240 sows inseminated were of two genotypes, Camborough and Standard PIC grandparents. Sows were pregnancy tested with an ultrasound device at 35 to 39 days of gestation. The following records were collected weekly: pregnancy status, date of return to estrus, date of abortion, sow death or culling, farrowing data, litter size, and number of piglets born alive.

The results of the United Kingdom study are indicated in Table 7. There was no significant difference in farrowing rate or litter size between the DeepGoldenpig and the Goldenpig when sows were inseminated with either 2 or 3 billion sperm per dose. When sows were inseminated with 1 billion sperm per dose, the Goldenpig had a lower ($P < .05$) farrowing rate (65.8%) and litter size born alive (9.0 piglets) compared to the DeepGoldenpig that had a farrowing rate of 86.9% and a litter size born alive of 10.9 piglets. The main effect of boar was not significant. Statistically, the DeepGoldenpig results were not different from the farrowing rate and litter size results for sows inseminated with either 2 or 3 billion sperm. Although the farrowing rate and

litter size of sows inseminated with the DeepGoldenpig and 1 billion sperm cells were not statistically different from sows inseminated with the Goldenpig (2 or 3 billion sperm cells), the fecundity index of sows inseminated with the DeepGoldenpig (1 billion sperm cells) had 46 to 53 less piglets per 100 sows bred than sows inseminated with the Goldenpig and 2 or 3 billion sperm. If this small difference is real, the accumulated loss in number of piglets born live would become important on a farm with several thousand sows ($[52 \text{ weeks/year}] \times [200 \text{ sows bred/week}] \times [46 \text{ piglets lost/100 sow bred}] = 4,784 \text{ piglets lost per year}$).

The conclusions from the initial experiment are: (1) It is not economical to use an intrauterine insemination device when inseminating sows with 2 or 3 billion sperm cells per dose, and (2) Because of a lower fecundity index, it is questionable as to whether an intrauterine insemination device should be used with 1 billion sperm cells per dose when compared with intra-cervical insemination with 2 or 3 billion sperm cells per dose.

The results from several IUBI studies conducted by scientists in Spain and United States are indicated in Table 8. The 12 trials by Gil et al. (2000; 2002) used several different volumes of semen and number of sperm cells per dose. When comparing fecundity indexes between treatments, only 4 of the 12 trials indicated an increase in fecundity index when inseminating sows with an intrauterine body insemination catheter. Lapuente et al. (2002) compared the use of a cervical catheter (3.5 billion sperm cells in 100 mL dose) with an intrauterine catheter (1.75 billion sperm cells in 50 mL dose) on reproductive performance. The fecundity index was slightly greater for the sows inseminated with a cervical catheter. The study by Gall (2002) found the fecundity index to be the same for sows inseminated with a cervical catheter (3 billion sperm cells in 75 mL dose) compared with sows inseminated with an intrauterine catheter (30 mL of 43 degrees C [109 F] extender was placed in the reproductive tract for 2 minutes before inseminating with 18 mL of semen that contained 0.62 billion sperm cells). Does the use of a warm extender prior to insemination enhance sperm transport? It is interesting to note that in 3 of the 4 studies where Gil et al. (2002) found an increase in fecundity index of sows inseminated with an intrauterine catheter compared with sows inseminated with a cervical catheter, the number of sperm cells per dose was .5 to .75 billion in a dose of semen containing 50 mL or less.

A recent study by Rozeboom et al. (2004) evaluated the effect of type of insemination catheter (intrauterine or a conventional foam tip), number of sperm cells per dose (.5, 1 or 4 billion), and weaning-to-estrus interval (3, 4, or 5 days) on reproductive performance of sows on commercial farms with 3,600 sows (Tables 9 and 10). The volume of each dose of semen for all treatments was 85 mL. The conclusions by the authors were: (1) the use of an intrauterine catheter to place a conventional volume and number of sperm cells in the uterine body produces results similar to placement of semen in the cervix with a conventional catheter, and (2) farrowing rate, total pigs born and total pigs born alive decreased ($P < .05$) when .5 billion sperm cells were used with an intrauterine catheter. However, when a fecundity index is calculated, the number of piglet born alive per 100 sows bred is always higher when 4 billion sperm cells per dose are use compared with .5 or 1 billion sperm cells per dose (Figure 2).

The results of a study conducted in Argentina by Dr. Sara Williams are indicated in Table 11 (Levis et al., 2002). The objective of the Argentine research was to compare the reproductive efficiency in three herds of sows under commercial conditions when using either the traditional

AI technique (100 mL dose with 3×10^9 total sperm) or the intrauterine method (50 mL dose with 1.5×10^9 total sperm or 30 mL dose with 1×10^9 total sperm). The sows were inseminated with a Soft Quick[®] (Imporvet, S.A., Spain) intrauterine catheter. The intra-uterine AI technique used for this study consisted of: (1) Wiping the vulva clean, (2) Placing 2 mL of gynecological gel on the tip of the catheter, (3) Inserting the catheter in a traditional way until “locked” in the cervix, (4) Pushing the inner cannula 1.5 cm (3.8 inches) out from the catheter, (5) Injecting 30 to 35 mL of boar semen extender (MR-A[®]) at a temperature of 107.6° F to 111.2° F, (6) Waiting 1 to 2 minutes, (7) Carefully push the cannula past the rings of the cervix and into the body of the uterus, and (8) Inseminating the dose (50 or 30 mL). In Herd A fertility rate at day 30 of gestation (pregnancy status determined by A-mode ultrasound) was higher for sows inseminated with 30 mL (1 billion sperm) compared to sows inseminated with either 100 mL (3 billion sperm) or 50 mL (1.5 billion sperm). In Herds B and C the traditional method of insemination (100 mL) produced the highest fertility rate at day 30 compared to the intra-uterine methods. With respect to farrowing rate for sows in Herd B, a higher farrowing rate occurred for sows inseminated with 50 mL (1.5 billion) compared to sows receiving 30 mL (1 billion) or 100 mL (3 billion). In Herds A and C, sows inseminated with 100 mL of semen had a higher farrowing rate compared to sows receiving an intra-uterine insemination. Sows inseminated with 100 mL of semen had the highest values for total piglets born (except for sows in Herd A inseminated with 50 mL dose) and the number of the piglets born alive.

The results of this study clearly demonstrate that the value of a product or procedure on reproductive performance cannot be determined by using a single reproductive trait, such as, farrowing rate or litter size. For example, sows inseminated with an intrauterine catheter (30 mL, 1 billion sperm cells) had the highest farrowing rate (87.5%) in Herd A compared to the farrowing rate (79.2%) of sows inseminated with a cervical catheter (100 mL, 3 billions per sperm cells). However, total litter size born was 2.4 piglets higher for sows inseminated with a cervical catheter (12.45 piglets) compared to sows inseminated with an intrauterine catheter (10.04 piglets). These types of results confuse the decision as to which insemination procedure should be used. To remove the confusion a fecundity index should be calculated; thus, a single value can be compared.

Table 11 indicates the fecundity index for sows inseminated with 100 mL (3.0 billion sperm) of semen into the cervix or intrauterine insemination with 30 (1.0 billion sperm) or 50 mL (1.5 billion sperm). In Herd A sows inseminated with 100 mL of semen (cervical) had 98 additional pigs compared to sows inseminated with 50 mL of semen (intrauterine) and 38 more pigs than sows inseminated with 30 mL of semen (intrauterine). In Herd C sows inseminated with 100 mL of semen had 106 and 201 additional pigs compared to intra-uterine inseminated sows receiving 50 mL or 30 mL, respectively. The only herd where the intra-uterine A.I. technique had a small advantage for fecundity index was Herd B. Sows receiving inseminations with an intrauterine catheter (50 mL, 1.5 billion sperm) had a 13-pig advantage compared to sows receiving a cervical insemination (100 mL, 3.0 billion sperm). This data clearly demonstrates that differences do exist between herds. The fecundity index value was significantly lower in Herd B compared to Herds A and C, regardless of the type of method used to inseminate sows.

The conclusion from the study in Argentina is that the use of an intrauterine catheter to inseminate sows with a lower volume and lower sperm cells per dose has detrimental effects on

reproductive performance as compared to inseminating sows with an intracervical catheter and 100 mL of semen containing 3 billion sperm cells.

A recent study by Gibson et al. (2004) evaluated the effect of number of inseminations (one or two), postweaning estrus (conceived at first estrus or conceived at first return after breeding), type of catheter (intrauterine or conventional), and use of oxytocin in semen deposited with an intrauterine catheter. Farrowing rate and subsequent litter size were not different between sows inseminated with a conventional or intrauterine catheter (Table 12). If sows only received one insemination, farrowing rate was greater ($P = .02$) for sows inseminated with an intrauterine catheter and oxytocin compared with sows inseminated with either a conventional catheter or intrauterine catheter.

Rippel and Althouse (2002) evaluated the effect of inseminating sows with an intrauterine catheter or conventional catheter on reproductive performance. The commercial swine operation was deficient on the number of boars needed to produce semen. Thus, the objective of this project was to increase the number of doses per ejaculate. By reducing the “total” number of sperm cells per dose from 3.0 billion to 1.5 billion the number of doses per ejaculate was increased. The total volume per dose was 80 mL for both 1.5 and 3.0 billion sperm cells per dose. Based on the United Kingdom data, it was hypothesized that reproductive performance would be adequate if the 1.5 billion sperm cells were deposited directly into the uterine body with an intra-uterine catheter (DeepGoldenpig). This project was not designed whereby a direct comparison could be made between types of insemination catheters (DeepGoldenpig versus Goldenpig) or number of sperm cells per dose (1.5 billion versus 3.0 billion). The number of sperm cells used with the Goldenpig was 3.0 billion; whereas, 1.5 billion sperm cells were used with the DeepGoldenpig. Although both types of catheters were used within each week, type of catheter is confounded with number of sperm cells per dose. In addition, boars contributing semen are confounded with type of catheter and number of sperm cells per dose. Semen from boars was randomly pooled and only one extension rate was used for the entire pool (either 1.5 or 3.0 billion sperm per dose). In essence, the DeepGoldenpig was used as a “Tool” to solve a shortage of semen problem. The extender used was X-cell and the age of sperm cells at time of mating ranged from 1 to 5 days. Sows were weaned into individual stalls and heat-checked daily during AM. Within one hour after detected in estrus, estrous sows were moved to another individual stall to be inseminated. Sows were only inseminated twice (late morning of Day 1 and approximately 24 hours later). Starting May 15, 2001, approximately the same number of sows was inseminated during the next four weeks with either the Goldenpig or DeepGoldenpig.

The results of the project are indicated in Table 13. Because of the confounding and data collection procedures (some aggregation of weekly data) the data could not be statistically analyzed. The data was partitioned into sows cycling by 7 days after weaning, opportunity sows (cycled > 8 days after weaning) and repeat breeders. Although main effects cannot be determined, sows inseminated with the Goldenpig and 3.0 billion sperm cells had a higher fecundity index value of 19 piglets per 100 sows inseminated. The fecundity index for opportunity sows or repeat breeders was not different between sows inseminated with the Goldenpig (3.0 billion sperm cells per dose) or DeepGoldenpig (1.5 billion sperm cells per dose).

Conclusions from the study by Rippel and Althouse are: (1) There was no difference in fecundity index for sows inseminated with an intra-cervical catheter (80 mL, 3 billion sperm cells) or intrauterine catheter (80 mL, 1.5 billion sperm cells), regardless of whether the sows cycled by 7 days after weaning, cycled more than 8 days after weaning, or were repeat breeders. (2) Regardless of the method used for insemination, farrowing rate was low for sows cycling by 7 days after weaning, sows cycling more than 8 days after weaning, and repeat breeders. (3) If an “in-house” boar stud is short on number of boars producing semen, inseminating sows with an intra-uterine device (1.5 billion sperm cells per dose) can help reduce “temporarily” the shortage in number of doses produced.

Economics. Although values for farrowing rate and litter size born live are routinely reported, a fecundity index value (farrowing rate x litter size) provides a more reliable estimate for determining the value of IUBI procedure. A decision for adopting a new reproductive technology should not be based on a single trait, such as, farrowing rate or litter size. When making a comparison between “treatments”, one frequently finds that Treatment 1 resulted in a greater farrowing rate compared with Treatment 2 but utilization of Treatment 1 resulted in a lesser litter size than Treatment 2. In order to evaluate the economics surrounding the use of IUBI, a Microsoft Excel spreadsheet was developed. The spreadsheet can simultaneously evaluate three scenarios. This spreadsheet is available from the Ohio Pork Industry Center’s website (<http://porkinfo.osu.edu/Excel%20Spreadsheets/Intrauterine-AIform.xls>). The farrowing rate and litter size born live data from Gil et al. (2002) was used to generate the economics of using intrauterine body insemination (Table 14). The basic factors used in the model are farrowing rate, litter size born live, weekly farrowing, number of farrowing crates per group per week, percentage preweaning death loss, duration of time (minutes) per insemination, dollars per hour of labor, percentage of group is gilts, cost per each type of insemination catheter, cost per dose of semen, number of inseminations per estrus, and assumed profit per pig. This model is designed to have a specific number of sows bred based on the estimated farrowing rate (over-breed); thus, all assigned farrowing crates per group are filled to capacity.

When a dose of semen is the same price (regardless of number of sperm cells per dose) for the data by Gil et al. (2002), the model indicated an economic loss (-\$615 to -\$79,693) in eight of the ten trials when IUBI was used compared with cervical AI (Table 14). If the price per dose of semen is \$3.00 for IUBI and \$6.00 for cervical AI, seven of the ten trials showed an economic advantage that ranged from \$3,066 to \$51,078 for IUBI. Using the data generated by Watson and Behan (2002), the cost of IUBI semen needed to be about \$1.00 less per dose to produce the same yearly net profit as cervical insemination (Table 15). The results from these trials clearly demonstrate that the price per dose of semen plays a critical role in the economical use of IUBI. What will semen suppliers charge per dose of semen that contains one billion or fewer spermatozoa? It must be remembered that a dose of semen is priced as a combination of genetic cost, number of sperm cells per dose, overhead costs, and profit. These factors will determine the differential price of semen doses that contain greater or lesser sperm numbers.

Absolute insemination catheter: I am aware of the new catheter on the market called Absolute (Ab™) Catheters (<http://www.absoluteinsemination.com/Timing%20Protocols.html>). Currently, I am not aware of any published data from scientifically designed experiments that have compared conventional catheters with the Absolute Catheter.

Deep Intrauterine Horn Insemination (DIUHI). To further reduce the number of spermatozoa per dose inseminated, techniques are being developed whereby sperm cells are placed deep into the uterine horn (Figure 3) at a lesser dosage volume as compared with that used with IUBI (Martinez et al., 2001b; Rath, 2002). Although it is not practical to surgically deposit sperm cells into the uterine horn on a commercial farm with the presently available technologies, it has been documented that fertilization potential is not substantially decreased when 100 million sperm are deposited about 5 cm (\approx 2 inches) distal from the uterotubal junction (Krueger et al., 1999; Krueger and Rath, 2000; Rath et al., 2000). A field experiment in the United States by Krueger and Rath (2000) did find a non-significant linear decrease in number of piglets born live as number of spermatozoa per dose decreased (Table 16). The difference detected might be significant when a larger number of sows per treatment are used. The encouraging results from depositing much reduced spermatozoa close to the uterotubal junction on farrowing rate and litter size has stimulated scientists to investigate non-surgical, non-sedative methods of depositing spermatozoa deep into the uterine horn.

Fiber Optic Insemination. The anatomy of the cervix (thick muscles, series of folds or ridges, cervical contractions during estrus) and long uterine horns (47 to 55 inches long with convoluted structures) previously impeded the development of a procedure for non-surgical insemination into the uterine horn. A fiber optic endoscope technique for non-surgical DIUHI of pigs has been investigated in Spain (Martinez et al., 2001a). Table 17 provides data that indicates the effect of number of sperm cells per dose on reproductive performance when inseminating non-sedated sows with a flexible fiber optic endoscope. Farrowing rate and number of piglets per litter were not significantly different when sows were inseminated using fiber optic technologies with 1 billion, 200 million or 50 million sperm cells as compared to cervical AI with 3 billion cells. Numerically, the number of piglets per litter was fewer on the fiber optic treatment. The lack of detecting a significant difference might be due to the small number of sow (13 to 18 sows) per fiber optic treatment group.

Flexible Catheter Insemination. Although estrus sows can be successfully inseminated with a fiber optic endoscope, the endoscope is expensive, fragile, and most likely unsuitable for use under field conditions. Scientists in Spain have evaluated a specifically designed flexible catheter (70 inches long) that is inserted through a traditional spirette catheter and passed through the cervix and moved forward along **ONE** uterine horn until its total length has been inserted to about the middle of the uterine horn (Martinez et al., 2002). In this study, crossbred sows were treated with 1250 IU equine chorionic gonadotrophin (eCG) 24 hours after weaning and with 750 IU of human chorionic gonadotrophin (hCG) 72 hours after eCG. DIUHI was performed once at 36 hours after hCG treatment with 150 million, 50 million, 25 million or 10 million sperm cells in 10 mL. Control sows were cervically inseminated twice with 3 billion sperm cells in 100 mL. Farrowing rate after DIUHI with 150 million or 50 million sperm cells did not differ from the control group (Table 18). However, farrowing rate was less ($P < .001$) after DIUHI with 25 million or 10 million sperm cells compared with control sows. Although litter size born was not significantly different between treatments, litter size was numerically smaller for sows inseminated with 10 million, 25 million or 50 million sperm cells.

Ipsilateral-Contralateral Fertilization. Because sperm cells are only deposited in one uterine horn, the question arises as to whether fertilization only takes place in the uterine horn where spermatozoa are deposited (ipsilateral fertilization) or whether fertilization also takes place in the opposite uterine horn of spermatozoa deposition (contralateral fertilization). Research has demonstrated that when spermatozoa are deposited close to the uterotubal junction in one uterine horn, spermatozoa are able to reach the contralateral oviduct and fertilize the oocytes (Martinez et al, 2002). The total number of normal embryos was fewer in the assumed “contralateral” uterine horn (Table 19). The mechanism by which sperm cells are transported to the contralateral oviduct is being studied. Hunter (1978) reported that fertilization of oocytes occurred after intraperitoneal deposition. In addition, Viring and Einarsson (1981) suggested that spermatozoa pass through the oviduct of pigs into the abdominal cavity during the first hours after natural mating. Yaniz et al. (2002) recently reviewed the scientific literature on intraperitoneal insemination in mammals.

Uterine Infection. If sows are inseminated during estrus, it has been suggested that uterine infections (vaginal discharges) is less than 1% (Martinez et al, 2002). The low risk of inducing uterine infection with DIUHI is most likely because sows are resistant to bacterial infections when circulating concentration of estrogen is elevated during estrus (De Winter et al., 1996). Vaginal discharges will be a problem if good estrous detection procedures are not utilized to prevent the insemination of anestrous sows or sows close to going out of estrus.

Animal Welfare. Will animal welfare activist accept the DIUHI procedure? Is the DIUHI procedure painful to the sow? Martinez et al. (2002) studied the difficulties encountered during insertion of the flexible catheter, duration of time to insert catheter and behavior of the sow during insertion. The flexible catheter was successfully placed into one uterine horn in 95.4% of the sows in an average of $3.7 \pm .09$ minutes. Parity (2, 3 or 4 to 6) did not significantly affect the difficulties or time required to insert the flexible catheter. The percentage of sows expressing good or moderate behavior during the insemination procedure was 97.1% when there was no or minor difficulty at insertion of catheter, 93.8% when there was medium difficulty at insertion of catheter, 85.7% when there was high difficulty at insertion of catheter and 94.4% when it was impossible to insert catheter.

Economics. At this point in time it is impossible to economically evaluate the use of DIUHI. The cost of semen and insemination device is unknown in the United States. MAGAPOR has a DIUHI device (FirFlex™) on the market in Europe (www.magapor.com). Fewer boars are needed to produce semen for cervical artificial insemination compared with natural service. Fewer boars are needed to produce semen for DIUHI compared with cervical insemination. Fewer boars are needed to produce semen for *in vitro* fertilization of ova (75 sperm cells per oocyte; Rath et al., 1999) compared with DIUHI. How many boars will be needed to produce sperm cells for use with DIUHI? Will the genetic companies have the correct boars identified to produce terminal and maternal semen?

Number of Boars Producing Semen. Scientists have made statements that: (1) DIUHI will be of great importance to the pork industry because superior boars can be more efficiently utilized, (2) DIUHI will complement the development of AI, especially with the use of sexed

semen, (3) DIUHI will allow a tremendous saving in cost of semen. However, using a lesser number of sperm cells per insemination will have a significant influence on genetic companies.

The influence of number of sperm cells per dose and genetic line on total number of doses packaged is indicated in Table 20. An estimated number of “productive” boars required in the United States for sperm production when servicing sows by natural service, cervical artificial insemination or DIUHI is indicated in Table 21. The number of boars needed to produce spermatozoa for use with DIUHI is about 890 (150 million sperm per dose) to 5,900 (1 billion sperm per dose). If only 890 boars are required, who will own this small number of boars?

Questions that need answers or clarification:

1. What is the true effect of the intra-uterine catheter on farrowing rate, litter size, and fecundity index?
2. What should the volume of semen be when inseminating with the intra-uterine catheter?
3. What should the number of sperm cells per dose be when inseminating with the intra-uterine catheter?
4. Is there a significant interaction between volume of semen and number of sperm cells per dose when inseminating with the intra-uterine catheter?
5. What is the true effect of the intra-uterine catheter on fecundity index of sows cycling more than 8 days after weaning and repeat breeders?
6. What is the correct procedure to use for inserting the intra-uterine catheter?
7. Is it easier to insert the intra-uterine catheter when the estrous sow has not had immediate boar exposure and the cervix is “relaxed”?
8. Should the sows be in a solid standing response with boar exposure at time of inserting catheter and inseminating?
9. Should the sows be heat-check one-hour before inserting the catheter and no boar is present when inserting the intra-uterine catheter and inseminating the sow?
10. If a boar is not present during the time of catheter insertion and insemination, should boar exposure be provided immediately after the insemination process? If so, how soon after insemination should boar exposure be provided to sows?
11. If insemination aids are used (weighted saddles, belts, etc.) with a traditional A.I. program, is the overall time spent inseminating sows reduced or increased when using an intra-uterine catheter?

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Appendix A: Example worksheet to evaluate the reproductive performance and economics of using intra-uterine insemination.

Items	Scenario 1	Scenario 2	Scenario 3
Input factors			
Type of catheter	Cervical	Intra-uterine	Intra-uterine
Farrowing interval, d	7	7	7
Number farrowing crates per group	64	64	64
Estimated avg yearly farrowing rate, %	90.5	92.5	86.9
Estimated avg litter size born live/litter	10.9	10.8	10.9
Preweaning death loss, %	10.0	10.0	10.0
Cost of each A.I. catheter, \$	.17	.79	.79
Time to perform each insemination, minutes	4	6	6
Labor cost per hour for inseminators, \$	10.00	10.00	10.00
Number of sperm cells per dose, billion	3	2	1
Cost of semen per dose, \$	7.50	7.50	7.50
Gilts inseminated per group, %	15.0	15.0	15.0
Avg number of insemination/female/estrus (without gilts)	2	2	2
Estimated profit per weaned pig, \$/head	\$8.00	\$8.00	\$8.00 ^a
Calculations			
Number of farrowings per year	52.1	52.1	52.1
Number of sows inseminated per group	71	69	74
Total number of females inseminated/year	3,699	3,595	3,855
Total number of females inseminated (without gilts)	3,144	3,056	3,277
Total number of insemination/year	6,288	6,112	6,554
Total cost of catheters	\$1,068	\$4,828	\$5,178
Total cost of labor	\$4,192	\$6,112	\$6,554
Total cost of catheter & labor	\$5,260	\$10,940	\$11,732
Total number of pig weaned/year	32,710	32,410	32,710
Total profit from pigs	\$261,680	\$259,280	\$261,680
Net (total profit – Catheter & labor)	\$256,420	\$248,340	\$249,948
Difference from cervical A.I.			
Scenario 1 – Scenario 2	-\$8,080		
Scenario 1 - Scenario 3	-\$6,472		

^a Value was not adjusted for a lower farrowing rate.

Figure 1. Placement of DeepGoldenpig™ catheter in female reproductive tract.

