

The Real Impact of Boars in Breeding Programs

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■ Introduction

Unquestionably, the boar has been an essential component in the success of swine production systems. This importance is independent of his role as provider of sperm for production of new offspring. What is under review in this article is the importance of the boar as it relates to his use in stimulating and eliciting the estrous response in females and his possible effect on the physiological systems of the female to improve reproductive processes. So why is it important to evaluate the role of the boar? Part of the reason for this is that modern pig production systems can now be described as having between 500 to 1000 sows, with housing almost entirely in crates, almost completely dependent upon artificial insemination, and with the availability of limited labour.

Current production standards recommend that AI procedures should include providing boar exposure before, during and even after AI to improve the uptake, transport, and retention of semen. However, there is limited evidence to support a benefit and justification for the labour and time associated with this procedure. Yet if providing boar exposure does have some positive impact on the efficiency of AI, perhaps ways to improve delivery of essential boar factors should be developed. Perhaps the best reason to re-evaluate the importance of the boar is that most new reproductive technologies being used such as IUI, DUI, frozen semen, long-term extended semen, and AI using only 2.5 billion sperm, rely on reduced numbers of fertile sperm. Therefore, methods which improve sperm transport or and longevity in the tract should be evaluated. If on the other hand, the boar is not needed, then procedures for breeding in the absence of the boar should be considered.

There is clear evidence that external boar stimuli can impact puberty, detection of estrous, and return to estrous in weaned sows. What is not so evident is whether there is a physiological effect of the external boar stimuli that impacts

fertility. Internal boar stimuli, from the act of natural mating, to components of seminal fluids have been shown to influence physiology within the female. The effects of these internal boar components have been reviewed elsewhere (Soede et al., 1993; Waberski et al., 1997) and this article describes the known external effects of the boar, independent of his contribution of semen and seminal components, on measures of female reproduction.

■ Physiological Effects of the Boar

There are instances where measurable physiological responses follow introduction of the boar to female swine. In prepubertal gilts, Kingsbury and Rawlings (1993) reported that boar introduction increased the frequency of LH pulses within a 6-hour period. Interestingly, this effect was only evident in gilts that would eventually express estrous by 200 days of age but not in those that did not. Similarly, in anestrous sows, van de Wiel and Booman (1993) observed that LH pulses became evident within 6 h following boar introduction, but this was not associated with estrous. Others have shown that within minutes of gilt exposure to a boar, cortisol (Pearce and Hughes, 1987b) and Prolactin (Prunier et al., 1987) increases are observed. However, there is no evidence to link the hormone responses to any fertility measure.

It is not entirely clear what boar factors may be influencing to the responses in the female, but pheromonal signals are likely candidates. Pheromones have been classified as either priming or signaling. Signaling pheromones are related to immediate changes in female behaviour and physiology as a result of "odors" produced by the boar. On the other hand, priming pheromones are those that are thought to have less immediate impact, such as age at puberty. In the pig, pheromones appear to influence the female through the olfactory (smell) system. The 16-androstene steroids, 3 α -androstanol and 5 α -androstene, the "musky smelling" compounds of the boar, are thought to be the leading candidates, since they facilitate the standing response in estrous females when aerosolized. These steroid compounds are produced in the greatest quantity by the testes of the boar and are then concentrated in the submaxillary glands (reviewed by Booth, 1982). Removal of these glands reduces the ability of the boar to induce the mating stance in females but yet the isolated androgens themselves have had only mixed results for inducing standing in females (reviewed by Pearce and Hughes, 1987a). Less than optimal results from isolated steroids when compared to the boar himself, has led to the hypothesis that the primer and signaling pheromones may originate from both the salivary gland, the urine, and the skin, and may be complexed with yet other stimuli, such as the sound, sight, and physical sensations from the boar, which act in unison to elicit the female response.

The circumstances and reliability with which the boar himself can induce physiological responses in the females appears highly variable. In prepubertal gilts exposed to boars at 