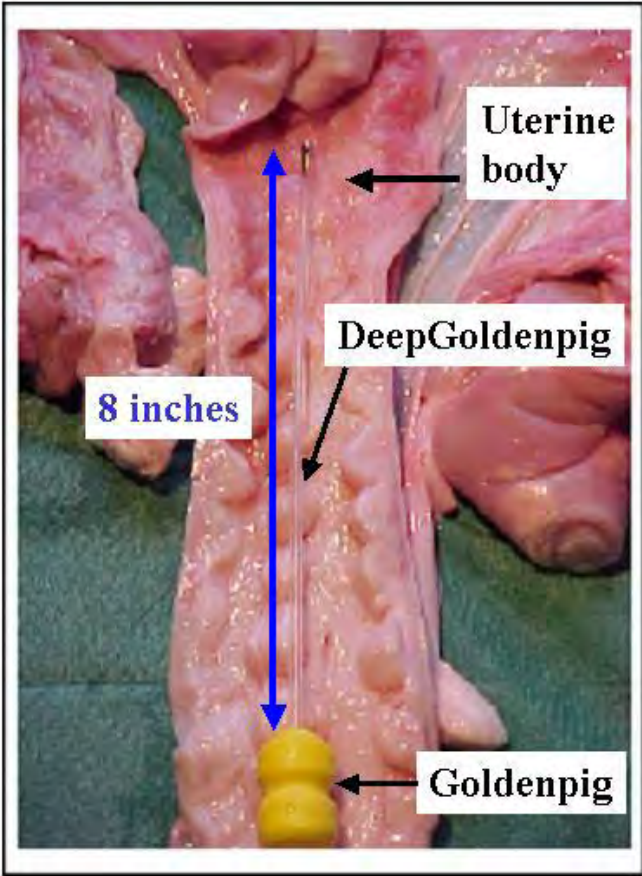
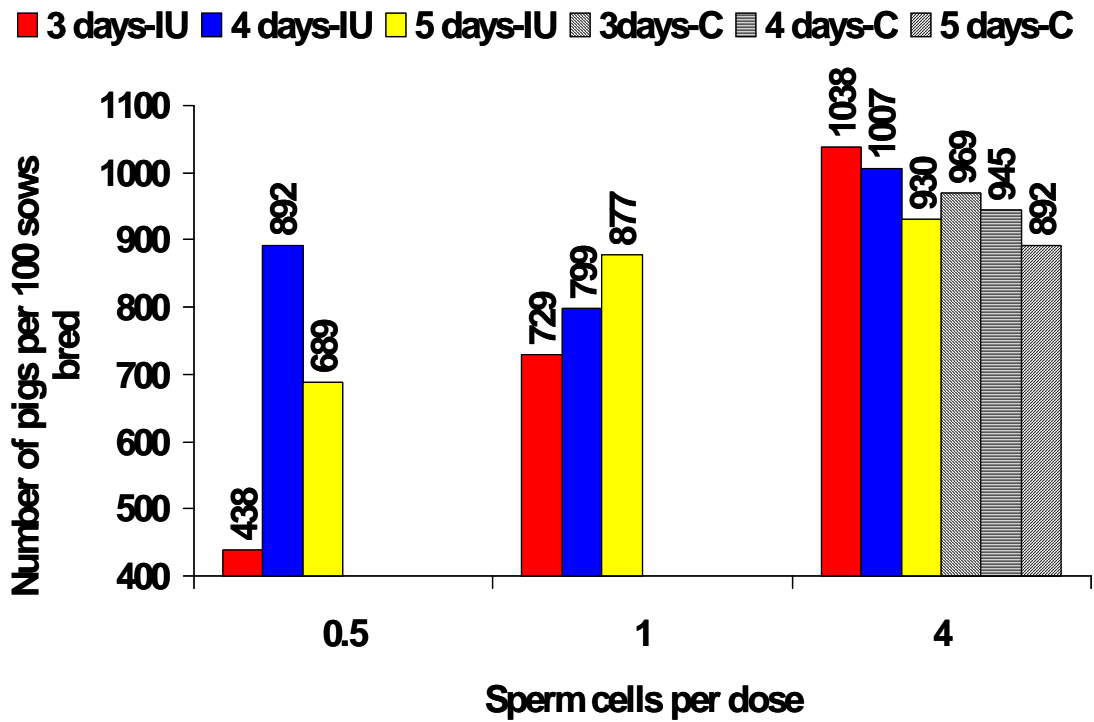


Figure 2. Effect of number of sperm cells per dose, type of catheter (IU, intrauterine; C, cervical) and weaning-to-estrus interval on number of pigs born per 100 sows bred.



Fecundity index calculated from data published by Rozeboom et al., 2004.

Figure 3. Location of semen deposition with different artificial insemination methods

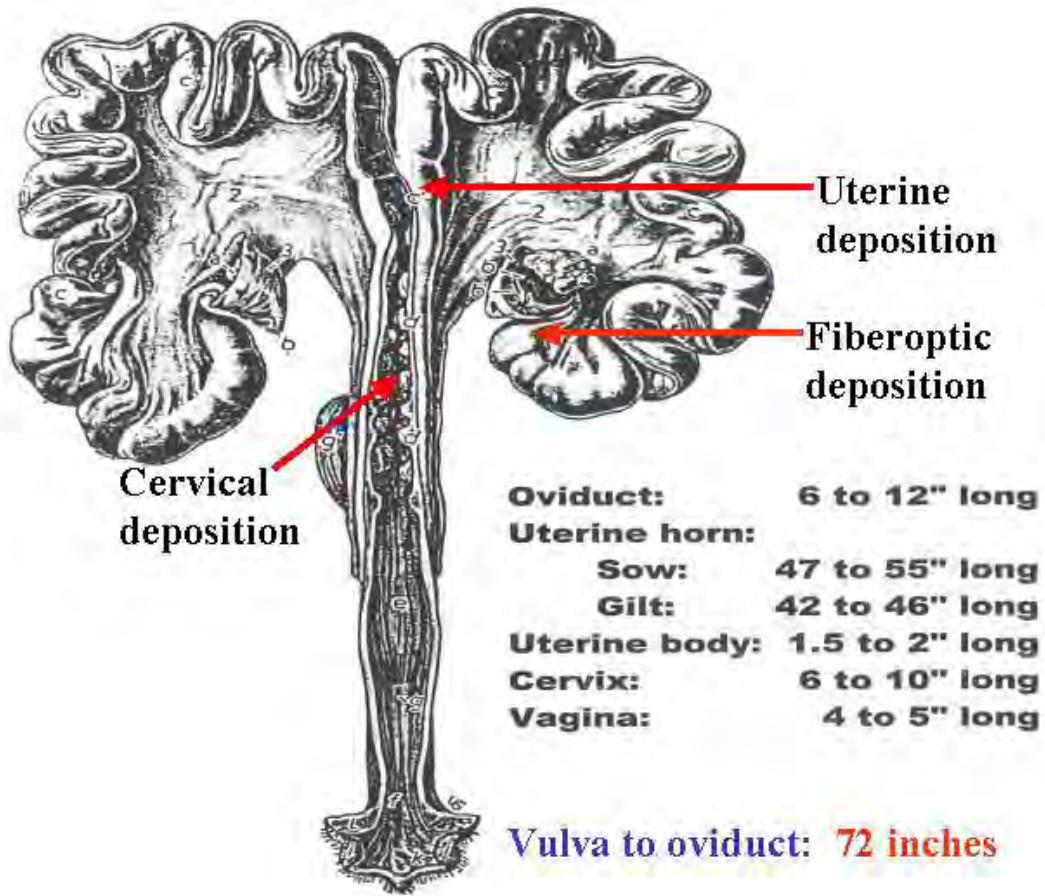


Table 1. The percentage of sows inseminated that have back-flow.

Time of back-flow	Number sows evaluated for back-flow	Number sows with back-flow	Sows with back-flow
During insemination	120	76	63.3%
0 to .5 hours after insemination	112 ^a	110	98.2%
.5 to 2.5 hours after insemination	80 ^a	78	97.5%

Reference: Steverink et al., 1998.

^a When a sow had urinated into the colostomy bag or the colostomy bag was damaged, the value was deleted from the data set.

Table 2. Proportion of total volume inseminated (80 mL) that was lost during and after cervical artificial insemination

Time of back-flow	Number of sows	Percentage of total volume lost	
		Mean \pm se	Range
During insemination	76	7 \pm 1.1%	1 to 56%
0 to .5 hours after insemination	110	31 \pm 1.7%	3 to 76%
.5 to 2.5 hours after insemination	78	36 \pm 2.6%	1 to 94%

Reference: Steverink et al., 1998

Table 3. Proportion of total number of sperm cells inseminated (80 mL dose with 1, 3, or 6 billion sperm) that was lost during and after cervical artificial insemination

Time of back-flow	Number of sows	Percentage of total spermatozoa lost	
		Mean \pm se	Range
During insemination	76	8 \pm 1.3%	.3 to 50%
0 to .5 hours after insemination	110	14 \pm 1.0%	.3 to 79%
.5 to 2.5 hours after insemination	78	9 \pm 0.8%	.3 to 30%

Reference: Steverink et al., 1998

Table 4. Influence of back-flow on fertilization rate of oocytes

Sperm Dosage	Back-flow observed	Interval from insemination to Ovulation (0 to 24 hours)				Interval from insemination to Ovulation (24 to 48 hours)			
		Low ^a		High ^b		Low		High	
		n ^c	Norm ^d	n	Norm	n	Norm	n	Norm
One Billion	During AI	28	100	4	68*	17	93	5	46*
	0-.5 hr after AI	22	100	5	100	18	85	4	90
	.5 to 2.5 hr after AI	14	100	2	100	9	70	4	98
Three Billion	During AI	12	98	3	96	17	68	4	89
	0-.5 hr after AI	6	98	4	97	15	71	5	100
	.5 to 2.5 hr after AI	7	95	1	96	13	88	3	53
Six Billion	During AI	2	92	1	-	21	90	6	97
	0-.5 hr after AI	4	100	0	-	21	100	3	42
	.5 to 2.5 hr after AI	1	-	0	-	17	72	5	100

Reference: Steverink et al., 1998

^a Low = 80% of sows with the lowest relative number of spermatozoa in back-flow

^b High = 20% of sows with the highest relative number of spermatozoa in back-flow

^c Number of embryos

^d Average percentage of embryos that were normal

* Within interval from insemination to ovulation, the percentage of normal embryos were different (P < .05) between low and high loss of spermatozoa

Table 5. Influence of number of “viable” sperm cells per dose and age of sperm cells at time of insemination on reproductive performance (90 mL dose; BTS extender).^a

Item	Age of sperm cells (Days)		Sperm per dose (billion)		Age x Sperm per dose			
	1 Day	4 Days	1.8	2.4	D1-1.8	D1-2.4	D4-1.8	D4-2.4
Number sows	498	504	503	499	253	245	250	254
Farrowing rate, %	93.0 ^b	87.6 ^c	90.1 ^b	90.6 ^b	91.9 ^{bc}	94.2 ^b	88.3 ^c	86.0 ^c
Born live	11.4 ^b	10.9 ^c	11.2 ^b	11.1 ^b	11.5 ^b	11.3 ^{bc}	11.1 ^{bc}	10.8 ^c
Total born	12.2 ^b	11.8 ^b	12.1 ^b	11.9 ^b	12.2 ^b	12.2 ^b	12.0 ^b	11.6 ^b
Fecundity index	1,060	955	1,009	1,006	1,057	1,064	980	929
Difference in FI	105		3		7		51	
	(D1-1.8) – (D4-1.8) = 77 piglets (D1-2.4) – (D4-2.4) = 135 piglets							

Reference: Mercat et al., 2000.

^a The average number of inseminations per sow was 2.7 ± .03.

^{bc} Unlike superscripts within a row are different (P < .05).

Table 6. Influence of number of motile sperm cells per dose on reproductive performance.^a

Item	Number of motile sperm per 80 mL dose (billion)			
	3.0	2.5	2.0	1.5
Number sows	3,757	1,123	1,078	860
Pregnancy rate at Day 30 of gestation	87.0	87.6	87.8	86.1
Farrowing rate, %	82.7	84.5	82.3	82.2
Litter size (Total born)	10.7	10.9	10.6	10.9
Litter size (born alive)	10.0	10.1	9.9	10.1
Fecundity index	827	853	812	830

Reference: Park et al., 2000.

^a Inseminations were performed twice per day with an interval of 12 hours (BTS extender).

Table 7. Effect of intra-uterine insemination and sperm cells per dose on reproductive performance (two inseminations at 24-hr interval; weaning-to-estrus interval < 4 to 6 days).

Item	1 billion sperm per dose			2 billion sperm per dose			3 billion sperm per dose		
	Parity		Weighted Average	Parity		Weighted average	Parity		Weighted Average
	2 to 7	> 7		2 to 7	> 7		2 to 7	> 7	
FR, % ^a									
GP ^b	65.7	68.8	65.8*	91.6	95.8	91.8	90.9	95.2	91.1
DGP ^c	86.7	94.4	86.9	92.5	92.9	92.5	90.6	86.4	90.5
DGP-GP	+21.0	+25.6	+21.1	+0.9	-2.9	+0.7	-0.3	-8.8	-0.6
PB-total ^d									
GP	10.3	10.1	10.3*	12.6	12.7	12.6	12.5	12.3	12.5
DGP	12.1	11.7	12.1	12.3	11.5	12.3	12.3	12.3	12.3
DGP-GP	+1.8	+1.6	+1.8	-0.3	-1.2	-0.3	-0.2	0.0	-0.2
PB-alive ^e									
GP	NR ^g	NR	9.0*	NR	NR	10.9	NR	NR	10.9
DGP	NR	NR	10.9	NR	NR	10.8	NR	NR	11.0
DGP-GP			+1.9			-0.1			+0.1
FI-alive ^f									
GP			592			1000			993
DGP			947			999			996
DGP-GP			+355			-1			+3

Although farrowing rate and litter size for DGP (1 billion sperm) is not statistically different from the GP (2 or 3 billion sperm), the fecundity index is numerically lower for the DGP. If the difference was real on a large scale farm, the difference would be:

GP (2 billion sperm) – DGP (1 billion sperm): 1000 – 947 = 53 piglets per 100 sows

GP (3 billion sperm) – DGP (1 billion sperm): 993 – 947 = 46 piglets per 100 sows

Reference: Watson et al., 2001; Watson and Behan, 2002.

^a Farrowing rate

^b Goldenpig® catheter Each ejaculate used had more than 70% motile sperm cells and less than 20% abnormal cells.

^c DeepGoldenpig catheter™

^d Total pigs born per litter, average

^e Total pigs born alive per litter, average

^f Fecundity index for pigs born alive per 100 sows (FI = farrowing rate x litter size)

^g NR indicates data not reported

* Goldenpig average was lower (P < .05) than DeepGoldenpig average

Table 8. Reproductive performance of sows artificially inseminated by intrauterine body insemination (IUBI) or traditional insemination (cervical)

Location	Farm ID	Number of sows	Type of insemination	Sperm per dose (billion)	Farrowing rate, %	Born live	Fecundity index*
Spain ^a (Trial 1)	A	130	IUBI	1.5	86.15	9.40	810
	A	110	Cervical	3.0	78.18	9.84	769
Spain ^a (Trial 2)	B	50	IUBI	1.5	94.00	11.60	1090
	B	51	Cervical	3.0	98.04	12.34	1210
Spain ^a (Trial 3)	C	117	IUBI	1.0	86.32	11.06	955
	C	112	Cervical	3.0	86.61	11.37	985
Spain ^a (Trial 4)	D	19	IUBI	1.0	84.21	12.31	1037
	D	19	Cervical	3.0	94.74	11.28	1069
Mexico ^a (Trial 5)	1	76	IUBI	1.0	76.32	10.81	825
	1	76	Cervical	3.0	82.89	10.24	849
Spain ^a (Trial 6)	C	48	IUBI	0.87	89.58	10.26	919
	C	47	Cervical	3.0	85.11	11.08	943
Spain ^a (Trial 7)	B	53	IUBI	0.75	88.68	11.51	1021
	B	43	Cervical	3.0	76.74	12.70	975
USA ^a (Trial 8)	1	121	IUBI	0.68	86.78	10.10	877
	1	121	Cervical	3.0	77.69	9.89	768
Spain ^a (Trial 9)	B	23	IUBI	0.5	86.96	12.66	1101
	B	21	Cervical	3.0	81.82	12.94	1059
Spain ^a (Trial 10)	C	17	IUBI	0.5	88.24	10.00	882
	C	17	Cervical	3.0	94.12	11.88	1118
Spain ^b	1	21	IUBI	1.5	68.18	12.40	845
	1	22	Cervical	3.0	85.71	12.05	1032
Spain ^b	2	19	IUBI	1.5	78.94	10.20	805
	2	19	Cervical	3.0	100	12.05	1205
Spain ^c		32	IUBI	1.75	78.12	10.12	790
		50	Cervical	3.0	84.0	9.84	826
USA ^d		150	IUBI	.62	86.2	9.9	853
		150	Cervical	3	85.1	10.1	859

* Fecundity index = farrowing rate x litter size born alive

^a Gil et al., 2002 (volume of IUBI is ≤ 50 mL; volume of cervical is 90 mL)

^b Gil et al., 2000 (volume of IUBI is 50 mL; volume of cervical is 100 mL)

^c Lapuente et al., 2002 (volume of IUBI is 50 mL; volume of cervical is 100 mL)

^d Gall, 2002 (IUBI involved placing 30 mL of 43 C extender in reproductive tract 2 minutes before inseminating with 18 mL of semen; volume of cervical is 75 mL)

Table 9. Effect of type of insemination catheter (intrauterine, IUBI; cervical) and number of viable sperm cells per dose (.5, 1, or 4 billion) on reproductive performance.

Treatment	Number of sows	Conception rate, %	Farrowing rate, %	Total pigs born per litter, avg.	Total live pigs born per litter, avg.	Fecundity index, pigs born live
IUBI						
0.5 x 10 ⁹	106	86.6	78.0 ^x	9.4 ^z	8.6 ^z	671
1 x 10 ⁹	106	88.2	87.0 ^{xy}	10.0 ^{yz}	9.3 ^{yz}	809
4 x 10 ⁹	106	96.5	94.4 ^y	11.0 ^{xy}	10.5 ^{xy}	991
Cervical						
4 x 10 ⁹	106	92.1	88.2 ^{xy}	11.6 ^x	10.8 ^x	953

Reference: Rozeboom et al., 2004.

^{x,y,z} Means with different superscripts within a column differ (P < .05).

Table 10. Effect of type of insemination catheter (intrauterine, IUBI; cervical), number of viable sperm cells per dose (0.5, 1, or 4 billion), and weaning-to-estrus interval on reproductive performance.

Treatment	Number of sows	Weaning-to-estrus interval, d	Conception rate, % at day 28	Farrowing rate, %	Total live pigs born per litter, avg.	Total pigs born per litter, avg.
IUBI						
0.5 x 10 ⁹	41	3	67.3 ^x	56.1 ^x	7.8	8.4
0.5 x 10 ⁹	33	4	93.6 ^y	93.9 ^y	9.5	10.0
0.5 x 10 ⁹	27	5	99.0 ^y	84.0 ^y	8.2	9.4
1 x 10 ⁹	33	3	88.0 ^y	84.8 ^y	8.6	9.5
1 x 10 ⁹	40	4	87.8 ^y	85.0 ^y	9.4	10.6
1 x 10 ⁹	35	5	88.7 ^y	91.4 ^y	9.6	10.6
4 x 10 ⁹	22	3	96.8 ^y	95.2 ^y	10.9	12.2
4 x 10 ⁹	49	4	97.1 ^y	95.9 ^y	10.5	11.4
4 x 10 ⁹	38	5	95.7 ^y	92.1 ^y	10.1	11.1
Cervical						
4 x 10 ⁹	35	3	91.7 ^y	91.4 ^y	10.6	11.7
4 x 10 ⁹	41	4	90.3 ^y	83.7 ^y	11.3	12.5
4 x 10 ⁹	28	5	94.3 ^y	89.2 ^y	10.0	10.9

Reference: Rozeboom et al., 2004.

^{x,y} Means with different superscripts within a column differ (P < .05).

Table 11. Reproductive performance for fertility rate at Day 30 (%), farrowing rate (%), total piglets born and piglets born alive, with traditional A.I. (100 mL in the cervix) and the intra-uterine technique (50 or 30 mL) in three different swine herds in Argentina.

Treatment	Fertility rate (Day 30)			Farrowing rate		
	Herd A	Herd B	Herd C	Herd A	Herd B	Herd C
30 mL dose (1.0 billion)	87.50 (22) ^a	70.83 (22)	94.12 (21)	87.50	62.50	94.12
50 mL dose (1.5 billion)	83.30 (21)	66.67 (21)	92.85 (20)	75.00	66.67	92.85
100 mL dose (3.0 billion)	81.25 (53)	82.42 (53)	96.77 (21)	79.20	64.58	96.77
Overall Mean	83.30	77.08	95.16	80.20	64.58	95.16
Treatment	Total piglets born			Piglets born alive		
	Herd A	Herd B	Herd C	Herd A	Herd B	Herd C
30 mL dose (1.0 billion)	10.05	10.85	11.56	9.58	8.92	10.44
50 mL dose (1.5 billion)	12.77	10.65	12.69	10.76	9.91	11.61
100 mL dose (3.0 billion)	12.45	11.28	13.33	11.42	10.03	12.23
Overall Mean	11.76	11.06	12.71	10.58	9.77	11.61
Treatment	Fecundity index					
	Herd A	Herd B	Herd C			
30 mL (1.0 billion)	838	558	983			
50 mL (1.5 billion)	807	661	1078			
100 mL (3.0 billion)	905	648	1184			
Difference between treatments						
100 mL – 50 mL treatment values	+98	-13	+106			
100 mL – 30 mL treatment values	+38	+90	+201			
50 mL – 30 mL treatment values	-31	+103	+95			

Reference: Levis et al., 2002.

^a Number of sows inseminated is in parenthesis

Table 12. Effect of number of inseminations, estrus number, type of insemination catheter (Goldenpig vs DeepGoldenpig) and oxytocin on farrowing rate and total number of piglets born per litter

Item	Cervical	Intrauterine body insemination (IUBI)	IUBI + 5 IU oxytocin in semen
Farrowing rate, %			
One insemination	71.5 ^a (47 sows)	67.9 ^a (43 sows)	93.9 ^b (38 sows)
Two inseminations	68.9 ^a (149 sows)	69.4 ^a (128 sows)	70.3 ^a (131 sows)
Total piglets born per litter			
Weaned sows	10.8 ^c (131 sows)	10.7 ^c (97 sows)	11.8 ^c (104 sows)
Repeat breeders	11.3 ^{cd} (15 sows)	13.1 ^c (19 sows)	9.3 ^d (18 sows)

Reference: Gibson et al., 2004.

^{a,b} Means within row with different superscript differ ($P < .02$). There was a treatment by number of insemination interaction ($P < .05$)

^{cd} Means within row with different superscript tended to differ ($P < .07$). There was a treatment by estrus number at insemination interaction ($P < .05$)

Table 13. Reproductive performance of sows inseminated with Goldenpig (3.0 billion sperm cells) or DeepGoldenpig (1.5 billion sperm cells).^a

Sperm per dose	Sows cycling by 7 days after weaning					
	Number of sows		Farrowing rate, %	Avg piglets born per litter		Fecundity index (born alive)
	Inseminated	Farrowed		Total	Born alive	
Goldenpig (3.0 billion)	192	149	77.60	11.86	10.28	798
DeepGoldenpig (1.5 billion)	189	144	76.19	11.70	10.55	779
Difference	3	5	1.41	.16	.27	19
Opportunity sows (cycled > 8 days)						
Goldenpig (3.0 billion)	58	32	55.17	12.80	10.96	605
DeepGoldenpig (1.5 billion)	59	34	57.62	12.17	10.55	608
Difference	1	2	2.45	.63	.41	3
Repeat breeders						
Goldenpig (3.0 billion)	37	17	45.94	10.29	8.24	378
DeepGoldenpig (1.5 billion)	32	11	34.37	12.36	10.9	375
Difference	5	6	11.57	2.07	2.66	3

Reference: Rippel and Althouse, 2002.

^a Because of confounding and some aggregated of data, statistical analysis could not be performed.

Table 14. Economic assessment when inseminating sows with an intrauterine body catheter or cervical catheter^a

Trial	Method of AI	Sperm number (billion)	Farrowing rate, %	Born live	Cost per catheter, \$	Cost per dose of semen, \$	Assumed profit per pig, \$	Estimated yearly net profit, \$	Advantage for IUBI
1	IUBI	1.5	86.15	9.40	.65	6.00	8.00	277,619	-\$ 5,051
	Cervical	3.0	78.18	9.84	.17	6.00	7.80 ^b	282,670	(+\$25,817) ^c
2	IUBI	1.5	94.00	11.60	.65	6.00	8.00	366,500	-\$34,965
	Cervical	3.0	98.04	12.34	.17	6.00	8.00	401,465	(\$-6,674)
3	IUBI	1.0	86.32	11.06	.65	6.00	8.00	340,088	-\$16,803
	Cervical	3.0	86.61	11.37	.17	6.00	8.00	356,891	(+\$14,005)
4	IUBI	1.0	84.21	12.31	.65	6.00	7.80 ^b	373,581	+\$14,064
	Cervical	3.0	94.74	11.28	.17	6.00	8.00	359,517	(+\$46,082)
5	IUBI	1.0	76.32	10.81	.65	6.00	7.80 ^b	310,712	-\$ 615
	Cervical	3.0	82.89	10.24	.17	6.00	8.00	311,327	(\$+34,229)
6	IUBI	.87	89.58	10.26	.65	6.00	8.00	312,788	-\$31,982
	Cervical	3.0	85.11	11.08	.17	6.00	8.00	344,770	(\$-2,296)
7	IUBI	.75	88.68	11.51	.65	6.00	8.00	358,982	-\$26,921
	Cervical	3.0	76.74	12.70	.17	6.00	7.80 ^b	385,904	(+\$3,066)
8	IUBI	.68	86.78	10.10	.65	6.00	8.00	304,446	+\$20,434
	Cervical	3.0	77.69	9.89	.17	6.00	7.80 ^b	284,011	(+\$51,078)
9	IUBI	.50	86.96	12.66	.65	6.00	8.00	400,710	-\$11,027
	Cervical	3.0	81.82	12.94	.17	6.00	8.00	411,737	(+\$19,554)
10	IUBI	.50	88.24	10.00	.65	6.00	8.00	301,928	-\$79,693
	Cervical	3.0	94.12	11.88	.17	6.00	8.00	381,621	(\$-49,556)

^a Additional assumptions of model: Weekly farrowing, 100 farrowing crates filled per week, 10% preweaning death loss, 4 minutes per insemination, \$10 per hour of labor, 15% of group is gilts, 2 inseminations per estrous female, and over breeding is accomplished to make sure all farrowing crates are filled.

^b Profit per pig is assumed to be lower because of a higher number of nonproductive sow days.

^c Values in parenthesis are the results when IUBI semen is \$3.00 per dose

Table 15. Influence of semen cost on net profit when inseminating sows with an intrauterine body catheter (IUBI) or cervical catheter^a

Method of AI	Sperm cells per dose, billion	Farrowing rate, %	Piglets born live per litter	Cost of semen per dose		
				\$6.00	\$5.50	\$5.00
				Estimated yearly net profit ^b		
IUBI	1	86.9	10.9	\$333,155	\$338,255	\$343,356
Cervical	2	91.8	10.9	\$343,202		
Cervical	3	91.1	10.9	\$342,644		

^a Farrowing rate and litter size data from Watson and Behan, 2001

^b Same assumptions as indicated in Table 14.

Table 16. Influence of insemination procedure and number of sperm cells per dose on reproductive performance

AI Method	Number of motile sperm per uterine horn	Number of sows bred	Farrowing rate, %	Number of piglets per litter (0 ± SD)		
				Total	Born live	Stillborn & mummy
Cervical	3 billion ^a	22	63.6	10.9 ± 2.3	10.4 ± 2.3	.5
Cervical	1 billion ^a	19	84.2	10.4 ± 2.9	9.7 ± 3.4	.7
Surgical	500 million ^b	17	64.7	8.6 ± 3.4	8.5 ± 3.3	.1
Surgical	100 million ^b	18	83.3	8.2 ± 3.5	7.3 ± 3.3	.9
Surgical	10 million ^b	14	92.2	7.6 ± 3.9	7.2 ± 3.9	.4

Reference: Kruegar and Rath, 2000

^a One standard AI into cervix (80 mL dose; sperm cells were used within 10 hours of collection)

^b Surgical AI into each uterine horn at approximately 24 to 32 hours after first detection of standing heat (.5 mL dose; sperm cells were used within 10 hours of collection)

Table 17. Effect of number of sperm cells per dose on reproductive performance when inseminating non-sedated sows with a flexible fiber optic endoscope.

Insemination procedure	Number of motile sperm	Number sows inseminated	Farrowing rate, %	Piglets per litter	Fecundity index
Cervical	3 billion ^a	48	87.5	10.02	877
Fiberoptic into one uterine horn	1 billion ^b	15	86.6	9.61	832
Fiberoptic into one uterine horn	200 million ^b	18	88.9	9.75	867
Fiberoptic into one uterine horn	50 million ^b	13	92.3	9.41	869

^a Sows were inseminated twice at 0 and 24 hours after the onset of estrus with traditional insemination dose (3 billion sperm diluted to 100 mL in BTS).

^b Estrus was hormonally induced by an intramuscular injection of 1250 IU equine chorionic gonadotrophin (eCG) at 24 hours after weaning, followed 72 hours later with an injection of 750 IU human chorionic gonadotrophin (hCG). Sows were inseminated once in one uterine horn at 36 hours after injecting hCG. Volume of semen inseminated was 5 mL. An extra 5 mL of BTS was used to force all spermatozoa out of the flexible fiber optic endoscope.

Table 18. Effect of number of sperm cells per dose on reproductive performance when inseminating non-sedated sows with a flexible catheter

Insemination procedure	Number of motile sperm	Number of sows	Farrowing rate, %	Piglets born (mean ± SEM)			
				Total	Live	Stillborn	FI*
Cervical [†]	3 billion	147	83.0 ^a	9.97 ± .17	9.40 ± .18	.57 ± .07	780
Flexible catheter [§]	150 million	117	82.9 ^a	9.70 ± .19	9.30 ± .20	.40 ± .08	771
Flexible catheter [§]	50 million	126	76.2 ^a	9.40 ± .19	8.91 ± .20	.49 ± .08	679
Flexible Catheter [§]	25 million	60	46.7 ^b	9.30 ± .35	8.75 ± .37	.57 ± .15	406
Flexible catheter [§]	10 million	69	39.1 ^b	9.44 ± .36	9.03 ± .38	.41 ± .15	353

Reference: Martinez et al., 2002

* FI is fecundity index (farrowing rate x litter size) for piglets born live

[†] Sows were inseminated twice at 0 and 24 hours after the onset of estrus with traditional insemination dose (3 billion sperm diluted to 100 mL in BTS).

[§] Estrus was hormonally induced by an intramuscular injection of 1250 IU equine chorionic gonadotrophin (eCG) at 24 hours after weaning, followed 72 hours later with an injection of 750 IU human chorionic gonadotrophin (hCG). Sows were inseminated once in one uterine horn at 36 hours after injecting hCG. Volume of semen inseminated was 5 mL. An extra 5 mL of BTS was used to force all spermatozoa out of the flexible catheter.

^{ab} Values within the same column with different superscripts are different (P < .001).

Table 19. Percentage of normal embryos collected in each uterine horn on day of the estrous cycle (day 0 = onset of estrus) from sows inseminated in one uterine horn with 150 million spermatozoa at 36 hours after hCG treatment using the flexible catheter^a

Sow	Uterine horn 1			Uterine horn 2		
	Number of unfertilized oocytes and degenerated embryos	Number of normal embryos	Normal embryos (%)	Number of unfertilized oocytes and degenerated embryos	Number of normal embryos	Normal embryos (%)
1	0	4	100.0	1	8	88.9
2	0	14	100.0	0	9	100.0
3	0	12	100.0	0	4	100.0
4	0	10	100.0	0	7	100.0
5	1	14	93.3	2	5	71.4
Total	1	54	----	3	33	----

Reference: Martinez et al., 2002

^a The uterine horn with the greatest percentage of normal embryos (or the highest number of embryos when the proportion was the same) were classified in uterine horn 1 to obtain the maximum difference possible in this parameter between the ipsilateral and contralateral uterine horn in relation to the unknown place of deposition of spermatozoa.

Table 20. Influence of number of sperm cells per dose on total number of doses packaged in a commercial stud (Levis, unpublished data)

Boar number	Genetic Line A				Genetic Line B			
	3 billion sperm/dose Total doses ^a	150 million sperm/dose Doses per collection (Avg ± SD)	150 million sperm/dose Total doses ^a	150 million sperm/dose Doses per collection (Avg ± SD)	3 billion sperm/dose Total doses ^a	150 million sperm/dose Doses per collection (Avg ± SD)	150 million sperm/dose Total doses ^a	150 million sperm/dose Doses per collection (Avg ± SD)
1	748	23 ± 4	14,958	453 ± 88	419	13 ± 2	8,380	254 ± 45
2	611	19 ± 4	12,225	370 ± 70	533	16 ± 4	10,655	323 ± 78
3	538	16 ± 3	10,750	326 ± 67	528	16 ± 4	10,567	320 ± 70
4	627	19 ± 3	12,531	380 ± 52	457	14 ± 3	9,131	277 ± 58
5	643	19 ± 3	12,866	390 ± 62	426	13 ± 3	8,521	258 ± 55
6	640	19 ± 4	12,802	377 ± 83	549	17 ± 3	10,985	333 ± 62
7	411	12 ± 2	8,223	249 ± 41	534	16 ± 3	10,689	324 ± 63
8	561	18 ± 2	11,222	351 ± 40	602	19 ± 4	12,043	376 ± 70
9	618	19 ± 6	12,359	375 ± 114	550	17 ± 3	10,991	333 ± 57
10	502	15 ± 4	10,050	305 ± 72	531	16 ± 3	10,622	322 ± 61
11	459	14 ± 4	9,180	287 ± 84	597	18 ± 3	11,944	362 ± 68
12	527	16 ± 3	10,537	329 ± 58	560	17 ± 3	11,199	339 ± 61
13	613	19 ± 2	12,261	383 ± 48	639	19 ± 3	12,782	376 ± 52
14	505	16 ± 3	10,094	315 ± 67	332	10 ± 5	6,637	201 ± 100
15	563	17 ± 3	11,257	341 ± 61	506	14 ± 4	10,112	316 ± 77
16	365	11 ± 3	7,295	228 ± 55	497	15 ± 3	9,932	301 ± 50
17	640	20 ± 3	12,791	400 ± 67	222	7 ± 3	4,441	135 ± 55
18	436	14 ± 3	8,728	273 ± 54	433	13 ± 2	8,657	262 ± 39
19	323	10 ± 2	6,466	202 ± 34	558	16 ± 4	11,153	328 ± 74
20	634	19 ± 3	12,681	384 ± 58	369	11 ± 2	7,384	224 ± 37
21	633	20 ± 2	12,665	396 ± 44	-	-	-	-
Total	11,597		231,937		9,842		196,825	

^a 33 collections per boar (Monday and Thursday)

Table 21. Estimated number of boars required for sperm production when servicing sows by natural service, cervical artificial insemination or deep intrauterine horn insemination (DIUHI)

Month bred	Number of sows bred ^a	Total number of services ^b	Number of natural services per boar per month		Avg motile sperm per collection (billion) ^c	Number of sperm cells per dose		
			8	16		Cervical AI		DIUHI
			Number boars required			3 billion	1 billion	.15 billion
						Number of boars required ^d		
Jan 01	1,169,000	2,338,000	292,250	146,121	50.86	17,238	5,746	862
Mar 01	1,175,000	2,350,000	293,750	146,875	50.86	17,327	5,776	866
Jun 01	1,197,000	2,394,000	299,250	149,625	50.86	17,651	5,884	883
Sep 01	1,171,000	2,342,000	292,750	149,375	50.86	17,268	5,756	863
Dec 01	1,189,000	2,378,000	297,250	148,625	50.86	17,533	5,844	877

^a Monthly Hogs and Pigs Report, National Agricultural Statistics, Agricultural Statistics Board, U.S. Department of Agriculture, August 30, 2002.

^b Each female is serviced twice

^c Average of 684 collections from 21 boars collected twice per week (Monday and Thursday), SD = 13.4; Levis, unpublished data

^d Boars are collected 8 times per month

Update on Current US Boar Stud Practices

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Utilization of artificial insemination technology has increased dramatically from its rather humble beginning of an estimated 8% of all US breedings in 1991 (Burke, 2000). There are now an estimated 120 dedicated boar studs in the US housing approximately 20,000 AI boars (Burke, 2000; Singleton, 2001; unpublished data, 2003). Implementation of artificial insemination technology by US producers is expected to peak at 80% by the year 2005, requiring an estimated 30 million doses of AI semen annually. The first comprehensive survey of US boar stud production practices was conducted in January of 2000, the purpose of which was to quantify selected boar stud practices employed in the US industry (Althouse and Kuster, 2000). A second survey, expanded to include areas of economic interest, was undertaken in 2002. This paper will review some of the data obtained from this survey.

An eleven page survey entitled “Boar Stud Practices and Cost of Production, 2002: Year in Review,” was developed and mailed to 84 boar studs between April and June of 2003. The Boar Stud Practices section of the survey was broken down into: 1) Boar Stud Demographics, 2) Boar Stud Productivity, 3) Ejaculate Utilization, and 4) Semen Processing (Dillman, 1978). Those participating in the survey were asked to provide data from the 2002 production year. Boar studs invited to participate in this survey had a minimum capacity of 40 boar spaces, a dedicated facility for the expressed purpose of collecting and processing boar semen for AI, and full time personnel for the management and staffing of the boar stud.

Survey Response and Boar Stud Demographics

Out of the original pool of 84 surveys, 30 were returned for data analysis, resulting in a 36% response rate. In comparison, a total of 35 completed surveys were returned in 2000 (Althouse and Kuster, 2000). The 30 boar studs responding to the present survey housed a total of 5,574 boars out of a potential 7,061 boar space inventory. Surveyed studs maintained facilities at an average of $82.1\% \pm 14.2\%$ (mean \pm sd) total capacity. A breakdown of respondents based on the capacity of their respective facilities is reported in Table 1. Stud type for survey participants was identified as 36% commercial sale, 4% custom collect, 39% dedicated farm/system stud, and 21% a combination of one or more of the previous categories.

Table 1. Respondents by stud capacity (mean \pm sd)

Percent of Respondents	Boar Spaces	Boar Inventory	Annual Dose Production
13.3%	40 to 100	46 \pm 10	81,326 \pm 26,357
40.0%	101 to 200	126 \pm 27	169,740 \pm 78,880
33.3%	201 to 400	230 \pm 81	281,329 \pm 179,119
13.3%	>400	452 \pm 133	562,498 \pm 164,397

A major disease problem was reported in 13.3% (N=4) of the responding studs during 2002. Three of these were due to PRRSV and one was due to *Pasteurella multocida*. Pre-entry isolation periods ranged from 28 to 120 days (55.3 \pm 19.8 days).

Boar Stud Productivity

Boar studs reported collecting and processing semen 2 to 6 days per week (4.6 \pm 0.83), with 93% of respondents collecting on 4 or more days per week. Collection frequency per boar ranged from 0.51 to 1.5 collections per week (1.11 \pm 0.22), resulting in 6.7 \pm 2.7 days rest between collections. Total number of sperm per ejaculate averaged 101.7 \pm 25.9 billion. Useable doses produced per boar per week was calculated to be 26.6 \pm 8.0, while doses per available boar space per week was 22.8 \pm 6.9.

The boar replacement rate for studs with stable populations was calculated to be 41.5% \pm 12%. This summary measure excludes the data from 5 studs that indicated unusual inventory fluctuations during 2002. Respondents were asked to rank reasons for boar turnover, and the results are provided in Table 2. In general, 34% of culls were classified as 'voluntary' or 'planned' (e.g., age or genetic improvement), while 66% were classified as 'involuntary' culls (e.g., poor semen quality, structural problems, etc.). Boars were culled due to poor semen quality after 59.9 \pm 18.9 days if they consistently produced poor quality ejaculates.

Table 2. Reasons for boar turnover, in rank order

Rank	Cause	Percent of Involuntary Culls
1	Poor semen quality	43%
2	Genetic improvement/age	<i>Voluntary Cull</i>
3	Structural problems (i.e., lameness)	24%
4	Death	18%
5	Behavioral problems	8%
6	Disease	5%
7	Other	2%

Ejaculate Utilization

The ejaculate discard rate during the summer months averaged 13.3% \pm 7.7%, whereas discard rates throughout the remainder of the year averaged 7.7% \pm 5.0%. Reasons

given for ejaculate rejection are given in Table 3. All of the respondents rejected ejaculates based on sperm morphology, with the maximum percentage of morphological abnormalities tolerated reported as $24.9\% \pm 6.2\%$ (range: 15% to 40%). Table 4 further describes the frequency of individual abnormalities as a cause for rejecting ejaculates. It should be noted that while distal cytoplasmic droplets were ranked first, abnormal tails (including distal midpiece reflex) and proximal cytoplasmic droplets ranked equally for second place. Eight boar studs (27% of respondents) recalled doses of extended semen in 2002, with poor motility the most frequently cited reason, followed by sperm agglutination.

Table 3. Reasons given for discarding ejaculates, ranked by frequency

Rank	Reason for Discard
1	Poor Sperm Morphology
2	Poor Sperm Motility
3	Agglutination/sperm clumping
4	Contamination with blood, urine, fecal material, etc.
5	Other

Table 4. Most commonly observed sperm abnormalities resulting in ejaculate discard, ranked by frequency

Rank	Morphologic Abnormality
1	Distal cytoplasmic droplets
2	Abnormal tails (including distal midpiece reflex)
2	Proximal cytoplasmic droplets
3	Abnormal Midpiece
4	Abnormal heads (including acrosomes)
5	Other abnormalities

Semen Processing

Target volume for a dose of semen averaged 79.45 ± 4.1 ml (range: 75 to 90 ml). The majority of studs (75.9%) applied some type of adjustment factor(s), including motility (22%), morphology (13%), or both motility and morphology (65%) to arrive at a target number of 'viable' sperm per dose of 2.96 ± 0.23 billion cells (range: 2.5 to 3.5 billion 'viable'). For studs which did not apply any adjustment factor(s), the total number of sperm per dose was reported to be 3.29 ± 0.57 billion (range: 3 to 4.5 billion). Participating boar studs reported making 29.2 ± 7.83 doses per ejaculate.

Of the studs that pooled semen in 2002 (90%), 54% used a limited volume of extender for an initial dilution (e.g., '1:1'), while 38% fully extended each individual ejaculate prior to pooling and 8% used some combination of these methods. Almost a third of the studs (31%) reported using one extender exclusively during 2002, while 50% used two extenders and 19% used three or more. On average, 4.5 ± 1.63 ejaculates were included

in each batch of pooled semen. Automated packaging systems were utilized in 70% of the studs, while the remainder used manually operated systems.

Delivery schedules varied between studs with 36.7% reporting daily deliveries, 13.3% 4x/week, 20% 3x/week, 26.8% 2x/week and 3.3% 1x/week.

Conclusion

Many of the values presented here are very similar to what was reported in 2000 (Althouse and Kuster) and what has been reported by other authors world-wide (Cameron, 1987; Colenbrander, 1993; Glossup, 1996). Notable exceptions include estimates relating to global measures of boar stud productivity, such as doses produced per boar space per week (Rutten, et al, 2000). Boar studs continue to evolve as they strive to fill the needs of the US swine industry. Surveys of this nature serve as valuable resources when used as benchmarking tools and provide a record of the changes our industry experiences with the evolution of swine artificial insemination in the USA.

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Commercial Information



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Semen dose production (3 boar studs)

Pig production

Genetics → Duroc breeders (sow farm)

Producers → Hog producers

Packers → Loin and ham

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Frozen semen & Embryo transfer

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- Equipment
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Optimization of reproductive performances

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- Reproductive management of sows
- Pathology of reproduction
- Audit farm results
- Exchange of field experiments with our customers



Optimization of reproductive performances

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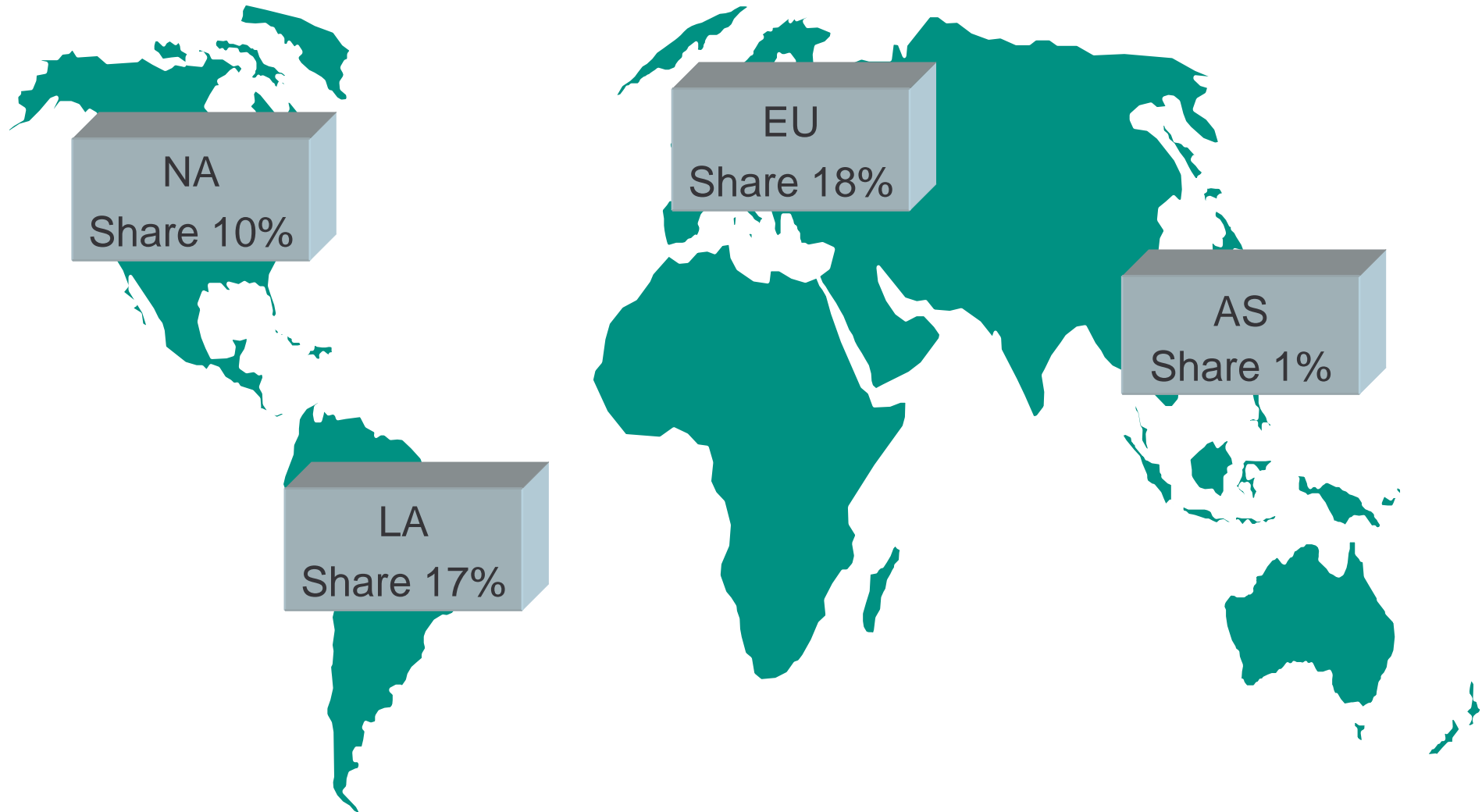
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- ✓ Muller AI
- ✓ North Iowa Boar Stud
- ✓ AI Technologies
- ✓ AI Partners
- ✓ Slezers Fertility Center
- ✓ West Point Genetics
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- a. Swine embryo preservation by vitrification. 3 years project with the Veterinary Faculty of Madrid University
- b. Transport and storage time effects on seminal quality in Iberic, Duroc and Pietrain boars. 2 years project with the Veterinary Faculty of Huelva University.

B. Subsidized by the Spanish Ministry of Industry (MINER) and by the Center of Industrial and Technological Development (CDTI):

- a. One farrowing management system in swine. Reduces piglet cost.
- b. Determination of alterations in reproduction in gilts.
- c. Meat quality in Duroc breeds for the one farrowing system.

C. International projects:

- a. SAFE SEMEN 2000. Eureka Program nº 1896. In collaboration with the French Society Synthèse Elevage. Duration: 3 years.

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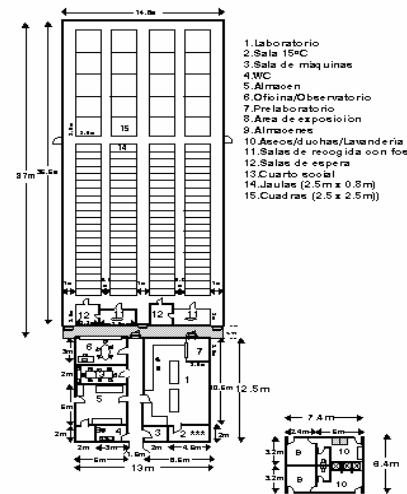
♂ BOAR ♂



*Levamix boar feeding
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Kubus Madrid laboratory



Boar stud design



Frozen semen

KUBUS' PRODUCTS



*Predil MR-A®
Synthetic seminal plasma*



*"Hands-free" breeding
saddle*



AI Caddy

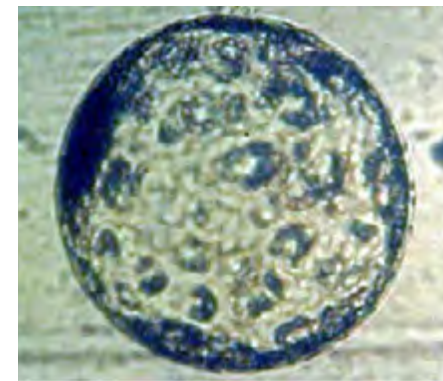
♀ SOW ♀



Graded catheter



AI equipment



Embryo transfer

KUBUS EXTENDERS



*MR-A
Long-term
extender*



*MR-A 3D
Mid-term
extender*



*BTS
Short-term extender*



*MR-A thaw
For frozen
semen*

Truth / Security / Economy

MR-A[®] RESULTS

COUNTRY	FARM	% FARROWING RATE	BORN ALIVE
SPAIN	TOP	87	11.80
	MIDDLE	83	11.00
	BOTTOM	75	10.30
CHILE		92.44	11.25
ARGENTINA		89	11.00
BRASIL	TOP	92.5	11.98
	MIDDLE	90.6	11.60
	BOTTOM	88	11.20
USA	TOP	88.3	10.8
	MIDDLE	85.1	10.6
	BOTTOM	79.2	10.4

PREDIL MR-A® (Synthetic seminal Plasma)



- ✓ Better than dead semen
- ✓ No contamination risk
- ✓ Increase 5-10% percentage of cycling:
 - Apply one dose (100 cc) of Predil MR-A®, at 37°C, during previous heat to the A.I.
- ✓ Increase 5% fertility rate and litter size in first parity:
 - Apply 30-35 cc of Predil MR-A®, at 37°C, previous to the seminal dose, according to the gilts A.I. method

KUBUS, S.A. SERVICES

- ✓ Boar stud design and evaluation in pig reproduction
- ✓ Technical assistance
- ✓ Training and update courses on Pig reproduction, Artificial Insemination technique, Boar Stud Management
- ✓ Semen assessment service, PCR and water quality controls
- ✓ Biosecurity program for A.I. Studs
- ✓ International Symposium on Reproduction and Swine A.I.

RESEARCH CENTERS



KUBUS
Semen Assessment



Veterinary Faculty
Embryo vitrification



Agronomic School
Frozen semen

KUBUS' PRODUCTS AND SERVICES



- ✓ Designed and developed to help you raise and maintain your pig farm profitable
- ✓ Our quality means truth and security

KUBUS' BRANCH OFFICE: KUBUS Inc.

Kubus Inc.

6600 Royal Street, suite 107

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KUBUS, S.A. MILESTONES

1987

MR-A®

The boar semen extender
More piglets

1993

MR-A® WinPro

Software for boar stud management

1995

Predil MR-A®

Synthetic Seminal Plasma for more fertility

1996

Duroc breeding selection

1997

Breeding saddle

Hands-free insemination to reduce insemination costs

Since 1997

Services

AI Training
AI lab projects
Boar stud design

Since 1997

A Complete catalog of AI and lab supplies

1998

Rabbit semen extender

1999

Graded catheter

For gilts insemination

2000

One farrowing technology

2001

AI Caddy



*With our acknowledgement
to Dr. Santiago Martín Rillo[†]*



SWINE ARTIFICIAL INSEMINATION

MR-A[®]

Long preservation extender for boar semen

Features

The boar semen extender **MR-A[®]** allows boar semen preservation up to 7 days. **MR-A[®]** extender increases reproductive performance versus short-term extenders in semen preserved during 1-2 days. **MR-A[®]** extender as a long preservation extender helps the boar studs management, allowing the scheduling and structure of the semen dose distribution routes to the farms.

Advantages

MR-A[®] extender reinforces the spermatic membrane structure after dilution, due to an

improvement in the spermatozoa membrane composition and delay of the seminal maturation processes after 24 hours preservation.

Results

MR-A[®] extender has been on the market since 1982, with distribution in 28 countries of Europe, North America, South America, Asia and Oceania and more than 14,000,000 doses used in the year 2001. **MR-A[®]** extender has been tested in numerous field trials in different countries.

Country	# sows	Fertility	Total born
Spain	70,000	87,0%	11,80
Argentina	4,000	89,0%	11,00
Brasil	20,000	92,5%	11,98
Chili	50,000	92,4%	12,13
USA	38,000	88,3%	10,8

- ❖ Hofmo, P. et al. 1999. *In vivo comparison of BTS and MR-A under Norwegian AI conditions*. IVth International Conference on Boar Semen Preservation, Beltsville, Maryland, USA.
- ❖ Lyczynski, A. et al. 1999. *Comparison of Insemination results for sows inseminated with semen stored for 4 days in 3 different diluents*. IVth Int. Conf. of Boar Semen Preservation, Beltsville, Maryland, USA.
- ❖ Peralta, W. 1999. *Sistema de producción en Chile*. VI Simposium Internacional de Reproducción e I.A. Porcina. España.
- ❖ De Alba, C. et al. 1996. *Aspartate aminotransferase activity changes during boar semen preservation at 15°C*. Journal of physiology and pharmacology. Vol 47, n° 2, sup. 1 jun
- ❖ De Alba, C. et al. 1996. *Effect of boar semen dilution on spermatic membrane phospholipidic composition*. 14th I.P.V.S. Congress. Bologna. Italia.
- ❖ Lyczynski et al. 1996. *Fertility and prolificacy in sows after insemination with boar semen preserved in MR-A diluent*. 14th IPVS. Bolonia, Italia
- ❖ Lyczynski et al. 1996. *Boar semen preservation in MR-A diluent*. Central European Conference on Animal Reproduction. Polonia.
- ❖ Lyczynski et al. 1996. *Fertilizing ability of boar semen stored for five days in MR-A diluent*. Journal of physiology and pharmacology. Vol 47, n° 2, sup. 1 jun
- ❖ Althouse, G. 1995. *Comparison of porcine semen extender*. Proc. Ann. Mtg. Soc. Theriogenology. Texas. E.E.U.U.
- ❖ Korniewick et al. 1995. *The survival rate and fertilizing capacity of boar semen diluted with different diluent*. 3rd Int. Conf. of Boar Semen Preservation. Mariensee. Germany.
- ❖ Laforest, J. et al. 1995. *Comparison of four extenders for long term storage of fresh boar semen*. 3rd Int. Conf. of Boar Semen Preservation. Mariensee. Germany.
- ❖ García Ruvalcaba, J.A. et al. 1994. *Improvement in reproductive performance in pigs with Artificial Insemination and MR-A long term preservation diluent*. 25th AASP Chicago. Illinois. E.E.U.U.
- ❖ Martín Rillo, S. et al. 1994. *Les dilueurs pour la conservation de la semence de verrats resultats*. Recontres Internationales de production porcine. France.
- ❖ Strzezek, J., et al. 1993. *Estudio bioquímico de la conservación del semen de verraco en distintos diluyentes*. Anaporc n°124.

SWINE ARTIFICIAL INSEMINATION

MR-A[®]

Long preservation extender for boar semen



Composition

Glucose, EDTA, sodium citrate, potassium acetate and buffer excipient. The extender antibiotic composition depends on the regulations established in each country.

Presentation

Packages to prepare 1 and 5 liters of extender.
Containers to prepare 100 liters of extender.

Instructions for use

Dilute the container contents in 1, 5 or 100 liters of distilled water (depends on presentation). Dilution will be quicker if the distilled water is prewarmed at 35-37°C (63-67°F).

Preservation

Powder MR-A[®]: can be stored for up to one year in a cool and dry place, away from sunlight. Recommended storage at 5-15°C (9-27°F).
Liquid MR-A[®]: the product, once it is diluted, can be kept in a sealed, sterile flask, at 4-5°C (7-9°F), for up to 1 week.

Expiration

The powdered extender can be stored for up to one year in a cool and dry place, away from sunlight. Recommended storage at 5-15°C (9-

27°F). The expiration date is stated on the left side of the container.

Technical characteristics of MR-A[®] extender

- Allows boar semen preservation up to 7 days.
- It can be diluted in a few minutes. Once diluted, it can be used immediately. No equilibration period is necessary for the pH.
- The buffer presence of high quality in its composition exerts a higher control over the pH oscillations during the diluted semen preservation.
- Higher protection of the spermatocell.
- Helps to control agglutination problems, decreasing protein precipitation and helping cell equilibrium metabolism.
- Optimum control over bacterial growth during the semen preservation period.
- Produces good fertility results following the Kubus insemination technique.

Product quality control

Each bag or container is identified with its batch number and expiration date. Each batch passes high quality control standards, including physico-chemical parameters (pH, osmotic pressure, conductivity, salinity, TDS...) and biological (preservation control in semen).

KUBUS, S.A.

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Internet: www.kubus-sa.com



SWINE ARTIFICIAL INSEMINATION

PREDIL MR-A®

Synthetic seminal plasma

Features

The seminal plasma, as well as being the spermatozoa transportation medium, contains organic and inorganic components needed for spermatozoa viability and egg fertilization (Glossop, 1992, Vigo, 1994 y Martín Rillo 2000).

The synthetic seminal plasma **PREDIL MR-A®** developed by KUBUS S.A., is a replacement of natural seminal plasma which give to the female genital tract salts, buffer and antibiotics that improve reproductive results.

	<i>Dead semen</i>	<i>Predil MR-A</i>	<i>Benefits Predil MR-A</i>
1. Microbiological charge	High	Zero	No sanitary risk
2. Composition	Variable	Constant	Stable results
3. Antibiotics	No	Yes	Lower bacterial growing
4. Cost	+ 1.80€	0.67€	Cost savings
5. Availability	Depends on needs	At disposition	Safe storage
6. Storage	Temperature control	At room temperature	Easily stored

Advantages

PREDIL MR-A® helps the spermatozoa movement into the female genital tract and acts as seminal plasma with zero microbiological charge.

Instructions for use

- Sensitization technique on gilts:** administration by cervical tract of **100 cc PREDIL MR-A®** in the previous estrus to insemination.
- Two phase artificial insemination technique in gilts:** administration by cervical tract of **30 cc PREDIL MR-A®** just before insemination.

Results

PREDIL MR-A® improve gilt productivity since:

Improve up to 5-10% gilt cycling

- ❖ *Lapunte et al. (2001). "The use of synthetic seminal plasma (PREDIL MR-A®) during artificial insemination in gilts as a method to increase productivity". ICPR, Missouri, E.E. U.U.*
- ❖ *García Ruvalcaba et al. (2000). "Avances en Inseminación Artificial: bioseguridad de los centros de I.A.". VII Simposio internacional de reproducción e I.A. en suinos. Foz de Iguazú. Brasil, 2000*
- ❖ *Darwin Reicks et al. (1999). "Synthetic Seminal Plasma (PREDIL MR-A®) for optimisation of reproductive efficiency in gilts". American Association of Swine Practitioners AASP, 1999. 30th Annual Meeting. St. Louis, Missouri.*

Improve up to 5% fertility and 0,5 piglets in the first farrowing

- ❖ *Ramírez Ovalle, F. (2002). "Efecto de la aplicación transcervical de semen muerto y plasma seminal sintético (PREDIL MR-A®) en el estro anterior a la primera inseminación en cerdas nulíparas, sobre su respuesta reproductora". Universidad Mayor. Facultad de Ciencias Silvoagropecuarias. Proyecto de Licenciatura en Medicina Veterinaria, Santiago. Chile. 2002.*
- ❖ *Lapunte et al (2001). "How to handle the new future breeding female. AASV. 31st Annual meeting. Nashville, Tennessee, E.E.U.U.*
- ❖ *G^a Ruvalcaba et al. (1997). "Improvement of Artificial Insemination Results by means f Synthetic Seminal Plasma (PREDIL MR-A®) in gilts. 28th American Association of Swine Practitioners. Annual Meeting, Quebec, Canada.*
- ❖ *Szarek M (1996). "La inseminación multifase: puesta a punto práctica". Synthèse Élevage. ZA du Bail. BP 39. 35137 Pleumeleuc FRANCIA*
- ❖ *Martín Rillo, S. et al. (1996). "Improvement of fertility results by means of usage of synthetic seminal plasma before artificial insemination. 14th IPVS. Bologna, Italy*
- ❖ *Martín Rillo, S. y De Alba Romero, C., (1996). "Resultats du Plasma Seminal Artificiel: Predi^{ti}". Rencontres Internationales de Production Porcine. Loudeac, France.*

SWINE ARTIFICIAL INSEMINATION

PREDIL MR-A[®]

Synthetic seminal plasma



Composition

Glucose; Potassium chloride; Potassium phosphate; Magnesium acetate; Sodium acetate; Hypotaurine; Antibiotics; Buffer excipient.

Presentation

Powder PREDIL MR-A[®]: packages of 41 +/- 0.5 gr. to prepare 1 liter
Liquid PREDIL MR-A[®]: tubes with 30 cc and 100 cc

Preservation

Keep stored in a cool, dry place, away from sunlight.
Powder PREDIL MR-A[®]: the product, once it is diluted, can be kept in a sealed, sterile flask, at 4-5°C, for up to 1 week.

Liquid PREDIL MR-A[®]: preservation at room temperature.

Use

Powder PREDIL MR-A[®]: dilute the contents of one package in 1 liter of pure distilled water (of controlled quality.) Once it is diluted, the product acquires green color.

Liquid PREDIL MR-A[®]: apply directly.

Expiration

Powder PREDIL MR-A[®]: one year from production date. Expiration date is stated on one side of the package.

Liquid PREDIL MR-A[®]: 6 months from production date. Expiration date is stated on the container.



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GRADED CATHETER WITH CENTIMETER SCALE FOR THE LENGTH MEASUREMENT OF GILTS VAGINA

(Utility model actually in request no. 9900681)

Features:

A disposable catheter with a centimeter scale for the measurement of gilts vagina length.

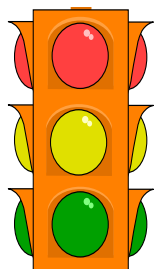
Advantages:

Measuring the gilts vagina length during the heat period will provide us with the optimal moment for the first insemination. Also the measurement of the genital tract of sows in heat after the first farrow can determine the prolificacy potential of these sows.

Benefits:

The optimal moment for the first service of a gilt enables a high prolificacy at first farrow and continues during the breeding life of the sow.

HOW TO DETERMINE THE OPTIMAL MOMENT FOR INSEMINATION IN ACCORDANCE WITH THE DEVELOPMENT OF THE REPRODUCTIVE TRACT.



<25 cm

Skip a heat → Poor development

25-30 cm

Inseminate → Good development

>30 cm

Inseminate → High prolificacy potential



KUBUS, S.A.
KUBUS, INC.

6600 Royal Street, Suite 107
Pleasant Valley, MO 64068

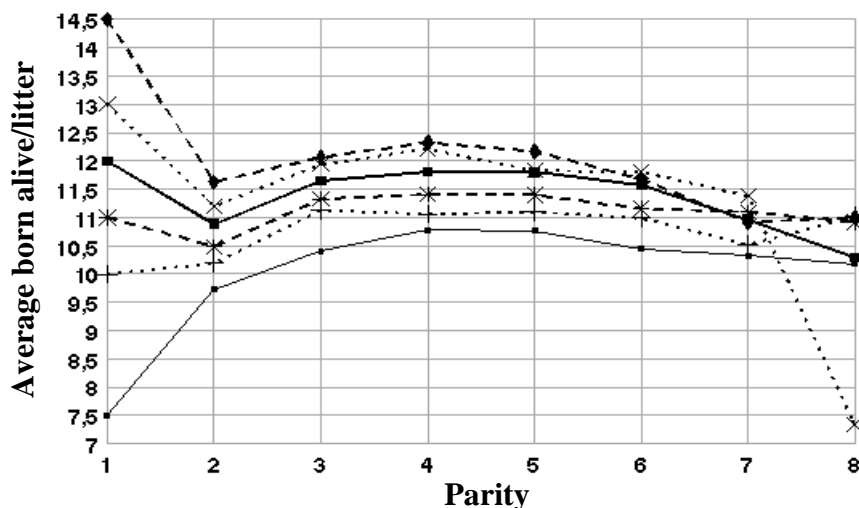
☎ +877-KUBUS AI

Fax 816-415-0073

Technical basis:

The average productivity in sows develops according to the number of piglets born at first farrow.

Figure 1. Litter Size in Consecutive Farrowings



Peralta and Bustamante (1998)

The most common reproductive parameters to bear in mind when determining the first service are the following: age, weight, number of heats and backfat thickness.

However, by the development of the genital tract we can assess the potential in gilts fertility.

The hormonal activity in the hypothalamic-hypophysis axis and its influence on follicular growth and ovulation determines the overcoming of the pre-puberty period.

In gilts the uterus size increases according to age and heat cycles.

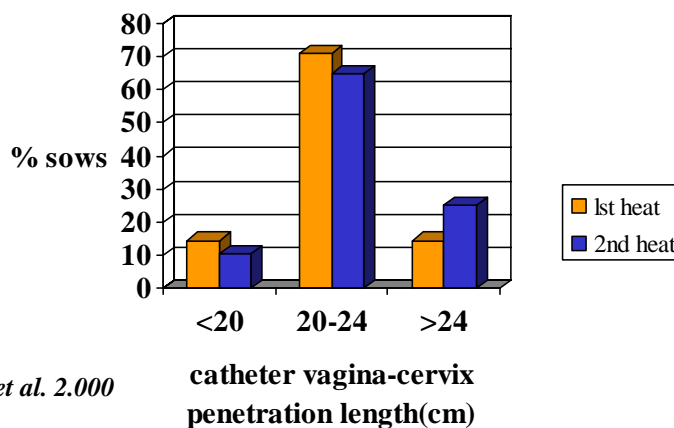
The existing correlation between the vagina length and the uterine horns size will enable an identification "in vivo" of the gilts first service.

Table 1. Relation between the vagina length and the development of the genital tract in Duroc gilts slaughtered with 160 days of age after first heat.

vagina cm	UTERUS	
	Left horn cm	Right horn cm
3	56.6	54.8
4	65.7	62.3
5	73.6	71.8
6-7	83.5	85.8

Martín Rillo et al. 1.999

Figure 2. Differences between the vagina size in Duroc gilts at first and second heat



Martín Rillo et al. 2.000

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National Pork Board Educational Materials Service

The purpose of the National Pork Board's educational materials service is to assist producers and other interested parties in obtaining educational materials about the pork industry. Transfer of current and future technology is the key for profitability in the pork industry.

To expedite handling of your order, please read this page and fill in all parts of the accompanying order form.



Instructions for Ordering

To place an order by phone using Visa or MasterCard, call the National Pork Board at 515-223-2600, Ext. 621 or FAX your order to 515-223-2646 with a credit card number.

Mail Orders with Payment to:

National Pork Board
Attn: Order Department
P.O. Box 9114
Des Moines, IA 50306

Identify Each Item

Order by catalog number, title and price. Orders should be made on the order form at the back of this catalog.

Shipping

Materials are normally shipped by the most practical and economical means based on weight and destination. Since most shipments are via United Parcel Service (UPS), please use a street address or route number. UPS deliveries cannot be made to a P.O. Box number.

Delivery Time

Indicate on your order if you need materials by a certain time. Most orders are shipped within 48 hours after received.



Conditions of Sale

Shipping Charges

Because the prices in our catalog are so near their production or purchase costs, extra charges cannot be absorbed.

\$ 1.00 - \$10.00	add \$ 3.00
\$10.01 - \$25.00	add \$ 5.00
\$25.01 - \$75.00	add \$10.00
\$75.01 - Up	add \$15.00

If actual shipping exceeds amounts shown here, you may be charged the difference.
Shipping prices subject to change without notice.

Any special shipping requests will be priced accordingly.

Return of Materials

Due to the narrow margin between costs of materials and the selling prices, it is our policy not to accept returned materials unless we erred in filling the order or the materials were defective. National Pork Board will make any reasonable adjustment for damaged materials, defective materials, or improperly filled orders. Requests for adjustment must be made within 90 days of shipment of the order.



Materials Available

The materials listed in this catalog come from the following sources:

- ?? Items produced by the **National Pork Board**.
- ?? **Items made available for resale from state Extension services, commercial sources, trade associations, etc.** These sources are indicated at the end of each description.



Pricing Chart & Guidelines

Pricing of Materials

The National Pork Board is a non-profit organization. Materials developed and published by the National Pork Board are priced to cover the cost of development and production. Prices are subject to change without notice as production costs increase or decrease. Prices of materials purchased by the National Pork Board for resale are subject to change without notice as our suppliers' change their prices.

PRICING CHART

Any item that refers to "See Pricing Chart" please use this when ordering.

Producer	\$10.00 each
Non – Producer	\$15.00 each
International	\$40.00 each

Note: "No Charge" items apply to U.S. Producers

Advertising

Consumer Advertising

Pork. The Other White Meat TV ads, print ads, billboards, and radio spots are available through the National Pork Board Consumer Advertising Department. Call the Advertising Department at 515-223-2600 for information about obtaining copies of these materials for use in the promotion of pork.

Animal Welfare

#3 Video - Swine Handling For Pork Producers

Covers the importance of proper handling as it relates to meat quality, pig behavior, methods to move pigs, handling breeding stock, the importance of human contact, facilities design, and loading pigs for transport. *Total running time: 15 minutes.*

#08037.....See pricing chart
Spanish Version #08038.....See pricing chart

#4 Video - Swine Handling For Transporters

Includes the importance of proper handling as it relates to meat quality, pre-loading, loading, transporting, delivery, truck and trailer washing, and adverse weather guidelines. Includes laminated adverse weather chart. *Total running time: 15 minutes.*

#08039.....See pricing chart

#7 Video - Proper Pig Handling for Markets & Packers

Proper pig handling is an important part of producing quality pork products. Handlers who do their job correctly and efficiently help insure high quality meat and help the pork industry maintain its high standard of animal well being. This booklet and accompanying video are designed to show and explain proper pig handling techniques.

LCI-04340.....\$50.00 each

Livestock Handling Guide

A guide prepared by the Livestock Conservation Institute to present management practices that reduce livestock bruises and injuries, and improve handling efficiency. Included in the pamphlet are handling facility design tips, loading chute recommendations, how to understand animal psychology and many other helpful ideas.

LCI-04067.....\$1.00 each

Livestock Trucking Guide

The purpose of this pamphlet is to help producers avoid losses due to improper trucking. Hot and cold weather trucking is discussed along with other trucking tips.

LCI-04064.....\$1.00 each

On Farm Euthanasia of Swine-Options for the Producer

It is inevitable that in every swine production system, animals will become ill or injured in such a way that euthanasia will be necessary. Since it is usually impossible or impracticable for the veterinarian to be available for all euthanasia on-farm, producers themselves often need to perform humane euthanasia of pigs. This pamphlet is done in cooperation with the American Association of Swine Veterinarians (AASV) - 2001. *(Reserve right to limit quantity)*

#04259.....No Charge

Swine Care Handbook

The purpose of this handbook is to provide pork producers with scientifically-based guidelines for maintaining and improving the welfare of their animals. Includes information about the producers code of practice, husbandry, systems management practices, environmental management, facilities and equipment, feeding and nutrition and her healthy management.

(Revised 2002 edition)

(Reserve right to limit quantity)

#04010.....No Charge

Swine Welfare Assurance ProgramSM (SWAPSM)

Swine Welfare Assurance ProgramSM (SWAPSM) Book

The Pork Checkoff's Swine Welfare Assurance Program (SWAP) maintains and promotes the pork industry tradition of responsible animal care through the application of scientifically sound animal care practices. This book is for use by producers and Certified SWAP Educators for education and assessment of animal welfare on the farm.

#04697.....No Charge

SWAPSM check stuffer

#04718.....No Charge

SWAPSM poster

#04723.....No Charge

SWAPSM wall chart

#04724.....No Charge

SWAPSM brochure

#04001.....No Charge

Swine Welfare Fact Sheets

U.S. Pork Producer Code of Practice	Vol. 1, No. 1, Dec. 2002	#03525	\$.10 each
Animal Ethics	Vol. 1, No. 2, Dec. 2002	#03524	\$.10 each
Welfare of Pigs During Transport	Vol. 1, No. 3, Nov. 2003	#03527	\$.10 each
Swine Stress and Pathogen Shedding	Vol. 1, No. 4, Nov. 2003	#03526	\$.10 each
Animal Welfare Resolution			
National Pork Board January 2002	Vol. 1, No. 5	# 04685	\$.10 each
Neonatal Management Practices	Vol. 1, No. 6	#04684	\$.10 each
Swine Welfare Assurance Program SM			
(SWAP SM) Frequently Asked Questions			
and Answers	Vol. 2, No. 1	#04683	\$.10 each
Animal Welfare Resolution for SWAP SM	Vol. 2, No. 2	#04026	\$.10 each
Sows and Space		#04725	\$.10 each
Facts on Animal Welfare		#04713	\$.10 each

Breeding and Genetics

Artificial Insemination . . . Striving For Perfection Video

This video demonstrates in practical, easy to follow steps, how to collect a boar using a dummy sow and a live sow. Included in this video are instructions on how to extend semen and artificially inseminate a sow. *Total running time: 16 minutes.*

#08005.....See pricing chart

The Swine AI Book

A field and laboratory technicians’ guide to artificial insemination in swine. A 2nd addition by North Carolina State University.

NCSU-03062.....\$40.00 each

Swine Breed Photographs

Sets 5 x 7-inch color photographs of the eight major U.S. hog breeds: Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland China, Spot and Yorkshire.

#04007.....\$12.00 per set

Distance Learning, CD-ROM Technologies

2003 PPRS Compendium 2nd Edition & Producer Edition CD-ROM

Both the 2nd Edition and the Producer Edition of the 2003 PPRS Compendium have been included on a single CD. The CD is in a searchable PDF format for use on most IBM-compatible computers.

#08124.....\$20.00

International #08124.....\$50.00

Environmental Assurance Program CD-ROM

This 8-lesson course reviews all the bases of environmental management, but will focus special attention to lagoon management.

#04550.....See pricing chart

Pork Industry Chart of Accounts CD-ROM

This program is a tool that allows you to structure and design a Chart of Accounts that you can subsequently apply to your accounting system-tailored specifically for your type of industry or business. Using this tool, you can also design your cost accounting structure as well. This program is available in CD-ROM or in a set of 3.5” diskettes.

#04418.....\$99.00 each

Pork Production Distance Learning Series CD_ROM

Developed by University Extension and Community College Educators across the United States. Provided at no charge to US Pork Producers. Each course is available on CD_ROM and through Porkboard.org

Production Technician Series – New titles continually being added

This series is designed to address the basics of day-to-day management activities in pork production. The intended audience is the group of people who are responsible for the day to day task of producing pork. These courses are appropriate for people with a limited knowledge of pork production as well as for a veteran who would like to review the basics and get updates on recent developments.

Farrowing Management	#08136.....Non-producer cost \$150
Grower-Finisher Management	#08139.....Non-producer cost \$70
Effective Handling of Pigs	#08137.....Non-producer cost \$50
On Farm Euthanasia of Swine	#08138.....Non-producer cost \$25
Pig Husbandry	#08141.....Non-producer cost \$65

Pork Production & Financial Standards CD-ROM

A 12-lesson curriculum focusing on the Production and Financial Standards for the Pork Industry. The curriculum will equip the pork producer of today and tomorrow with an understanding of the importance of Production and Financial Standards and how application of industry standards can enhance profitability.

#04498.....See pricing chart

Trouble Shooting Guide CD-ROM

This resource guide can be used as a tool for identifying items that could be problematic when a producer is not satisfied with a production and / or financial benchmark from their herd.

#08100.....See pricing chart

Consumer Nutrition Education

A DASH of Prevention with Pork: Reducing the Risk of Hypertension

This resource kit contains a reference paper on the DASH and DASH-Sodium trials, which examined the role of diet in reducing hypertension. The professional paper also includes practical advice for helping patients achieve DASH diet goals. The kit included five reproducible education handouts.

#03487.....\$2.00 each

Healthful Eating For Hungry Kids Tearpad

A 50-page tearpad for educating parents of children ages 2 to 6, using the USDA’s Food Guide Pyramid for Young Children. One side offers the colorful food pyramid, which promotes healthful food choices and physical activity for young children. The back side of each page offers tips to parents.

#03407.....\$1.50 per tearpad

Spanish Version #03471.....\$1.50 per tearpad

Making the Most of Family Mealtime Fact Sheet

A reproducible handout covering the benefits of shared meals and ideas for encouraging family mealtime. Developed in cooperation with the American Dietetic Association.

#03482.....No Charge

Weighing In On Fad Diets

This resource kit contains a reference paper on healthful weight control based on the guidelines of the National institutes of Health. The kit also contains four reproducible educational handouts. Also includes four copies of the recipe brochure Lean Meals in Minutes.

#03405.....\$1.20 each

8 Ways to Cut Fat

This tear pad has 50 single page sheets with strategies for cutting fat without cutting taste. The tear pad, which was developed with technical assistance from the American Heart Association, comes with an easel-backed stand for easy waiting room education. Also included are 5 copies of the recipe booklet, Lean Meals in Minutes.

#03318.....\$3.00 each

Eat To Compete

A sports nutrition kit, favorably reviewed by SCAN, which includes a professional reference section and reproducible consumer education materials.

#03344.....\$2.00 each

Lean Pork and Health-Facts About The Other White Meat®

This new resource answers frequently asked questions about lean pork’s role in heart-healthy and cancer-risk reducing diets. The kit contains five reproducible consumer education handouts.

#03350.....\$2.00 each

Consumer Recipes

One to Five copies complimentary

American Family Food Journal

This 52-page brochure highlights winning recipes from the 1999 “Favorites From Our Family” recipe contest. A scrapbook of America’s tastes from traditional to the hottest trends.

#01122.....\$1.75 each

Another Look @ Ham

This convenient, ready-to-eat meat is a versatile solution for today’s busy and health conscious families. This brochure includes cooking tips that go beyond ham and cheese sandwiches.

#01126\$.12 each

Cookin’ Up Conversation

Finding time to spend together is a challenge facing most families today. This guide includes delicious time-saving recipes and menu ideas as well as fun ideas to spark conversations at your next family meal.

#03485.....\$.20 each

Cook Once, Eat Twice

We assembled menu suggestion that banish boring leftover ideas. Each main recipe have additional recipes for great “planovers” as well as tips for planning menus and safe storage.

#01195.....\$.30 each

Farm Table to Family Table

America’s pork producers proudly present their favorite family pork recipes to make the most of dinnertime. 48-page booklet.

#01203A.....\$.50 each

Fire Up!

This essential reference will guide you through grilling and barbecuing pork from lighting the charcoal to cleaning the grate. Recipes and pointers from grilling and barbecue pros will help fan the flames of love for grilled pork.

#01207.....\$.50 each

Healthy and Delicious Hispanic Recipes

A bi-lingual recipe brochure that celebrate El Cerdo Es Bueno! Creative recipes that maintain Latino traditions.

#01206.....\$.10 each

Healthy Helpings

This collection of nutritious recipes features an array of good-for-you foods that are delicious as well as heart-healthy

01192.....\$.08 each

Hot Topics

The Ultimate Guide to Pork and Grilling - America loves to grill. This handy reference guide to pork and grilling covers everything from how to get the grill started to recipes and safety tips.

#01201.....\$.20 each

Kids’ Pork Cookbook

Kids’ Pork Cookbook covers basic cooking terms and equipment, measuring ingredients, shopping for pork, setting the table and table manners. It includes eight quick and easy pork recipes.

#01102.....\$.30 each

Lean Meals in Minutes

Sometimes a family gets hungry for a change. When they do, here are seven lean meals you can make in minutes that really break from the routine.

#01117.....\$.07 each

New Holiday Traditions

Holidays are the traditional time for family gatherings. Maybe it’s time to break from the routine. Try any of these six tasty, easy-to-prepare, and year-round pork holiday recipes.

#01118.....\$.07 each

The Official Hambook

Whether it’s sliced or cubed, on the breakfast table, piled high on a sandwich, topping a salad or the centerpiece of a special meal, the mildly sweet, smokey flavor of ham has made it a hero for

many tasty meals. We've assembled this collection of ham facts and history, information, tips and recipes to help you enjoy this classic favorite.

#01090.....\$.24 each

Pork Kitchen Companion

The Essential Guide to Cooking Pork. Tips and recipes from chefs, cooking chart storage time and a simple meat cuts chart are included in this 16-page booklet.

#01203.....\$.60 each

Quick & Easy Family Dinners

If your family is routinely late for dinner, change your dinner routine. One sure way to bring them back is by adding a little variety to the table. By adding pork to the menu. Here are seven great recipes that are so quick and easy they'll fit into your busy schedule. Each one is a welcome break from the routine and a tasty way to get the family interested in dinner all over again.

#01115.....\$.07 each

Rib Revelations

This booklet is designed to reveal the hidden secrets of ribs – how to choose'em, how to cook'em, and how to savor every mouthful!

#01007.....\$.05 each

Slimmed Down Soul Food

Eat your favorite soul food while keeping sodium and fat to a minimum.

01200.....\$.30 each

Slim Story Profile Card

Fresh pork has shaped up and slimmed down so much in recent years that it's an average 31% lower in fat, 4% lower in calories and 10% lower in cholesterol than in 1983. The facts are on this card.

#03179\$.05 each

Tabletime Traditions

Easy Tips for Meaningful Family Meals. Contains recipes, fun conversation starters and ideas for involving kids in meal preparation.

#01078.....\$.30 each

Today's Fresh Pork: Something's Changed Video

This 20-minute tape covers everything from shopping for fresh pork to preparing it. Following a brief introduction about pork, the videotape is divided into segments on nutrition, meal planning, shopping and preparation. The segments are separated by pork trivia questions designed to test everyone's knowledge about the industry's interesting history. *Total running time: 20 minutes.*

#08004.....\$5.00 each

Where There's Pork, There's Fire

Family no longer warming up to the same old burgers on the grill? Maybe it's time to toss a little variety their way. And throw on the pork. Here are seven easy recipes that are a snap to make the first time out. And a cinch to bring the family hurrying back to the table.

#01116.....\$.07 each

Contracting

Guide to Contracting – Marketing Contracts

The Guide to Contracting – Marketing Contracts is designed to be used as a reference manual by those involved in the preparation and negotiation with packers to market hogs.

#04455.....See pricing chart

Employee Management

Employee Management in the Pork Industry

A nationwide survey of randomly selected pork producers, employees, and consultants is conducted every three years with the last update completed December 2000. The intent of this report is to provide producers (employers) and employees information on items such as salaries and benefits offered, level of education and experience in the industry, employee management and satisfaction levels, and to track industry trends.

#04261.....See pricing chart

Environmental

Basics of Manure Management Video

Through actual on-site farm footage and computer graphics, different manure management systems now used in the pork industry are defined and illustrated. This video was produced primarily for non-pork audiences.

#08053.....See pricing chart

Environmental Stewardship. A Way of Life

The environmental stewards videos highlight four regional pork producer winners each year since 1995. Recognizing those who have done something to improve their operation, which directly benefits the environment. Responsible producers are stewards of the industry’s image - a critical link to the future of our pork industry. Included with each video are corresponding inserts from *National Hog Farmer* magazine.

2001- #08091/04604No Charge

2002- #08108No Charge

2003- #08135/04660No Charge

Feasibility Study: Waste Management Technologies Used in the Swine Industry

Each study consists of a Technology Evaluation Narrative, a Technical Analysis, Site Specific Data (Daily Basis), and an Economic Analysis. Of great benefit to the producer is the cost per pig for each technology (found in the Economic Analysis portion of each study).

#04460.....See pricing chart

Odor Solutions Initiative - Manure Pit Additive Testing Results

This book presents the final results of 35 manure pit additive products that were evaluated for odor reduction. This project is the most comprehensive testing that has been conducted with manure pit additives. The report shows the potential of a product to reduce odor and other odorous compounds.

#04537.....See pricing chart

Comprehensive Nutrient Management Planning Producer Curriculum

The training goal is to provide producers and consultants with the background, specific tools, and a proven process to develop a Comprehensive Nutrient Management Plan (CNMP) as a subset of an overall conservation plan and to ensure producers long-term economic and environmental sustainability.

These planning skills will add value when used to make solid business decisions that influence production efficiency, economic competitiveness, environmental sustainability and social responsibility.

CNMP Book	#04627	See pricing chart
CNMP Teaching Curriculum CD	#08109	See pricing chart
CNMP Producer Video	#08119.....	See pricing chart

Principles of Mortality Composting for Pork Producers

This video provides audiences with a basic introduction to mortality composting including benefits, principles, site selection and design.

#08062.....See pricing chart

Food Safety

Food Safety Magnet

Round, colorful magnet concerning Pork Food Safety-keep it clean, keep it cold, and cook it properly.

Order Online at www.porkboard.org

Pork Fact Sheets

Individual fact sheets developed by the National Pork Board and the American Meat Science Association concerning different topics for pork quality and safety.

.....See *Pork Quality*

Recipe for Safe Food Preparation & Handling

There is a lot of emphasis on healthy eating today, and you may be cooking differently as a result. But whether cooking from scratch, or bringing food home from your favorite restaurant

or carryout spot, don't forget the most important ingredient-food safety. Developed by the International Council on Food Safety.

#04296.....No Charge

Serving Up Safety (Consumer Brochure)

You and your family don't need to be the next food-related illness statistic, because you can help keep your food safe. From the grocery store to the kitchen to the dinner table, this guide will help you select, prepare, cook and serve meals with confidence.

#04326.....No Charge

You Can Keep It Safe

Book mark detailing how to handle meat and food the right way can help you "keep it safe" when it comes to buying, preparing and safely serving food for your family.

#04348.....No Charge

Foodservice Information

Cut Out for Any Taste

For exciting creations, pork is the perfect fit. Tempt your customers with these creations cut out for their tastes.

#01124.....\$.80 each

Deli Sandwiches

For recipes that raise the sandwich to entrée status try some of these pork sandwich recipes. Sandwiches are one of the most popular entrees you can add to your lunch or dinner menu. Include pork and they're suddenly the most delicious and versatile as well.

#01131.....\$.80 each

Explore the Wide World of Pork

Why give kids the same old thing? Today's pork offers a world of possibilities for globally inspired dishes that kids really go for. Here's how a group of school food service professionals got creative with new exciting pork recipes.

#01108.....\$.50 each

A Few Rustic Pork Dishes

If you are looking to take part in the rustic revival, don't forget to include pork. It easily embraces bold flavors, complements hearty vegetables and communicates that nostalgic down-home feeling in any dish. Let a rustic pork dish renew your menu.

#01128.....\$.80 each

Pow! Right In the Chops

Pork chop recipes with a bang. Popular choice for customer, these updated versions of classic pork chop recipes will satisfy their desire to try something new and different.

#01194.....\$.80 each

Show A Little Leg. Hubba Hubba

These leg of pork recipes are “can’t resist” menu items. Discover bold and delicious ways to expand your menu.

#01198\$.80 each

Smashing Dishes Recipes

Find out how satisfying Smashing Dishes can be! Variety is the key to any dining experience. Whether pork is part of an Asian appetizer, a Mediterranean salad or a Mexican entrée, pork has the flavor excitement and uniqueness to meet the demands of today's dining customers.

#01113\$.80 each

Surf and Turf

Move over steak and lobster. Discover the new definition of surf and turf from this brochure. A colorful brochure to spark imagination by highlighting menu ideas from chefs from around the country.

#01111.....No Charge

Try Something Off the Shoulder. Ooh-la-la

Make your guests “ooh” and “ahh” for these irresistible pork shoulder recipes.

#01197.....\$.80 each

Miscellaneous

A Look at the Organization - Its Purpose and Its Programs

A pamphlet looks at the many different segments of the National Pork Board, and explains what it is, its history, how it is funded, and its programs.

#05024No Charge

Family Tree Poster

A colorful poster showing hogs from prehistoric times to symbol, the graphic representation of a standard of performance and carcass composition providing a basis for the continuing improvement of the modern hog. *Vertical, 24-27-inch.*

#04144.....\$3.00 each

Pork Facts Book

An excellent reference presenting the history of the pig, industry statistics, including hog and pig inventories, production profile, annual slaughter by state, and many other important facts and figures of the pork industry. Management and production practices from breeding to farrowing are included. Excellent swine reference for educators.

Also available on our web site www.porkboard.org as a PDF file.

#04057\$5.00 each

Pork Industry Progress Brochure

This brochure includes historical information about the pork industry, the origins of the National Pork Board, by-products, as well as interesting facts about the industry and pigs in general.

#04139.....\$.10 each

Networking

Case Studies in Value Added Pork Production

This case study book provides an in-depth look at three successful producer owned pork marketing businesses. From startup to day to day management, the guide will teach you what is required to market pork successfully. Also included is information on applicable regulations, HACCP and state assistance programs.

#04432.....See pricing chart

Front End Guidance for Value-Added Networks

The front end guidance material is an illustration of how value-added market development and implementation might be investigated. It is the initial briefing for networks interested in serving special or segmented markets. It contains information, which can guide the development of an actual business and marketing plan to assess the viability of an investment.

#04322.....See pricing chart

Latino Meat Cutting Video

This video shows meat cutters preparing retail cuts to Latino market specifications. Both full carcass and boxed product fabrication is shown. This video is a valuable tool to train meat cutters or gain insight into Latino customer preferences. *In English only*

#08072.....See pricing chart

Latino Pork Guide

This comprehensive guide shows pork carcass fabrication Latino style. Includes retail cut pictures, cutting procedures, cooking methods, yields and relative pricing. *In English only*

#04409.....See pricing chart

Past Educational Conference Proceedings

2003 P.O.R.K. Academy CD-ROM Proceedings

CD-ROM proceedings from the 2003 P.O.R.K. Academy. Presentation topics cover Comprehensive Nutrient Management Plans (CNMP's), Air Quality, Maximizing Sow Production, Closed Herds, Pork Quality, PRRS, Antimicrobial Uses and Alternatives, Herd Health, Environmental Regulations and Standards and the Swine Welfare Assurance Program.

CD Rom #08125.....See pricing chart

Estimating Whole Hog Value Symposium Proceedings

Producer profitability depends upon knowledge of pig and/or pork marketing procedures. The proceeding topics will provide current information to plan marketing strategies to get the most value and will give producers marketing information for pigs and pork and as well as show them how to access current price information from marketing reports.

Hard copy #04703.....See pricing chart

CD Rom #08121.....See pricing chart

Environmental Symposium CD-ROM (2001)

This conference CD contains information on CNMPs, Hypoxia, Watershed Planning, Biosecurity, Spill Prevention and Counter Control (SPCC), as well as New Technologies. This conference was held in November of 2001.

#04566.....See pricing chart

Financial Management Conference (2001)

CD-ROM of the 2001 Financial Management conference held in July. Topics presented at this conference were mergers & acquisitions, lender requirements and expectations, new tax legislation, and valuing a pork company.

#04559.....See pricing chart

Human Resource Management Conference CD-ROM (2001)

Receive the most up to date information on Human Resource practices and procedures. On the CD-ROM you will find how to hire top talent, how to keep your organization and yourself out of court, dealing effectively with unacceptable employee behavior, harassment, and worker's compensation. The conference was held in December 2001.

#04567.....See pricing chart

Maternal Line National Genetic Evaluation Program (MLP) Symposium (2000)

Proceedings containing the results of the Maternal Line National Genetic Evaluation Program. This is the first complete evaluation of the genetic value of commercial sow lines handled in modern pork production facilities with modern management techniques.

#04466.....See pricing chart

National Pork Lending Conference CD-ROM (2001)

Proceedings from the 2001 Lending Conference includes topics from Mergers & Acquisitions, Federal Policy, Contracts, and Environmental Issues.

#04565.....See pricing chart

P.O.R.K. Academy Proceedings (2001)

CD-ROM proceedings from the 2001 P.O.R.K. Academy. Presentation topics ranged from Comprehensive Nutrient Management Plans (CNMPs), Wean to Finish vs. Conventional Facilities, Dietary Effects on Pork Quality and Maternal Performance, as well as Price Risk Management.

#04557.....See pricing chart

Swine Educators Conference Proceedings CD-ROM (2000)

The Swine Educators Conference proceedings focus on hot topics within the pork industry. The conference allows critical pork industry information to educators to be able to go out to the grass root producer. Topics covered include Environmental, Networking, Production and Financial Standards, Marketing, Swine Health, Producer Insurance, and the Coop Movement.

#04501.....See pricing chart

Swine Educators Conference Proceedings CD-ROM (2001)

The conference proceedings from this year includes topics from Employee Management, Nutrition, Marketing 101, Strategic Planning, Meat Quality, Herd Health and Farm Bill Choices 2002.

#04564.....See pricing chart

Swine Health Symposium (2001)

This Symposium focused on some of the hot topics of swine health. Issues that were focused on were Foreign Animal Disease, Animal Welfare, Biosecurity, Health Issues in Breeding Herds, Enteric Diseases, Porcine Reproductive and Respiratory Syndrome (PRRS) as well as a Health Alert: Report from the Field. The Symposium was held in November 2001.

CD-ROM #08090.....See pricing chart

Proceedings #04610.....See pricing chart

Pork Quality

Pork Composition and Quality Assessment Procedures

This 2000 revision of the old 'Procedures to Evaluate Market Hogs' makes this the 4th Edition of this publication. The new publication explores all the technologies currently available to measure hogs, carcasses, and pork products in carcass contests, in the lab and in practical on-line situations in packing plant. Also contains the newly revised Fat-Free Lean Index and the new color and marbling standards.

#04412.....See pricing chart

Module 1: Muscle Physiology, Handling & Pork Quality for Meat Processors

Basics of Manure Management Video - This training module, prepared by the American Meat Science Association, has a manual and videotape representing an excellent basic introduction to the science of pork quality and the factors that affects it. Intended for meat processor workers, the module would have application to anyone interested in the subject.

#08074.....See pricing chart

Module 2: Pork Carcass Fabrication and Defects - Video

This training module, prepared by the American Meat Science Association, contains an extensive array of pictures of the carcass broken into primals. Each primal is broken down into boneless retail cuts through the help of a descriptive narrative. Although intended for packing plants personnel, this module would be very useful for classrooms, producers, extension and others interested in carcass fabrication. There is also a section on pork quality defects.

#08075.....See pricing chart

Module 3: Factors in the Slaughter Process Affecting Pork Quality

This module provides excellent training on areas of handling and stunning that affect product quality. Much of the information came from the National Pork Board's technical workshop on handling and stunning. This module is available as a compact disc or as a slide set with a script.

#08076.....See pricing chart

Module 4: Food Safety for Slaughtering and Dressing Operations in Pork Packing Plants

This module is a slide set with a script. It is packed full of very useful information on Pre-Requisite Programs, Good Manufacturing Practices, Standardized Operating Procedures, Sanitation Standardized Operating Procedures, HACCP, decontamination treatments and microbial testing in packing plants.

#08077.....See pricing chart

Module 5: Carcass Chilling Effects on Pork Quality

This training module, prepared by the American Meat Science Association, is a Power Point presentation with note pages on CD. It contains information presented at the National Pork Board Chilling Workshop during which there were presentations on the engineering aspects of carcass chilling, the effects on pork quality, the effects on food safety, and some information and data collected in the U.S. and Canada about different chilling systems.

#04464.....See pricing chart

Module 6: pH Implications for Pork Quality

This training module, prepared by the American Meat Science Association is a Power Point presentation with note pages available on CD. It contains information presented at the National Pork Board workshop by the same name. There is information about the effects of pH or color, water holding capacity, flavor, tenderness, and shelf-life. Measuring techniques and industry programs are also presented.

#08081.....See pricing chart

Meat Evaluation Handbook

For years the MEH has served as the primary text for training thousands of meat science professionals in the area of fresh meat evaluation. New in a completely revised and expanded edition, the MEH is poised to be the industry standard guide for fresh meat grading and selection.

AMSA-04625\$65.00 each

Porcine Myology

This publication is an update/revision of the earlier Meat Board publication which explains the musculature of the pig carcass. Color pictures of the carcasses and each cross section are shown with scientific and common names applied to each. This publication is also available on CD.

Publication #04386.....See pricing chart

CD-ROM #04387.....See pricing chart

View the material online at:

<http://deal.unl.edu/porcine>

National Pork Board Pork Quality Standards

New color and marbling standards are now available for use in evaluating fresh pork. The individual cards show color standards ranging from one to six and marbling from one to ten in pork loin chops. These are ideal for packing plants, meat labs and judging teams, and are available in a vinyl pouch. The quality standards are also available in a poster chart (which shows ham color, texture, exudation) and a notebook size chart.

Laminated Card Sets in Vinyl Pouch #04427.....\$32.50 set

8 ½ x 11 Notebook Insert #04037.....\$1.00 each

Poster

#04036.....\$5.00 each

Producer Pork Quality Checklist

This pamphlet outlines the portion of the factors affecting pork quality for which the pork producer has an influence over. Factors relating to genetics, nutrition, handling, transporting and packer selection and the interaction of these with pork quality are covered along with recommendation on each.

(Reserve right to limit quantity)

#04442.....No Charge

Pork Fact Sheets – also see web-site at www.porkboard.org

Individual fact sheets developed by the National Pork Board and the American Meat Science Association or American Association of Swine Veterinarians concerning different topics for pork quality, safety and animal health.

I. Pork Quality & Safety

Irradiation – General Fact Sheet #04286.....\$.10 each

II. Pork Safety

A. Systems Management

Safety of Cured Pork Products #04275.....\$.10 each

Irradiation – Safety #04284.....\$.10 each

Extension of Chilled Pork Storage Life #04282.....\$.10 each

Meat Inspection #04313.....\$.10 each

Employee Involvement in HACCP #04376.....\$.10 each

What will HACCP Mean to My Business #04372.....\$.10 each

Pre-Shipment Record Review Options #04451.....\$.10 each

Sanitation of Meat Plants #04616.....\$.10 each

HACCP Plan Assessment for Smaller Plants #04617.....\$.10 each

HACCP Validation & Verification #04618.....\$.10 each

Handwashing – General Employee

Sanitation #04620.....\$.10 each

B. Potential Microbial Pathogens or Parasites

Trichinae #04377.....\$.10 each

Industry Guidelines to Prevent Contamination

from *Listeria monocytogenes* #04497.....\$.10 each

Spanish Version #04614.....\$.10 each

Toxoplasma #04494.....\$.10 each

National Pork Retail Microbiological

Baseline #04497-A\$.10 each

An Overview of Rodent Control for Commercial

Pork Production Operations #04648.....\$.10 each

Antibacterial Resistance & Antibiotic Use

In Animals #04528.....\$.10 each

An Overview of Methods for Measuring the

Impact of Sanitation Procedures for Swine		
Transport Vehicles	#04532.....	\$.10 each
Transportation Cleaning and Disinfection	#04533.....	\$.10 each
Implementing a Recall Program for		
Small Processors	#04452.....	\$.10 each
Swine Influenza Virus	#04535.....	\$.10 each
Methods and Value of Sequencing for		
Differentiation of Isolates of Porcine Reproductive &		
Respiratory Syndrome Virus (PRRS)	#04536.....	\$.10 each
Postweaning Multisystemic		
Wasting Syndrome	#04534.....	\$.10 each
Basic Guidelines of Judicious Therapeutic Use		
Of Antimicrobials in Pork Production		
For Pork Producers	#04647.....	\$.10 each
Hepatitis E Virus	#04710.....	\$.10 each

III. Pork Quality

A. Genetic & Production Effects on Fresh Pork

Marbling and Pork Tenderness	#04310.....	\$.10 each
The Impact of Genetics on Pork Quality	#04341.....	\$.10 each
Pork Quality Targets	#04366.....	\$.10 each
Nutritional Influences on Pork Quality	#04422.....	\$.10 each
Procedures for Estimating Pork Carcass		
Composition	#04341A.....	\$.10 each
Variation in Pork Lean Quality	#04522.....	\$.10 each

B. Processing Effects on Fresh Pork

Irradiation – Quality	#04285.....	\$.10 each
Critical Points Affecting Fresh Pork Quality		
Within the Packing Plant	#04328.....	\$.10 each
What is ‘Warmed-Over Flavor’?	#04373.....	\$.10 each
The Role of Carcass Chilling in the Development		
of pork	#04521.....	\$.10 each
Functionality of Non-Meat Ingredients		
Used in Enhanced Pork	#04527.....	\$.10 each
Pork Irradiation Project	.....	\$.10 each
Current Issues for Country Cured Hams	#04624.....	\$.10 each

C. Consumer and Niche Marketing Pork

Consumer Attitudes Towards Color and Marbling		
of Fresh Pork	#04520.....	\$.10 each
Ethnic Marketing of Pork	#04523.....	\$.10 each
Organic Pork Standards	#04524.....	\$.10 each
Sensory Evaluation of Pork	#04526.....	\$.10 each
Consumer Attitudes: What they Say		
And What they Do	#04621.....	\$.10 each

New Product Development Guidelines	#04622.....	\$.10 each
Meat Case Lighting	#04623.....	\$.10 each
Current Issues for Country Cured Hams	#04624.....	\$.10 each

Swine Nutrition & Pork Quality

This new publication was compiled and written by Dr. Jim Pettigrew of Pettigrew Consulting in Missouri. It contains all the information known about the nutritional factors associated with pork quality such as those associated with lean:fat ratios, fat metabolism, carbohydrate metabolism, pH, and with calcium metabolism.

#04458.....See pricing chart

System for Assuring Pork Quality

This free publication contains a flow chart of all the factors affecting pork quality on the farm, in transport, and in the plant organized under nine “quality control points” (QCP’s). There is a brief literature review followed by a recommendation for each opportunity for intervention for quality improvement.

#04421.....No Charge

Pork Quality Assurance - (One Complimentary Copy Per Educator)

#1 Video - Injection Techniques For Swine

This video reviews the medication types, injection sites, routes of administration, restraint methods, and needle size and gauges. Written outline and quiz included.

Total running time: 16 minutes.

#08034.....See pricing chart

Spanish Version #08035.....See pricing chart

#2 Video - Medication Handling and Storage

Discusses temperature and light exposure, proper medication labeling, storage and record keeping. Written outline and quiz included. *Total running time: 12 minutes.*

#08036.....See pricing chart

#3 Video - Swine Handling For Pork Producers

Covers the importance of proper handling as it relates to meat quality, pig behavior, methods to move pigs, handling breeding stock, the importance of human contact, facilities design, and loading pigs for transport. *Total running time: 15 minutes.*

#08037.....See pricing chart

Spanish Version #08038.....See pricing chart

#4 Video - Swine Handling For Transporters

Includes the importance of proper handling as it relates to meat quality, preloading, loading, transporting, delivery, truck and trailer washing, and adverse weather guidelines. Includes laminated adverse weather chart. *Total running time: 15 minutes.*

#08039.....See pricing chart

#5 Video - Needle Strength Evaluation

Shows an objective, scientific evaluation of needle strength and consequences of bending using different needle sizes and types. Written outline and quiz included.

Total running time: 15 minutes.

#08051.....See pricing chart

#6 Video - Mixing Medicated Feed for Pigs

This video covers the current Good Manufacturing Practices (cGMP) that need to be followed by all feed processors when mixing medicated feeds. It emphasizes the cGMPs that address medication carryover and proper record keeping. It describes the different types and categories of feed medication as well as the Veterinary Feed Directive. Includes video outline and quiz.

Total running time: 15 minutes.

#08054.....See pricing chart

#7 Video - Proper Pig Handling for Markets & Packers

Proper pig handling is an important part of producing quality pork products. Handlers who do their job correctly and efficiently help insure high quality meat and help the pork industry maintain its high standard of animal well being. This booklet and accompanying video are designed to show and explain proper pig handling techniques.

LCI-04340.....\$50.00 each

Packing Plant Changes Affecting Pork Production (PQA/HACCP Brochure)

This brochure outlines the changes that packing plants are adhering and how this affects pork producers.

#04353.....No Charge

PQA Fact Sheets

.....*See Pork Quality*

Pork Quality Assurance/HACCP Orientation Video

Food Safety is of utmost importance for the U.S. Pork Industry. This video takes you from farm to plate, explaining what each link of the food chain is doing to assure that a safe product is delivered to consumers. *15-20 minutes approximately*

#08011.....See pricing chart

PQA Injection Chart

The injection chart reviews proper injection techniques, needle sizes and gauges and the hazards of bent or broken needles. Designed to hang in swine barns for easy reference.

Available for download at: <http://www.porkboard.org/docs/InjectionReference.pdf>

PQA Level III Certification Video

This video will assist educators in communicating and reviewing the ten Good Production Practices outlined in the PQA manual.

#08097.....See pricing chart

Spanish Version

#08113.....See pricing chart

The PQA Level IIIsm Manual

PQA is a multi-level producer education program to enhance the quality of pork sold to the world's pork consumers. The booklet emphasizes good management practices in the handling and use of animal health products, bio-security, rodent control and encourages producers to review their approach to their herd's health programs. Also examines the 10 Critical Control Points for quality assured pork production. Points covered include establishing an efficient and effective herd health plan, storing and administering drugs, treatment records and drug residue tests.

	#04279.....	No Charge
<i>Revised, Summer 2002</i>	#04162.....	No Charge
<i>Spanish Version</i>	#08095.....	No Charge
<i>PQA Power Point CD</i>	#08122	No Charge
<i>PQA Power Point CD (Spanish Version)</i>	Outside of U.S.....	See pricing chart

PQA Medication Withdrawal Charts

A chart listing the common injectable, oral, feed and water medications used in swine production, their trade names and the pre slaughter withdrawal times. This is designed to hang in swine barns for easy reference.

Available for download at:

PQA Youth Program Training Manual

This manual and CD-ROM assist PQA Trainers (veterinarians, extension agents, and ag instructors) with educating young pork producers on the importance of good production practices, food safety and HAACP. The manual contains a teaching script and various activities for youth.

#04510.....No Charge

Weather Chart

Laminated adverse weather chart included with the *#4-Swine Handling For Transporters* video or can be purchased separately.

#04126.....\$1.00 each

PQA Brochure

A brochure describing the basic concepts, benefits, and background of the Pork Quality Assurance Program.

#04016.....No Charge

Youth PQA Brochure

A brochure describing the basic concepts, benefits, and a background on the Youth Pork Quality Assurance program along with activity suggestions to aid in the Youth PQA education training.

#04745.....No Charge

Distance Learning CD-ROM

A self directed learning tool which provides information to producers in developing a comprehensive management system to address health and welfare of animals and the proper use of animal health products to prevent violative drug residues.

#08142 No Charge to U.S.
Pork Producers

#08142.....\$75.00 non US
pork producers

Pork Safety

Drug Residue Check Stuffer

News USDA rules have dramatically changed the consequences to producers of finding a drug residue. This check stuffer is designed for use by packers, veterinarians, and others. It outlines the rule changes and gives information on avoiding drug residues.

#03496.....No Charge

Fact Sheet: Risk factors associated with *Salmonella* on Swine Farms

This literature review outlines the on-farm risk factors associated with *Salmonella* infection that have been identified in the scientific literature

#04721.....No Charge

Fact Sheet: *Salmonella* in the Pork Production Chain

This sheet is a review of the scientific literature on the potential points of introduction of *Salmonella* in pork from farm-to-fork

#03558.....No Charge

Fact Sheet: 3550 How do Violative Residues Happen in Swine?

This fact sheet explains factors influencing the potential for residues, and management practices to help to avoid a violative residue

#03550.....No Charge

One Is Too ManySM Awareness Poster - Large

A 22"x34" poster with the One Is Too ManySM logo and the "Accept nothing but Zero" message to help remind producers of the importance of preventing broken needles in pork products through applying a Standard Operating Procedure for handling and using needles.

#04515.....No Charge

One Is Too ManySM Brochure

A brochure suitable for distribution to producers that raises awareness about the issue of broken needles in pork products and gives producers steps to consider when developing their farm-specific prevention plan.

#04512.....No Charge

Packer Check Stuffer

An awareness piece, sized to fit into a business envelope, that presents One Is Too ManySM information and encourages the producer to talk with their packer about their identification, notification and payment policies.

#04513.....No Charge

Pork Fact Sheets

.....*See Pork Quality*

Poster: Bait and Switch Poster

Barn poster illustrates rodent baits with a reminder that cats do not provide proper rodent control, and may carry disease
#04719.....No Charge

Salmonella: Small Plant Fact Sheet

Summary of findings of the NPB *Salmonella* Intervention for small plants assistance program.
#04664.....No Charge

SOP Poster – Small Laminated

A 17”x22” laminated poster suitable for hanging in a production facility. It contains suggestions for developing a farm-specific Standard Operating Procedure (SOP) for handling and using needles – prevention, identification of ‘at-risk animals’, notification and training.
#04514.....No Charge

Trichinae Herd Certification

This brochure describes the history and progress of the development of a Trichinae Herd Certification Program, a pre-harvest pork safety program designed to provide documentation of swine management practices that minimize risk of exposure of swine to the zoonotic parasite *Trichinella spiralis*.
#04488.....No Charge

Veterinarian Check Stuffer

An awareness piece, sized to fit into a business envelop, that presents One Is Too ManySM information and encourages the producer to talk with their veterinarian about designing a farm-specific Standard Operating Procedure for handling and using needles.
#04516.....No Charge

Producer Health and Safety

Designing & Implementing Your Safety System-Stage 1

The first in the pork production safety training series. This kit has nine steps of written materials and two videos to make producers, family members and employees more aware of a safe working environment. Materials included: Introduction, Farm Evaluation, Employer Video, Employer Tutorial, Employer Teaching Manual, Employee Handbook, Sample Tests & Answers, Sample Documentation Forms, and Employee Video.
#04262.....See pricing chart

Designing & Implementing Your Safety System – Stage II

The second kit in the Designing & Implementing Your Safety System include a video and supporting written materials that outlines training and information about animal handling and producers safety.

#08063.....See pricing chart

Working Safe Posters

Three new posters designed to be displayed in pork production units or offices to remind producers of the safety points from the corresponding Designing and Implementing Your Safety System Kit.

Set of three #04413.....\$1.00 each

Production Management

Security and Biosecurity

This publication offers a comprehensive review of risk factors associated with unintentional and intentional introduction of disease causing agents to pork production operations. These Security and Biosecurity Guides for pork producers were developed as a collaborative effort by the National Pork Board’s Swine Health Committee, the National Biosecurity Research Center at Purdue University, and the National Pork Board and American Association of Swine Veterinarian’s Biosecurity Working Groups.

Security Guide and Biosecurity Guide #04632.....\$10

Foreign Animal Disease Awareness Video

This video presents educational information on the threat of foreign swine diseases to our industry and how producers and veterinarians can help to prevent the occurrence of these diseases in the United States. It will also inform producers of the efforts industry and government are now undertaking to better protect the pork industry.

#08070.....See pricing chart

Grow-Finish: Getting Started Video

The Grow-Finish: Getting Started video shows how to define and handle subject pigs; protocol for loading and unloading pigs; describe how pigs need to be handled in feedlot; and how to interact with truck drivers. It will also walk through the grow-finish barn management checklist. *Total running time: 18 minutes.*

#08064.....See pricing chart

Isolation of Incoming Breeding Swine

Isolation is the housing and observation of incoming pigs in a separate facility before introduction into the main herd. A properly designed and managed isolation facility will protect a herd from the introduction of new infectious agents from an outside source.

#04229.....\$.60 each

PRRS Compendium, 1st Edition: A comprehensive reference on Porcine Reproductive and Respiratory Syndrome for pork producers, veterinary practitioners, and researchers

A comprehensive reference on Porcine Reproductive and Respiratory Syndrome for pork producers, veterinary practitioners and researchers. The Swine Health committee has released

this compendium to provide pork producers, swine veterinarians and swine researchers with the latest and most concise information available on PRRS. It also serves as a catalog for PRRS research that has been funded by pork producers at the state and national level.

#04349.....Call for Pricing

PRRS Compendium, *Second Edition*: A comprehensive reference on Porcine Reproductive and Respiratory Syndrome for pork producers, veterinary practitioners, and researchers

The 2003 PRRS Compendium Second Edition is a comprehensive review of the scientific literature published on the PRRS virus. A great deal has been learned about the virus since the First Edition was published in 1998 and necessitated the development of this greatly expanded Second Edition. This edition contains the input of over 70 national and international experts on the virus and the disease as it presents on swine operations. In addition to a scientific review of PRRS virus, further chapters have been devoted to describing techniques used to manage or eliminate the virus from farms. Finally, numerous authors from around the world have supplied summary chapters that provide their perspective on PRRS virus in their own countries. The 2003 PRRS Compendium Second Edition stands out as the unequivocal source of PRRS virus information in the world.

#04702.....\$30.00 each

International #04702.....\$90.00 each

PRRS Compendium, *Producer Edition*

The PRRS Compendium Producer Edition is an abridged version of the 2003 PRRS Compendium Second Edition. The nature of the material published in the Second Edition was quite detailed and resulted in a document that, while comprehensive, provided a level of detail that may be beyond the needs of many producers and others who desire information about PRRS. To serve these audiences, we have selected and reduced the number of the chapters found in the full 2003 Edition and created this Producer Edition. It provides an overview of many aspects of PRRS virus clinical signs, epidemiology, interaction with other pathogens, and control strategies. Also, under the direction of the National Pork Board’s Swine Health Committee, a chapter entitled “A Producer’s Guide to Managing PRRS Virus Infection – What Do You Need to Know?” has been created and included only in this Producer Edition. It can serve as a framework for developing a producer’s farm-specific plan to controlling the disease. Those individuals wanting a more detailed discussion of any of the topics presented in this Producer Edition are encouraged to refer to the full Second Edition.

#04701.....\$10.00 each

International #04701.....\$30.00 each

PRRS Compendium, *Second Edition & Producer Edition* – CD ROM

Both the Second Edition and the Producer Edition of the 2003 PRRS Compendium have been included on a single CD-ROM. The CD-ROM is in a searchable PDF format for use on most IBM-compatible computers.

#08124.....\$20.00 each

International #08124.....\$50.00 each

Rodent Control for the Pork Industry Video

This video presents educational information on why on-farm rodent control is important and how to implement control programs in both confinement and outdoor/hoop structure facilities.

Rodent control industry experts are featured sharing their knowledge of rodent control products and the proper use of these products.

#08069.....See pricing chart

Rodent Control Techniques Video

This educational video demonstrates techniques proven to reduce the rodent population on pork production operations. A pest management consultant walks through several on-farm scenarios where rodent control is a problem and discusses what signs producers should look for and what producers can do to combat a rodent problem. *Total running time: 37 minutes*

#08083.....See pricing chart

Retail Information

Combo Fact Sheet

A fact sheet on the correct cuts, as well as dimensions for America's Cut, Chef's Prime, and Chef's Prime Filet.

#03173No Charge

Food Photography Posters

Set of 3 (each 15"x20") that include prepared food shots of a roast, a ham, and a chop.

#03511.....No Charge

Ground Pork Point of Sale Materials

This kit includes one each 11"x7" and 5"x3" 2-sided, 4-color meat case cards; channel strips and 2 pads of 50 recipes using ground pork as an ingredient.

#03427.....No Charge

Bacon Makes it Better - Breakfast Point of Sale Materials

This kit includes on each 11"x7" and 5"x3" 2-sided, 4-color meat case cards and channel strips.

#04539.....No Charge

Bacon Makes it Better – Dinner Point of Sale Materials

This kit includes on each 11"x7" and 5"x3" 2-sided, 4-color meat case cards and channel strips.

#04541.....No Charge

Bacon Makes it Better-Floor Graphic

Place this Bacon Makes it Better color photo on the floor leading to the meat case.

#04542.....No Charge

Other Tailgate Party Point of Sale Materials

This kit include one each 11"x7" and 5"x3" 2-sided, 4-color meat case cards and channel strips.

#04652.....No Charge

Other Tailgate Party Floor Graphic

Place this Other Tailgate Party color photo on the floor leading to the meat case.

#03430.....No Charge

Hispanic Point of Sale Materials

This kit includes on each 11”x7” and 5”x3” 2-sided, 4-color meat case cards and channel strips featuring “El Cerdo es Bueno”.

#04657.....\$.10 cents

Healthy and Delicious: A Bilingual Spanish Recipe Brochure

Recipe brochure including 4 Mexican recipes with English translations as well; w/photos

#01206.....No Charge

Spanish-language Meat Cuts Chart

This wallchart features popular pork cuts from each primal, listed in Spanish language.

#04675.....\$2.00 each

Spanish-language Meat Cuts Notebook Chart

This chart is 8.5" x 11" notebook sized and features popular pork cuts from each primal, listed in Spanish language

04675ANo Charge

Spanish-language Pork A-Z Consumer Education Brochure

Spanish-language comprehensive booklet that includes nutritional information, cooking directions for various cuts, and storage information for fresh cuts.

#04694.....\$.45 cents

About Ham Point of Sale Materials

This kit includes one each 11”x7” and 5”x3” 2-sided, 4-color meat case cards and channel strips.

#04678.....No Charge

About Ham Floor Graphic

Place this About Ham color graphic on the floor in the meat case.

#04680.....No Charge

Sausage Sizzles Point of Sale Materials

This kit includes one each 11”x7” and 5”x3” 2-sided, 4-color meat case cards and channel strips.

#04629.....No Charge

Sausage Sizzles Floor Graphic

Place this series of three Sausage Sizzles color photos on the floor in the meat case or as a cross-merchandising piece in other departments.

#04630.....No Charge

Uncle Sam Program Point of Sale Materials

This kit includes one each 11”x7” and 5”x3” 2-sided, 4-color meat case cards.

#04690.....No Charge

Uncle Sam Poster

Poster depicting the traditional Uncle Sam image with the verbiage “I Want Pork” below.

#04691.....No Charge

Pork. Now that's BBQ Point of Sale Materials

This kit includes one each 11"x7" and 5"x3" 2-sided, 4-color meat case cards; channel strips and 2 pads of 50 recipes.

#04700.....No Charge

Pork. Now that's BBQ Floor Graphic

Place this Pork. Not that's BBQ color photo on the floor leading to the meat case.

#04699.....No Charge

Pork. The Other White Meat? Point of Sale Materials

This kit includes 2 colored 11"x17" meat case cards (each side is a different pork shot) and 4 3.5" x 8" meat case cards (2 of each with different pork shots) and 5 Pork. The Other White Meat? channel strips

#04722.....No Charge

Pork. The Other White Meat? Rail Strips

Designed to dress up your meat case. A 12 inch plastic strip with Pork. The Other White Meat.

#03028.....No Charge

Pork. The Other White Meat? Stickers

A roll of 250 blue Pork. The Other White Meat? Stickers.

#03005.....\$2.25 each

Purchasing Pork Notebook Chart

A consumer guide to identifying retail pork cuts for shoulder butt, picnic shoulder, ribs, chops, roasts, side, and legs. (8 1/2 x 11)

#03342.....\$.10 each

Purchasing Pork Poster

A consumer guide to identifying retail pork cuts for shoulder butt, picnic shoulder, ribs, chops, roasts, side, and legs. (33"x24")

#03341.....\$.60 each

Retail Marketing CD-ROM Program

This CD-ROM program is ideal for anyone who designs print advertising or consumer brochures. Containing both high and low-resolution files, the set includes four-color cooked pork photography and recipes for hundreds of pork products. (New 2002)

#03528.....See pricing chart

Retail Merchandising Manual

This comprehensive manual contains both a printed and an electronic versions of information designed for retail use. Included here is information covering the subjects of marketing to consumers, new technology, category management, pork cuts, and meatcase research. The manual is four-color, coated pages designed to be used in-store for meat department personnel. The CD-ROM contains the same information as the printed form.

#03515.....See pricing chart

School Foodservice

Explore the Wide World of Pork Menu Planner and Recipes

From roast pork subs to fajitas to pizza, pork is always a favorite with kids. Did you know pork is the most popular meat in the world? Make the most of your menu with these fun themes, and recipes in the school foodservice cafeteria. You can order the menu planner (03367) and recipes (01108).

#01108.....No Charge

School Foodservice Recipe Cards

Set of 10

#01205.....No Charge

Swine Nutrition

Kansas Swine Nutrition Guide

A set of eight fact sheets providing the latest recommended nutrient allowances and answers some of the more frequently asked questions concerning swine nutrition.

KSU-04143\$8.00 each

Swine Nutrition & Pork Quality

This new publication was compiled and written by Dr. Jim Pettigrew of Pettigrew Consulting in Missouri. It contains all the information known about the nutritional factors associated with pork quality such as those associated with lean:fat ratios, fat metabolism, carbohydrate metabolism, pH, and with calcium metabolism.

#04458.....See pricing chart

U.S. Pork and Export Marketing

American Pork Export Manual

The American Pork Export Manual has been prepared as a reference guide for international pork customers. This manual is merely a guide for identification of the most common pork cuts. Written in 5 languages. Developed by the National Pork Board and the U.S. Meat Export Federation.

#20000.....\$5.00 each

Hispanic/Spanish Language Marketing Materials

There are a number of different marketing materials in both English and Spanish that are targeted at the Hispanic customer. Contact the National Pork Board Demand Enhancement Department at 515/223-2600 for more information on specific items.

U.S. Pork Brochure

America’s pork producers are committed to making U.S. Pork the best pork product the world has to offer. Four-color brochure written in 6 languages (*English, Spanish, Russian, Korean, Chinese, and Japanese*).

#20001.....\$5.00 each

Videos

THESE VIDEOS ARE ALSO FOUND THROUGHOUT THE CATALOG

Artificial Insemination . . .

Striving For Perfection Video

#08005.....See pricing chart

Basics of Manure Management Video

#08053.....See pricing chart

Foreign Animal Disease Awareness Video

#08070.....See pricing chart

Grow-Finish: Getting Started Video

#08064.....See pricing chart

Injection Techniques for Swine

#08034.....See pricing chart

Spanish Version

#08035.....See pricing chart

Latino Meat Cutting Video

English Only

#08072.....See pricing chart

Medication Handling & Storage

#08036.....See pricing chart

Mixing Medicated Feed for Pigs

#08054.....See pricing chart

Needle Strength Evaluation

#08051.....See pricing chart

A New Look at Pork Educators Packet & Video

#08055.....See pricing chart

Pork Quality Assurance/HACCP Orientation Video

#08011.....See pricing chart

<i>PQA Level III Certification Video (English Version)</i>	#08097.....	See pricing chart
<i>Proper Pig Handling for Markets & Packers</i>	LCI-04340.....	\$50.00 each
<i>Rodent Control for the Pork Industry Video</i>	#08069.....	See pricing chart
<i>Rodent Control Techniques Video</i>	#08083.....	See pricing chart
<i>Swine Handling for Pork Producers</i>	#08037.....	See pricing chart
Spanish Version	#08038.....	See pricing chart
<i>Swine Handling for Transporters</i>	#08039.....	See pricing chart
<i>Today's Fresh Pork: Something's Changed Video</i>	#08004.....	\$5.00 each
<i>Welcome to Our Farm Video Teacher Packet</i>	#08084.....	\$6.00 each

Youth Education

Bookmarks

Colorful neon bookmarks that have a pork nutrition puzzle on one side and an easy kid's pork recipe on the other side. Available in bundles of 100.

#06003.....No Charge

Crayons

Box of 4 crayons imprinted with Pork. The Other White Meat® and the statement, "Did you know...by-products from pigs are used to make crayons and other household products."

#03325.....\$.25 each

"Go Hog Wild About Learning" Stickers

Round purple sticker encouraging everyone to go "hog wild about learning". Comes in sheets of 35 stickers.

#03419.....\$0.35 per sheet

"I Love Pork" Stickers

Brightly colored round stickers featuring Peggy the Pork Chop. Comes in a roll of 250 stickers.

#03412.....\$2.50 per roll

Kids Ham It Up

Quick ham recipes for lunches and snacks.

#03347.....\$0.25 each

Kids’ Pork Cookbook

Kids’ Pork Cookbook covers basic cooking terms and equipment, measuring ingredients, shopping for pork, setting the table and table manners. It includes eight quick and easy pork recipes.

#01102.....\$.20 each

Learning About Pork – Primary Activity/Coloring Book

This 16 page (8.5 x 11) coloring book includes color-by-numbers, connect-the-dots, and a simple maze to help K-3rd grade students better understand the pork industry.

#06029.....\$0.10 each

Neon Pencils

Neon pencils imprinted with Pork. The Other White Meat®.

#03326.....\$.10 each

A New Look at Pork Educators Packet & Video

Covers pork nutrition, purchasing, cookery, and food safety. The kit includes lesson plans, reproducible handouts, a Purchasing Pork poster, pork cuts flash cards, and A New Look At Pork booklet, and an educational video (three 10-minute segments).

#08055.....\$6.00 each

Pork Industry Progress Brochure

This colorful brochure includes the history of the pork industry, pictures of various hog breeds, pig trivia, pork nutrition, and hog by-products.

#04139.....\$.10 each

Welcome To Our Farm Book

This 18-page (11x 8.5) storybook takes you on a tour of a modern hog farm. The book includes classroom activities and a reproducible handout for preK-1st grade students.

#03332.....\$.50 each

Welcome To Our Farm Video Teacher Packet

This kit is designed especially for the first grade classroom as an introduction to farm life. Included a 12-minute news-style video for the classroom, Welcome To Our Farm storybook, a teacher’s guide book and various blackline masters for handouts.

#08084.....\$6.00 each

Where Pork Comes From

A multi-media elementary teaching packet for kindergarten through fourth graders teaching students the “farm to table” story.

INFB-04222\$25.00 each

Pick Protein Poster

A poster with lesson plans to help teens take responsibility for their own health. Great for FACS and other educators for grades 9-12.

NPB-03568.....\$.25 each

Miscellaneous Promotional Items

National Pork Board Showables

Stuffed Pig “Hambone”	#02258	.....	\$8.00 each
Grill w/3 pc. utensils	#02032	.....	\$45.00 each
Pork Mark golf ball, set of 3	#02459	.....	\$8.50 each
Genuine Pigskin Portfolio	#02566	.....	\$35.00 each
Genuine Pigskin Billfold			
Black	#02566	.....	\$25.00 each
Brown	#02566	.....	\$25.00 each
NEW! Chef Pig Oven Mitt	#02024	.....	\$6.00 each
NEW! Pork. The Other White Meat® Piggy Key Chain	#02465	.....	\$1.50 each
Porkmark Lapel Pin (<i>white</i>)	#02042	.....	\$1.50 each
Pork. The Other White Meat® Apron (<i>navy</i>) with pocket	#02046	.....	\$8.50 each
Pork. The Other White Meat® Mug (<i>black acrylic</i>)	#02047	.....	\$6.00 each
Pork. The Other White Meat® Balloons (<i>250 per bag</i>)	#02050	.....	\$29.00 each
Pork. The Other White Meat® Button	#02052	.....	\$.65 each
Pork. The Other White Meat ® Koozie Brand 12 Pk cooler bag	#02265	.....	\$16.00 each
Pork. The Other White Meat ® Paper Place Mat	#03019	.....	\$.06 each
Pork. The Other White Meat ® Plastic Bag	#02029	.....	\$.05 each
Pork. The Other White Meat ® Silver Rollerball Pen	#02292	.....	\$7.00 each
45” Pig Shoelaces (<i>blue</i>)	#02096	.....	\$2.00 each
45” Pig Shoelaces (<i>red</i>)	#02097	.....	\$2.00 each
Pork Instant Read Thermometer	#02118	.....	\$8.00 each
Pork. The Other White Meat® Ink Pen	#02144	.....	\$.50 each
Pig Lapel Pin (<i>gold</i>)	#02030	.....	\$2.00 each
U.S. Pork Pig lapel Pin (<i>red, white and blue</i>)	#02065	.....	\$2.00 each

National Pork Board Wearables

Youth Sizes: X-Small = 2 - 4; Small = 6 - 8; Medium = 10 - 12; Large = 14 - 16

Pork. The Other White Meat®	X-Small	#02001	..... \$6.00 each
	Small (<i>white</i>)	#02001	..... \$6.00 each
Adult T-shirt	Small (<i>navy</i>)	#02009	..... \$6.00 each
	Medium (<i>white</i>)	#02002	..... \$6.00 each
	Medium (<i>navy</i>)	#02010	..... \$6.00 each
	Large (<i>white</i>)	#02003	..... \$6.00 each
	Large (<i>navy</i>)	#02011	..... \$6.00 each
	X-Large (<i>white</i>)	#02004	..... \$6.00 each
	X-Large (<i>navy</i>)	#02012	..... \$6.00 each
	XX-Large (<i>white</i>)	#02066	..... \$8.00 each
	XX-Large (<i>navy</i>)	#02076	..... \$8.00 each
Pork. The Other White Meat®	Small (<i>white</i>)	#02020	..... \$5.00 each
Youth T-shirt	Small (<i>navy</i>)	#02017	..... \$5.00 each
(<i>See above for youth sizing</i>)	Medium (<i>white</i>)	#02021	..... \$5.00 each

Medium (navy)	#02018	\$5.00 each
Large (white)	#02022	\$5.00 each
Large (navy)	#02019	\$5.00 each

Pork. The Other White Meat® Polo Shirt (Black w/tri color collar)	Medium	#02061	\$35.00 each
	Large	#02062	\$35.00 each
	X-Large	#02063	\$35.00 each
	XX-Large	\$02064	\$37.00 each
(White w/tri color collar)	Medium	#02057	\$35.00 each
	Large	#02058	\$35.00 each
	X-Large	#02059	\$35.00 each
	XX-Large	#02060	\$37.00 each
Pork. The Other White Meat® Adult Sweatshirt	Small (white)	#02005	\$13.00 each
	Small (navy)	#02013	\$13.00 each
	Medium (white)	#02006	\$13.00 each
	Medium (navy)	#02014	\$13.00 each
	Large (white)	#02007	\$13.00 each
	Large (navy)	#02015	\$13.00 each
	X-Large (white)	#02008	\$13.00 each
	X-Large (navy)	#02016	\$13.00 each
	XX-Large (white)	#02079	\$15.00 each
	XX-Large (navy)	#02084	\$15.00 each
Pork. The Other White Meat® Youth Sweatshirt (navy only) (See page 39 for youth sizing)	Small	#02036	\$10.00 each
	Medium	#02041	\$10.00 each
	Large	#02051	\$10.00 each
Pork Mark Hooded Work Jacket (Dark Blue)	Medium	#02554	\$55.00 each
	Large	#02555	\$55.00 each
	X-Large	#02556	\$55.00 each
	XX-Large	#02557	\$57.00 each
	XXX-Large	#02558	\$59.00 each
Pork. The Other White Meat® Cap Pork. The Other White Meat® Cap	Navy	#02039	\$5.50 each
	White	#02040	\$5.50 each
Pork Mark Denim Shirt Long Sleeve	Small	#02260	\$35.00 each
	Medium	#02261	\$35.00 each
	Large	#02262	\$35.00 each
	X-Large	#02263	\$35.00 each
	XX-Large	#02264	\$37.00 each
	XXX-Large	#02508	\$39.00 each
Pork Mark Denim Shirt Short Sleeve	Small	#02266	\$33.00 each
	Medium	#02267	\$33.00 each
	Large	#02268	\$33.00 each
	X-Large	#02269	\$33.00 each
	XX-Large	#02270	\$35.00 each
NEW! Navy Polo with U.S. Pork Logo Adult Shirt	Small	#02510	\$30.00 each
	Medium	#02511	\$30.00 each
	Large	#02512	\$30.00 each
	X-Large	#02513	\$30.00 each

	XX-Large	#02514	\$30.00 each
NEW! Burgundy Polo with U.S. Pork Logo Adult Shirt	Small	#02519	\$30.00 each
	Medium	#02520	\$30.00 each
	Large	#02521	\$30.00 each
	X-Large	#02522	\$30.00 each
	XX-Large	#02523	\$30.00 each
NEW! Tan Button Down Long Sleeve U.S. Pork Logo Shirt – Adult Shirt	Small	#02524	\$35.00 each
	Medium	#02525	\$35.00 each
	Large	#02526	\$35.00 each
	X-Large	#02527	\$35.00 each
	XX-Large	#02528	\$35.00 each
White U.S. Pork Cap with Red Bill		#02271	\$5.50 each
Pork. The Other White Meat? Racing Short Sleeved T-shirt	Large	#02403	\$10.00 each
	X-Large	#02404	\$10.00 each
	XX-Large	#02405	\$12.00 each
Pork. The Other White Meat? Racing Cap	Black	#02445	\$15.00 each
Pork. The Other White Meat® Racing Visor	Ladies	#02516	\$5.00 each
Short Sleeved sport shirt w/ racing trim (White/Black)	Small	#02426	\$45.00 each
	Medium	#02427	\$45.00 each
	Large	#02428	\$45.00 each
	X-Large	#02429	\$45.00 each
	XX-Large	#02430	\$47.00 each
	3X-Large	#02448	\$49.00 each
Pork. The Other White Meat? Racing Short Sleeved Sport Shirt (White)	Small	#02411	\$40.00 each
	Medium	#02412	\$40.00 each
	Large	#02413	\$40.00 each
	X-Large	#02414	\$40.00 each
	XX-Large	#02415	\$42.00 each
(Red)	Small	#02416	\$40.00 each
	Medium	#02417	\$40.00 each
	Large	#02418	\$40.00 each
	X-Large	#02419	\$40.00 each
	XX-Large	#02420	\$42.00 each

Pork. The Other White Meat? Racing Lightening Jacket	Medium	#02441	\$60.00 each
	Large	#02442	\$60.00 each
	X-Large	#02443	\$60.00 each
	XX-Large	#02444	\$62.00 each
Pork. The Other White Meat? Racing Lanyard Strap <i>(white strap w/red imprint)</i>	One Size	#02447	\$2.00 each
Gentlemen Start Your Pork Chop Apron		#02517	\$8.00 each
Life is Bowl of Pork Chops Apron		#02295	\$8.00 each
One Potato, Two Potato, Three Potato Pork Grocery List Pad		#03509	\$.75 each
Notecube, adage slogans		#04605	\$3.00 each
Set of 4 Posters, adage slogans		#04606	\$2.00 each
One Potato, Two Potato Postcard <i>(up to 5 complimentary)</i>		#03488	\$.01 each
Gentlemen Start Postcard <i>(up to 5 complimentary)</i>		#03489	\$.01 each
Duck, Duck Postcard <i>(up to 5 complimentary)</i>		#03490	\$.01 each
Life is a Bowl Postcard <i>(up to 5 complimentary)</i>		#03491	\$.01 each
Buy Me Some Peanuts Postcard <i>(up to 5 complimentary)</i>		#03492	\$.01 each
One Potato, Two Potato, Three Potato Pork T-Shirt	Large	#02299	\$7.00 each
	X-Large	#02300	\$7.00 each
	XX-Large	#02301	\$7.00 each
Life is a Bowl of Pork Chops T-Shirt	Large	#02302	\$7.00 each
	X-Large	#02303	\$7.00 each
	XX-Large	#02304	\$7.00 each
Gentlemen Start Your Pork Chops Racing T-Shirt	Large	#02305	\$7.00 each
	X-Large	#02306	\$7.00 each
	XX-Large	#02307	\$7.00 each



State Pork Producer Organizations

Alabama Pork Producers Asc.
PO Box 11000
Montgomery, AL 36191-0001
1-800-392-5705
334-284-3957 Fax
bhardin@alfafarmers.org

Arizona Pork Council
1102 E Avenida Grande
Casa Grande, AZ 85222-1004
520-836-0050
520-836-3507 Fax

Arkansas Pork Producers Asc.
PO Box 1417
Russellville, AR 72811-1417
1-877-444-PORK
479-967-6056 Fax
appa1357@cei.net

California Pork Producers
Asc.
1225 H. St
Ste. 106
Sacramento, CA 95814
916-447-8950
916-443-1506 Fax
calpork@innercite.com

Colorado Pork Council
10135 Vine St
Denver, CO 80229
303-255-9967
303-255-2029 Fax

Connecticut Pork Producers
Asc.
139 Wolf Den Rd
Brooklyn, CT 06234
860-774-9600
860-774-9480 Fax
Joyce.Meador@Uconn.edu

Delaware Pork Producers Asc.
27701 James Rd
Laurel, DE 19956
302-745-7107
302-875-8022 Fax
robininde@juno.com

Florida Pork Improvement
Group
PO Box 147030
Gainesville, FL 32614-7030
352-374-1542
352-374-1592 Fax
fhall@sfbic.com

Georgia Pork Producers
100 Miller St
Camilla, GA 31730
229-336-7760
229-336-8240 Fax
GAPORK@bellsouth.net

Hawaii Pork Industry
Association
87-1550 Kanahale Rd
Waianae, HI 96792
808-676-9100
808-676-9200 Fax
vkane@alohoa.net or
hawaiiifood3@aol.com

Idaho Pork Producers
Association
3650 N 1500 E
Buhl, ID 83316
208-543-4412
208-326-3692 Fax
bennettgo@juno.com

Illinois Pork Producers
Association
6411 S. 6th Street Rd.
Springfield, IL 62707-8642
217-529-3100
217-529-1771 Fax
jim@ilpork.com

Indiana Pork Producers
8902 Vincennes Circle, Suite F
Indianapolis, IN 46268
317-872-7500
317-872-6675 Fax
tfleck@inpork.org

Iowa Pork Producers
Association
PO Box 71009
Clive, IA 50325-0009
515-225-7675
515-225-0563 Fax
info@iowapork.org

Kansas Pork Association
2601 Farm Bureau Road
Manhattan, KS 66502-3031
785-776-0442
785-776-9897 Fax
kpa@flintheills.com

Kentucky Pork Producers
Association
1110 Hawkins Dr.
Elizabethtown, KY 42701-0607
270-737-5665
270-769-9079
kypork@kfbol.com

Louisiana Pork Producers
Asc.
319 W. Claude
Lake Charles, LA 70605
337-562-8776
225-763-5573 Fax
clemieux@mail.mcneese.edu

Maine Pork Producers Asc.
1204 Main Road
Bradford, ME 04410-3021
207-327-1398
207-327-2076 Fax
countryjet@msn.com

Maryland Pork Producers
Association
53 Slama Road
Edgewater, MD 21037-1423
410-956-5771
410-956-0161 Fax
lynnehoot@aol.com

Michigan Pork Producers
Association
4801 Willoughby Rd. Suite 5
Holt, MI 48842-1000
517-699-2145
517-699-2233 Fax
MIPorkAsso@aol.com

Minnesota Pork Producers
Association
360 Pierce Avenue, Suite 106
N Mankato, MN 56003
507-345-8814
507-345-8681 Fax
porkmn@hickorytech.net

Mississippi Pork Producers
Association
Box 9815
Mississippi State, MS 39762
662-325-1689
662-325-8873 Fax
markc@ext.msstate.edu

Missouri Pork Association
6235 W Cunningham Drive
Columbia, MO 65202
573-445-8375
573-446-2398 Fax
pork@mppa.net

Montana Pork Producers
Council
Montana State University
11th Ave
Bozeman, MT 59717-0058
406-994-3595
406-994-7715 Fax
mtpork@180com.net

Nebraska Pork Producers
Association
PO Box 830909
Lincoln, NE 68583-0909
888-627-7675
402-472-4930 Fax
rod@nepork.org

Nevada Pork Producers
Association
PO Box 493
Winnemucca, NV 89446
775-623-0199
775-623-5821 Fax
ksmama@iglide.net

New Hampshire Pork Producers
Council
47 Dunlap Rd
Danbury, NH 03230
603-768-5545
603-768-3194 Fax
info@nhpork.org

New York Pork Producers
Cooperative, Inc.
12 N Park St.
Seneca Falls, NY 13148
315-568-2750
315-568-2752 Fax
unitedag@flare.net

North Carolina Pork Council
2300 Rexwood Dr., Suite 340
Raleigh, NC 27607
919-781-0361
919-510-8546 Fax
ncpork@ncpork.org

North Dakota Pork Producers
Council
HCR 1, Box 77
Regent, ND 58650
701-563-4513
701-563-4523 Fax
ndppccm@pop.ctctel.com

Ohio Pork Producers Council
5930 Sharon Woods Blvd.
Suite 101
Columbus, OH 43229-2666
614-882-5887
614-882-6077 Fax
oppc@ohiopork.org

Oklahoma Pork Council
2501 Exchange, Suite 146
Oklahoma City, OK 73108
405-232-3781
405-232-3862 Fax
oklaporkcouncil@okpork.org

Oregon Pork Producers
PO Box 549
Newberg, OR 97132
503-538-7380
503-554-1548 Fax
mmf@gte.net

Pennsylvania Pork Producers
Council
1631 Grim Road
Kutztown, PA 19530
610-285-6519
610-285-4074 Fax
madyshick@juno.com

South Carolina Pork Board
PO Box 11280
Columbia, SC 29211-1280
803-734-2218
803-734-0325 Fax
scpork@mindspring.com

South Dakota Pork Producers
Council
1404 W Russell
Sioux Falls, SD 57104-1328
605-332-1600
605-332-9646 Fax
info@sdppc.org

Tennessee Pork Producers Asc.
13994 Versailles Rd
Rockville, TN 37153
615-453-2585
615-453-258 Fax
tnpork@nash.tds.net

Texas Pork Producers
Association
PO Box 10168
Austin, TX 78766
512-453-0615
512-451-5536 Fax
tpa@austin.rr.com

Utah Pork Producers
Association
Utah State University
Animal Science, UMC 4815
4815 University Ave
Logan, UT 84322-4815
435-797-2141
435-707-2118 Fax
havenh@ext.usu.edu

Virginia Pork Industry
Association
1012 Washington Bldg.
1100 Bank Street, Suite 106
Richmond, VA 23219-3642
804-786-7092
804-371-7786 Fax
jparker@vdacs.state.va.us

Washington Pork Producers
2001 Vantine Rd.
Garfield, WA 99130
509-397-2694
dvanline@colfax.com

West Virginia Pork Producers
Council
PO Box 1050
Martinsburg, WV 25402
304-263-4278

Wisconsin Pork Producers
Association
9185 Old Potosi Rd.
PO Box 327
Lancaster, WI 53813-0327
608-723-7551
608-723-7553 Fax
wppa@wppa.org

Wyoming Pork Producers
45 Greenhouse Rd.
Newcastle, WY 82701-9432
307-746-4278
307-746-2608 Fax
judy_lee_hansen@hotmail.com



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NATIONAL PORK BOARD

Catalog of Materials and Audio-Visuals --- ORDER FORM

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 Attn: Ordering Department
 PO Box 9114
 1776 N.W. 114th St.
 Des Moines, IA 50306
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 515- 223-2600, Ext. 621
 Fax:515-223-2646

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Company Name: _____
 Attention: _____
 Street: _____
 City: _____
 State: _____ Zip: _____
 Country: _____
 Phone #: (_____) _____



Purchase Order #: _____

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 COMPLETE THE FOLLOWING INFORMATION:**

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Credit Card Number

Signature

****Refer to the pricing chart on page 4 if you have questions****

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Photocopying of order form is encouraged.

Prices subject to change without notice.

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NATIONAL PORK BOARD
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SWINE



REPRODUCTION TECHNOLOGIES

2002 • 2003



I.M.V. INTERNATIONAL

IMV is the worldwide leader in assisted reproduction technologies, with a strong staff exceeding 250 employees, 120,000 sq.ft. of ISO 9002 certified production facility, a research center, 4 subsidiaries, and a huge network of distributors spanning over 100 countries. The company designs, develops and manufactures the vast majority of the products it distributes. Our past and present innovations have yielded a portfolio of over two hundred patents, marks and trademarks and we spend a considerable amount of money per year maintaining or defending our intellectual property in many different countries.

From semen collection to embryo freezing and splitting, over 1,000 trainees worldwide have been trained in our own unique training center. This expertise is put to work for the benefit of producers and breeders every day. Our knowledge and expertise comes from years of field practice and our many research contracts with various universities, research institutions and governmental organizations worldwide. Our DVMs, PhDs and technical staff know more about instrumental reproduction of any animal on earth than any of the other companies in this industry combined.

For over 40 years, our practical knowledge has made us a leader in the preservation of cellular life. Through the use of our insemination, embryo and cryopreservation equipment, we are proud to be an important part of the effort to preserve rare or endangered species, such as yaks in Tibet, camelides in the Persian Gulf and Africa, white rhinos in South Africa with the World Breeding Resource Center or orcas, through work performed in the USA. In total, we help in the reproduction or preservation of 14 animal species worldwide and are a dominant force in the commercial meat production industry, working with cattle, swine, turkeys and even fish. IMV is also strongly involved in the companion and working animal reproduction industries with innovative research done with horses and dogs.

Our extensive line of products further includes high precision laboratory equipment used in the preservation of human tissue samples and cancer research centers. We also produce equipment and software to set up human serum banks used for epidemiological studies which represent the medicine of tomorrow.

IMV also boasts of having invented the original foam tip catheter for swine insemination. Our Goldenpig® catheter is so widely used that one insemination is carried out somewhere using this catheter every second of the day. The simplicity and quality of our Goldenpig® catheter, the practicality of the Cochette® bag and the flexibility of the



IMV-USA

full line of excellent, innovative, ISO 9002 manufactured, independently tested semen extenders have set IMV International apart.

Today, with more than 35 million swine inseminations per year performed worldwide using IMV products, our research continues and our product line is constantly evolving. From products that cater to the small family owned operation to the large integrated production systems, IMV offers a product to meet your every need.

IMV has been present in the USA since the late 60's and, through IMV International Corp, has established its permanent home in Minnesota since 1980. The geography at the time was at the core of the dairy belt, a perfect balance between East and West. Today, with excellent transportation and distribution systems and the Minneapolis-St Paul airport hub, we are within hours of any US city in product delivery, service or technical support as needed. With after-sales service teams spanning 3 continents, we are making ourselves available on the phone to offer the most comprehensive service anywhere around, virtually 24/7. To serve the needs of our US customers better and to bolster our commitment to the United States market, we have recently moved into a brand new building with expanded storage and with an enhanced maintenance facility.

Your success is our success, and all of our US employees thank you for your continued patronage. Our pledge is to continuously strive to be an even better part of a strong and productive American agriculture through constantly innovative reproduction tools.

Sincerely,

IMV International Corp



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Anticipating the Needs of the Future



COLLECTION



Powder Free Vinyl Gloves

- F041** Large - Package of 100
- USA706** Extra Large - Package of 100

Insulated Collection Cups

- USA701** Collection Cup 30 oz.
- USA707** Styrofoam Cups for USA701 Case of 500
- USA708** Collection Cup 34 oz.
- USA709** Styrofoam Cup for USA 708
- ZS709** 2 Liter Bag 9" x 13", Package of 100

Thermometers

- XA180** Mercury Filled, 12"
- USA050** Digital, 8" Stem

Semen Filtration

- 005400** Semen Filter, 10" Lint Free, Non-woven, Box of 200
- 007769** Gauze 20cm x 20cm, Package of 5

USA108

Metal dummy sow with adjustable height and inclination. The shape is designed with the collector in mind, providing easy access to collect the boar.

USA700

Non-skid Rubber Mat
48" x 48"

005137

Pre-Collection Glove -
Shoulder Length

006521

Sensitive Pre-Collection
Glove - Shoulder Length



EVALUATION

USA112 pictured



Binocular scope
pictured with USA113
Mycrocam mounted
to eyepiece



USA056 complete

Microscopes

- USA006** Binocular, 10x, 40x, 100x Oil Objectives, Light Source, Mechanical Stage
- USA007** Monocular, 10x, 40x, 100x Oil Objectives, Light Source, Mechanical Stage
- USA109** Binocular, Phase Contrast, 10x, 20x, 40x, 100x Oil Objectives, Light Source, Mechanical Stage
- USA110** Trinocular, Phase Contrast, 10x, 20x, 40x, 100x, Oil Objective, Light Source, Mechanical Stage
- USA112** USA110 with Camera, Black and White Monitor, Green Interference Filter
- USA056** Heated Stage, Dual LED Display for Stage And 3" x 5" Slide Warmer Plate
- USA113** Mycrocam Universal Video Camera

Slide Warmers

- USA072** 25" x 8" Holds 56 Slides With Lid
- USA023** 14" x 14" Holds 56 Slides
- USA056** Slide Warmer & Heated Stage

Semen Evaluation

- U925** Live Dead Stain - 2ml
- USA926** Live Dead Stain - 20ml
- USA114** Acro-See Stain - 5ml Ampoule
- USA130** Revive Caffeine Solution - 5.0/10ml Test Tube
- USA131** Suspend Solution - 4.0./10ml Test Tube
- 005670** Graduated Test Tube - 10ml
- 005263** Cap for UB320
- USA065** Rack 13mm Glass Test Tubes
- USA066** Rack for UB320 Test Tubes

Microscope Supplies & Accessories

- 005795** Slides 1" x 3" Degreased
- 006557** Cover Slips 18mm x 18mm
- 005760** Cover Slips 22mm x 22mm
- 006452** Semen Sampling Tubes

EVALUATION

Micro-Reader Photometer

USA414 Micro-Reader

005155 Cuvette for USA414

USA008 Micropipettor 100ul

USA009 Tips for USA008, Pkg. of 1,000

USA010 Bottle Top Dispenser

ZA976 Sodium Citrate 33 grams,
1 Liter

USA028 Kim Wipes®
100% Virgin Fiber

Accucell Spectrophotometer

016453 Accucell

012930 Automatic Dilutor

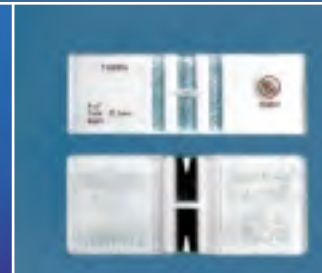
014441 Thermal Printer

Accucell Features

- Bi-directional RS232C interface
- Watertight keypad
- Automatic standby function
- Multiple measurement capabilities
- Optical system/calibrated filters
- Back-lit display
- Multiple language capabilities
- Memory: stores up to 50 readings
- Halogen bulb: easy access for replacement
- Light-weight (5 lb)
- Concentration results from a quadratic equation that averages 12 absorbency readings per sample

Measurement Modes

- Absorbency only
- Absorbency/Concentration simultaneously
- Concentration/Calculation: calculates concentration, extender volume, and number of doses to be produced
- Complies with ISO 9000 standards: a complete self-test and calibration when the unit is turned on. These results can be printed on the optional printer
- The use of an optional automatic dilutor allows an absolute repeatability of the volumes drawn and released during the sampling



Counting Chambers

USA029 Unopette® System 1:200 Dilution

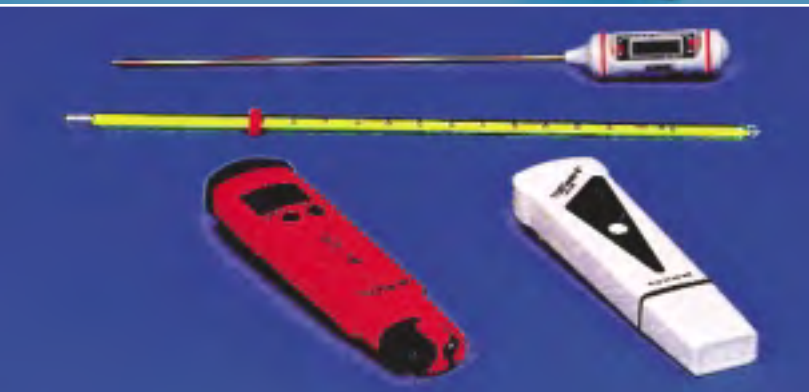
005786 Thoma Cell Chamber

USA090 Neubauer Double Ruling Bright Line

USA705 Hand Tally Counter



PROCESSING



Digital Balances ■ Stirrers ■ Hot Plates

- USA011** Balance, 0 to 2000g Tare 1g Precision
- USA012** Balance, 0 to 5000g Tare 2g Precision
- USA015** AC Adapter for USA011 & USA012
- USA057** Balance 200g, 0.01g Precision
- USA034** Balance 600g, 0.1g Precision
- USA058** Balance 6000g, 1g Precision
- USA123** Balance - 10 Kg, Elevated Display, 0.5g Precision
- USA067** Teflon Coated Spoon 7"
- USA053** Scoop for Bulk Extender
- USA059** Small Weighing Dishes Disposable
- USA060** Large Weighing Dishes
- USA024** Stirrer/Hot Plate - 7" x 7" Surface Size
- USA062** Stirrer Only - 7" x 7"
- USA025** Magnet

Water Bath

- USA014** Water Bath - 19.5 Liter, Stainless Steel with Cover, Temperature Control, High Temperature Limit
- USA122** Water Bath - 80 Liter, Stainless Steel, Integrated Heater, Circulating Pump, Digital Display

Water Quality Testing

- USA063** Pocket pH Meter, with Integrated Digital Thermometer, Waterproof
- USA064** pH 7.0 Solution - 500ml
- USA073** TDS Tester

Glassware

- | | |
|------------------------------|--------------------------------|
| XA022 Erlenmeyer, 1L | USA102 Beaker, 4000ml |
| XB183 Erlenmeyer, 2L | XB620 Highbeaker, 250cc |
| USA055 Erlenmeyer, 4L | XB174 Highbeaker, 400cc |
| XA027 Beaker, 1000ml | XA028 Cylinder, 500ml |
| XB175 Beaker, 2000ml | |

Plasticware

- USA051** Beaker with Handle, 1000ml
- USA036** Pitcher with Handle, 3 Liter
- USA103** Pitcher with Handle, 5 Liter
- USA107** Pooling Container, 10 Liter
- USA052** Wash Bottle
- USA053** Scoop - 65ml for Bulk Extender
- USA054** Parafilm 4" x 125'
- USA067** Teflon Spoon 7"
- USA003** 3 Liter Bag 9" x 18"
- ZS711** 4 Liter Bag 11"x15", Used w/USA036, Pitcher 3 Liter
- ZS714** 5 to 8 Liter Bag 14" x 16 1/2", Used with USA103, Pitcher 5 Liter
- USA107** 10 Liter Bag 20" x 16", Used with USA106 Pooling Container



Cleaning Supplies

- USA070** Alconox Lab Detergent 4 lbs.
- USA128** Isopropyl Alcohol 4L

STERILE LIQUID EXTENDERS

SafeCell™ Plus

New fast dissolving concentrated liquid extender medium for the preservation of swine semen.

New Super Long Term Extender



016181

100ml makes 1 Liter

016182

500ml makes 5 Liters

016182

1000ml makes 10 Liters

We already know the advantages that a super long term preservation extender may bring to various operations: some will benefit from reducing the number of semen shipments per week, others will choose to run specific laboratory tests on samples of the doses to be shipped, and boar studs may get to take the weekend off from producing doses while feeling comfortable that the Monday inseminations at the farms will be just as good as any others during the week.

So, What Makes SafeCell™ Plus Stand Apart From Others?

SafeCell™ Plus is the First Liquid Concentrated Extender

SafeCell Plus is the first **concentrated liquid** semen extender made commercially available in the American swine industry. Having a liquid product has many advantages, one of them being that it easily dissolves in water, an attribute not readily present with powder extenders, especially those formulated for long term and super long term preservation. A homogeneous solution is achieved rapidly and pH equilibration with SafeCell Plus takes considerably less time than with common powder form extenders.

SafeCell™ Plus Second to None in Hygiene

Another “Plus” for SafeCell Plus is that it is the only **sterile** extender available. The media is sterilized by micro-filtration, a process that is only possible with a liquid product. No powder extender today on the market can guarantee the sterility of its final product. Take your **biosecurity** to a higher level!

SafeCell™ Plus Designed with a Specific Blend of Antibiotics

Today, most commercially available extenders present the same base of antibiotics. SafeCell™ Plus is unique in its antibiotic formulation. The **new antibiotic** composition of SafeCell™ Plus is not toxic to the sperm cells and controls the bacterial flora with more efficacy.

SafeCell™ Plus Storage

SafeCell Plus is a **10x concentrated** liquid extender and can be stored in temperatures ranging from +2°C to +22°C. Expiration date: 1 year.

SafeCell™ Plus Production

IMV Technologies has its own biological product production laboratory for IVF (In Vitro Fertilization), ART (Assisted Reproduction Techniques) and ET (Embryo Transfer) media as well as for extenders used in the preservation on fresh and deep-frozen semen. Our media lab is certified **ISO 9002**, is designed to meet the strict quality assurance standards in the manufacture of reproduction media.



POWDER EXTENDERS



X-CELL®

**Semen Preservation
up to 7 days**

Today's choice of the 21st century. Over 7 million doses are produced yearly with X-Cell in North America. The swine industry has been shifting to longer term products such as X-Cell.

X-CELLERATE YOUR PROFITS!

- **X-CELL** increases the storage time of boar semen without any significant loss of fecundity up to 6 days*.
* Theriogenology 52 ; 365-376
- **X-CELL** decreases the distance constraints associated with delivery of the doses from the boar stud.
- **X-CELL** maximizes the management of boars with high quality semen doses.

IMV International Offers a Complete Line of Semen Extenders for all of Your Preservation Needs.

All IMV powder extenders are manufactured in the USA in an ISO 9002, FDA approved facility. All processes are documented and controlled from the quality of the analytical grade ingredients to the packaging and identification of the finished product. Traceability of the product includes individual lot numbers and expiration dates on each labeled product. This guarantees proper handling, storage, and "first in – first out" inventory management.

Each extender lot is tested by the manufacturer for biochemical characteristics and by an independent third party using fresh boar semen *in vitro* for pertinent semen quality traits to its maximum storage capacity. Samples of each lot are retained for quality assurance and certificates of all performed tests are kept on file.

BTS Formula

Short Term
Up to 3 Days
Powder
Gentamycin
ZA8541 1 Liter
ZA859 100 Liter

V.S.P. Formula

Mid-Term
Up to 4 Days
Powder
Gentamycin
USA801 1 Liter
USA899 100 Liter

Vital® Formula

Long Term
Up to 5 Days
Powder
Gentamycin
ZS991 1 Liter
ZS997 100 Liter

X-Cell® Formula

Long Term
Up to 7 Days
Powder
Gentamycin
USA851 1 Liter
USA859 100 Liter

EXTENDER VATS

USA900

Dilution Vat – 100 Liter

All stainless steel construction. Double walled with a water chamber Mixer. Mechanical Stirrer, LCD Temperature display, Integrated Timer (On/Off), Drain Valve, Dip Stick. 220 volts – 3,800 watts

USA870

Dilution Vat – 30 Liter

All stainless steel construction. Double walled with a water chamber Mixer. Mechanical Stirrer, LCD Temperature display, Integrated Timer (On/Off), Drain Valve, Dip Stick. 110 volts

USA886

Liner for 100 Liter Vat

USA871

Liner for 30 Liter Vat

USA069

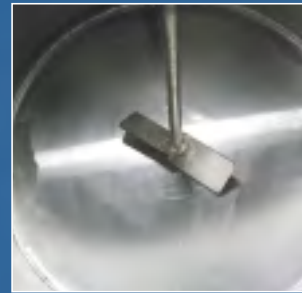
Programmable Pump - 3.5 Liters per Minute - 25 feet Tubing

USA104

Peristaltic Pump - 2.3 Liters per Minute - 25 feet Tubing

USA127

Double Head Pump 4,600ml per Minute - 25 feet Tubing



PACKAGING



As the practice of artificial insemination has increased in the swine industry, the Cochette® bag has become the number one packaging method for swine semen worldwide. Today, over half of the doses produced in the USA are processed in the Cochette bag, which was introduced in 1994. While other packaging methods have been around for over 30 years, the Cochette bag revolutionized the AI industry and remains the most effective way of genetic transfer today.

Advantages of the Cochette® Bag

- Designed to synchronize with the sow's own natural physiological uterine contractions, rather than a forced intake
- Increases the semen dose shelf life due to the excellent surface to volume ratio which reduces sperm cell degradation
- Unique combination of two medical grade plastic layers which are sperm-friendly
- Designed to be easily processed, labeled, transported and stored
- More doses can be packed in shipping containers and stored on farm, reducing costs
- Aseptically manufactured bag (ISO 9002 standards)
- Economically packaged in rolls of 1,000 or 500 resulting in reduced shipping and storage costs
- User friendly "peelable" opening that is easily attached to the Goldenpig® and most catheters.



The Cochette® Bag continues to be the number one packaging system in the world. Two new bags, the Goldenbag™ and Cold Seal Cochette® Bag have joined the Cochette® Bag family.

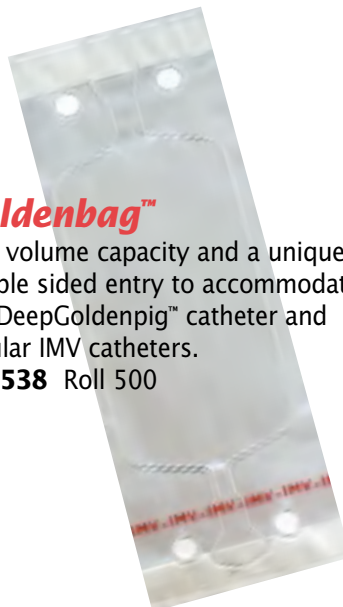
Cochette® Bag

The semen packaging system that took swine AI into the 21st Century
008603 Roll 1000
007402 Roll 500



Goldenbag™

Low volume capacity and a unique double sided entry to accommodate the DeepGoldenpig™ catheter and regular IMV catheters.
016538 Roll 500



Cold Seal Cochette® Bag

The advantages of the Cochette® Bag without the need for a heat sealing machine. Self sealing adhesive strip.
016539 Pkg. 200



MANUAL PACKAGING SYSTEMS

016739 Cold Seal Cochette® Machine

One of our newest products is the Cold Seal Cochette Bag. This innovative product features the same advantages as the Cochette® Bag but does not require heat for sealing. Operations using AI bottles for packaging can exploit the advantages of preserving sperm in the world-renowned Cochette bag without investing in a heat-sealing machine. Filling is done through an opening on one end of the bag. A peel-off strip reveals adhesive to close the bag after filling. The bag peels open at the other end as our Cochette bag. There is no need for cutters or scissors to open this semen package. Tap into the advantages of the Cochette bag, no matter what size operation you manage! The Cold Seal Cochette Bag is conveniently packaged in re-sealable bags of 200 units. A convenient stand for the filling of the cold seal bag is also available.



USA075 Mini Cochette System

Challenger One - Single Cochette Bag Filler w/Impulse Sealer

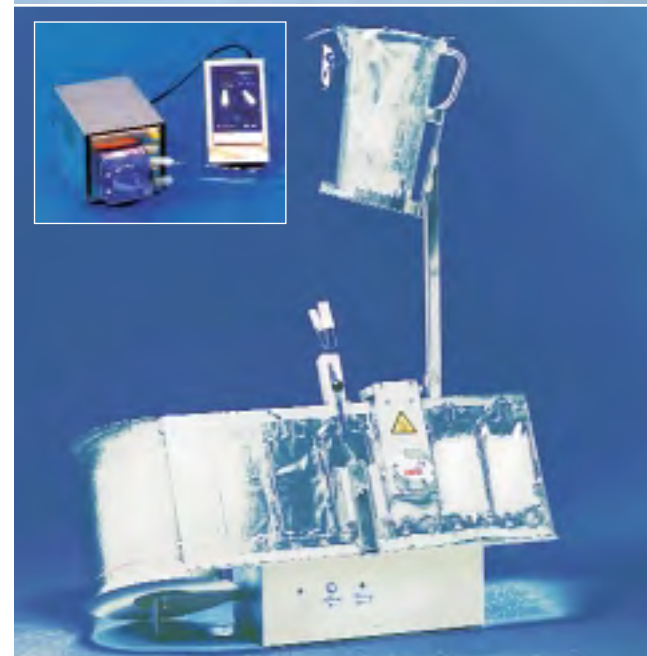


010176 Manual Cochette Machine

Simple and reasonably priced, the Manual Cochette Machine fills and seals the Cochette bag. The Cochette bags move one by one in front of the filling and sealing station. The bag filling operation uses a disposable needle and tube siphoning from the extended semen. The semen flow is manually controlled with a clamp. A proximity switch automatically seals the previous bag while the operator is filling the next bag. The new and improved system is equipped with a ^ shaped seal for the new peelable cochette bag.

This efficient system permits the boar stud to package the semen doses with a single work station, reducing the amount of semen handling. The unit is made primarily of stainless steel for ease of cleaning. The practical output is about 200 units per hour depending on both the operator and laboratory procedures. An optional peristaltic pump and timer increases the output of the machine and assures better volume accuracy.

- | | |
|--|--|
| 007402 Peelable cochette bag | ZS714 5 to 8 Liter bag 14"x16 1/2" |
| 007730 Sinkers | USA026 Peristaltic pump with timer and foot pedal |
| 005133 Accordion bottle | USA027 Silicone tubing autoclavable |
| ZS412 Flow clamp | USA036 Pitcher, 3 liter |
| 006447 Filling tube w/blue needle | USA103 Pitcher, 5 liter |
| ZS711 4 Liter bag 11" x 15" | |



AUTOMATIC PACKAGING SYSTEM

010330 Automatic Cochette System

This compact machine sets the standard in Computer Controlled Filling Systems.

- It automatically fills, seals and labels the Cochette bags. Sophisticated in design, the unit is simple and user-friendly.
- A computer software program combined with a Programmable Logic Controller (PLC) monitors the proper running of the system.
- Several safety mechanisms are built-in to automatically stop the system in the event of an abnormal cycle.
- The potential output is 700 doses per hour, depending on lab procedures and the operator. One person is capable of not only running the machine, but also to perform other tasks while the Cochette bags are being processed.



**NEW
ITEM!**



017441 Semen Agitator

It has been proven that settling of sperm cells occur in the extended volume, resulting in difference in concentration between doses being packaged. This difference is exacerbated as the volume of final diluted ejaculate (or pooled ejaculates) increases. This agitation system designed by IMV will continuously stir the diluted ejaculate while being packaged. Months of testing at our research stations determined the type and shape of the stirring paddle and the speed at which it has to operate so that no damage to the suspended sperm cells occurs.

ARTIFICIAL INSEMINATION

For Years the Goldenpig® has been Considered the Quality Standard in Disposable AI Catheters



Goldenpig®

More than 35 million inseminations are performed worldwide using the Goldenpig catheter!
006957 (ZS778)

XL Goldenpig™

Longer than the conventional Goldenpig. Great for hands-free AI.
016735

Goldengilt™

For gilts, we offer a smaller diameter, tapered and longer sponge tip.
016624

Deep Goldenpig®

Intrauterine insemination of low dose concentration doses is possible.
016311

The Number One AI Catheter, with Over 35 Million Inseminations Performed per year Worldwide.

The specific shape, texture of its foam and dimensional characteristics (internal and external diameters) make the Goldenpig the ideal catheter for the genital tract of the sow or gilt. It is easy to insert, no need to screw as with traditional spiral type catheters.

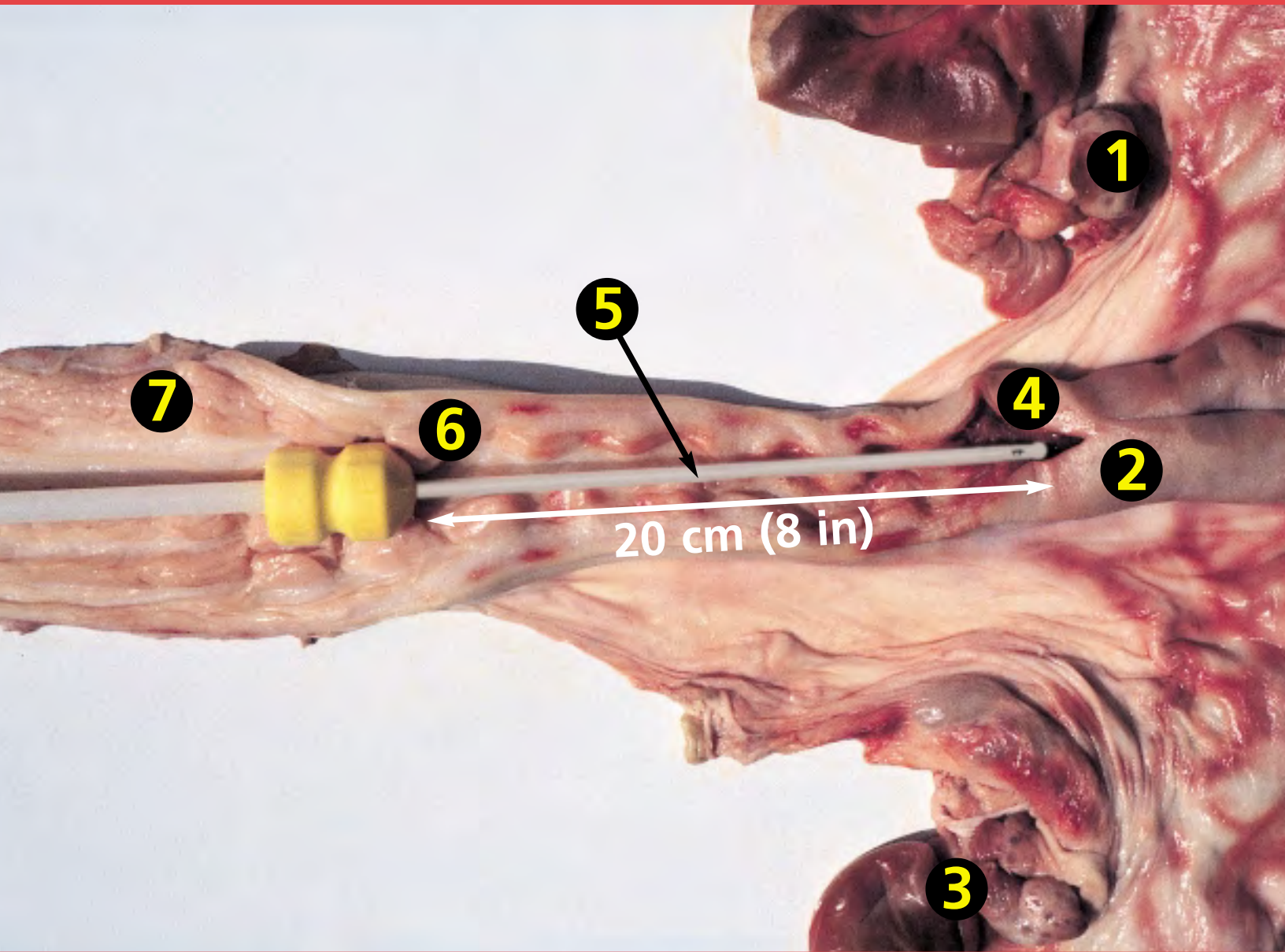
Easy to use, it decreases semen backflow without inhibiting the uterine contractions. The size of the tip makes it too large to penetrate the bladder area.

The yellow color is a registered trademark of IMV International Corp.

USPTO Reg. No. 2,222,162



INTRAUTERINE INSEMINATION



DeepGoldenpig™

Take your AI doses farther...

Reduce sperm concentration to 1 billion cells per dose with this tested combination. Over 3,000 sows tested in field trial.

- 1 Ovaries**
- 2 Uterine horns**
- 3 Follicles**
- 4 Uterus** (site of semen deposition)
- 5 DeepGoldenpig**
- 6 Cervix**
- 7 Vagina**



The use of the DeepGoldenpig™ for intrauterine insemination does not replace semen quality, good heat detection, AI timing, boar stimulation of the female during AI, good animal husbandry practices or good breeding sow management. In summary, all other details pertaining to good AI practices still need to be observed for the success of the intrauterine insemination technique.

Watson, P.F., *et al.*, Intrauterine Insemination of sows with reduced sperm numbers: results of a commercially based field trial. *Theriogenology* 57 (2002) 1683-1693.

AI ACCESSORIES

Both 3.6 cu.ft. size units hold about 200 bottles, tubes, or 300 Cochettes. The Semen Saver is supplied in 110 volts for increased reliability.

The temperature controller is a separate unit preset at 17°C and can be changed. The controller has a high quality thermostat for precise regulation ± 1 degree. The unit is installed with a probe to simulate product temperature rather than air temperature. A fan ensures an even air temperature distribution.



ZS409 Semen Saver - Cool. Cools only. For use in an environment above 17°C (62°F)

ZS509 Semen Saver - Heat & Cool. Cools and heats.

USA111 Junior Semen Saver An economical unit for storing semen doses.

- Portable
- Temperature accuracy to ± 1 degree
- Celsius or Fahrenheit readout
- Digital readout
- 12V-DC with 110v adapter
- One year warranty

The A.I. Challenge Video

ZZ001 This video is a comprehensive overview of the current A.I. procedure and will be a valuable reference for years to come for anyone who is currently or intends to do artificial insemination. All the latest in equipment and technology is shown.

The following subjects are covered:

- Boar Anatomy and Physiology
- Boar Collection
- Semen Processing
- Sow Anatomy and Physiology
- Heat Detection and Insemination

Available in English and Spanish



XB640 Priority Care



Reproductive Management of Pigs, Guides and Problem Solving" CD.

USA135 Authored by eight renowned researchers and practitioners from four countries authored and sponsored by IMV. Here are the tools to help you increase overall reproductive output and decrease the variability of reproductive efficiency. The CD includes a problem-solving area where solutions to known, short-term problems can be found. If the problem has still not been identified, a guide to identifying problems is included. The CD's goal is to help managers solve long-term problems, and train breeding area personnel in sow, gilt or boar



IMV Saddle

The IMV saddle stimulates uterine contractions of the sow to naturally absorb the dose and limit backflow of semen. Light, solid and easy to maintain, the AI saddle is made of a semi-rigid stainless steel. The saddle simulates the grasping of the front legs of the boar. The Cochette Bag suspends from the metallic bar. The sow, through her uterine contractions, does the AI herself under visual control of the technician who simultaneously is preparing other sows to breed.

016174 Sow Saddle

016606 Gilt Saddle



PREGNANCY DETECTION



Agroscan



IMV brings you the latest technology in real time ultrasound! The Agroscan is a very light (3.3 lb), autonomous ultrasound that features a long lasting built in lithium-battery. The unit is water tight and completely sealed, keeping dust and humidity out of the internal electronics, an advantage over similar units on the market today that contain exhaust fans. With a high resolution, low-glare, 5.2 inch flat screen, the Agroscan offers unbeatable 256 gray tones, and image quality. The Agroscan features a dual frequency 3.5/5.0 MHz sector probe that constantly updates the wide 90d image on the screen. The easy to navigate keyboard is water proof and allows the user to change depth, gain, frequency and brightness. An added feature of the Agroscan Model A16 includes a freeze button, automatic back fat measurement, lineal and surface area calculations.

The two available models are the Agroscan Model A8, for pregnancy detection only **USA168**, and the Agroscan A16, for pregnancy detection and back fat measurements with image freeze button, **USA160**.



ADVANCED SEMEN ANALYSIS

IVOS Swine A.I. System

All of the components needed to quickly and easily assess sperm concentration, motility and morphology are integrated into one workstation.

- Automated heated stage for maintenance of sample at 37° C
- Stage “jog” buttons for easy positioning of sample
- Internal optical system featuring strobe illumination to produce superior sperm imaging
- Connections for electronic scale and barcode reader to make data input a breeze
- High speed Pentium computer running Windows® NT with the power to analyze sperm in just seconds
- Ability to network to other laboratory computers.



FACSCount® BD™ Sperm Counting System

Incorporating fluorescent staining and flow cytometry, the FACSCount® BD™ Sperm Counting System is the newest addition to the IMV product line! Evaluation of stained cells with flow cytometry is a highly accurate technique to determine total concentration of viable cells in a sample. This technique can also be very useful for estimating the viability of frozen-thawed semen. Flow cytometry has proven to be more efficient than microscopy to determine viable cells for its speed and accuracy.^a This system uses two of the most effective DNA stains available, propidium iodide (PI) and SYBR-14, to quantify live (green), dead (red) and dying cells (which absorb both stains) in a sample. Check out our web site for more info: www.imvusa.com.

a - Maxwell, et.al., Evaluation of Morphology and Function of Frozen-Thawed Boar Spermatozoa in Vitro, Proceedings of the IVth International Conference on Boar Semen Preservation, 1999.

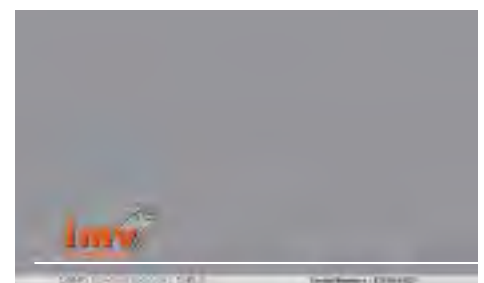
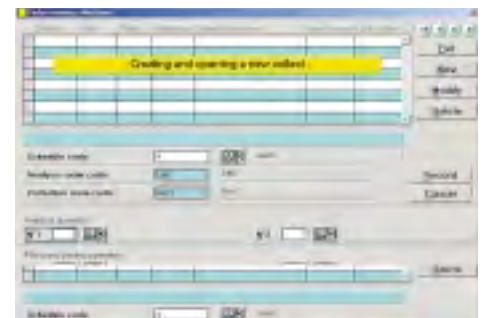


SMILE MANAGEMENT SOFTWARE

SMILE: Software for the Management of the Integrated Laboratory Environment

For years, SMILE has been used in many bull studs around the world. In 2002, we are proud to announce the launch of the swine version of SMILE, a software for the management of semen processing which also allows for surveillance and data recording of all the steps of the ejaculate's processing, including laboratory analysis, dilution, packaging and post-packaging controls. Windows-based, the proposed or user-definable procedures also permits the integration and simultaneous interface of other software and equipment (photometer, balance etc.) used by the semen production unit. This greatly enhances traceability, productivity and the overall efficiency of the laboratory staff. With IDEA, the electronic boar identification system, SMILE allows a secure semen identification.

Since the ejaculate's analysis is input into the software, SMILE becomes also a powerful database that can at any time display one or several boars' production history in order for the laboratory to make decisions based on facts. SMILE is set-up to allow for both single ejaculates (genetic selection) and/or pools for commercial boar studs.



FROZEN SEMEN SYSTEMS



016415
MRS-1 Straw Filler Sealer

MRS 1 Medium Straw Filler-Sealer

016415 MRS 1 Machine, 3,600 Straws/Hour, Ultrasonic Seal & Vacuum Pump

005569 Clear PVC 0.5cc Straws

005565 Clear PVC 0.25 Straws

007215 PACE CBS Filler-Sealer

IML CBS Pre-Printed White Straws

Other colors available

016296 SYMS Manual Straw Filler

ZS993 Washing Buffer

002278 Boarciphos Freezing Extender

I.M.V. Programmable Freezer

007261 Microdigitcool - Includes Freezer & 120l Nitrogen Tank, 240 Straws 0.5ml

15397 Software for PC Use, Piloting, Freezing Curves & Individual Runs

007119 Freezing Rack, 40 Medium Straws

007215
PACE CBS Straw Sealer



016296
SYMS Manual Straw Filler



007261
Microdigitcool



007214
Vacuum Pump for
SYMS Manual Straw Filler

Since 1990, IMV has been refining its swine freezing program in order to make both the logistics and the results comparable with fresh semen. If this goal is getting close, today, the implementation of an in-house contingency freezing program becomes a must due to newer, more resilient viruses that can incapacitate production for months. Also, since many countries do not allow the import of fresh semen or the health requirements make it too long to clear customs, frozen semen is the only way to securely send genetics overseas. From over 15 straws of 0.5 ml volume per dose in the early 90's to 5 to 6 straws of 0.25 ml, IMV has tremendously refined its process. Today also, the biocompatible, human-used CBS™ straw has yielded great results with a single straw of 1 ml using the DeepGoldenpig™ with 2 billion cell per straw. The new technique involves a single straw followed by a "chaser" of extender. For more information on our program, please contact us at 800-342-5468.

REPRODUCTION TECHNOLOGIES



IMV International Corporation

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1-800-342-5468

Telephone: 763-488-1881 ■ **Fax:** 763-488-1888

E-mail: contact@imvusa.com ■ www.IMVUSA.com

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Spreadsheet

[Click here](#) to be taken to
Experiment Size Calculator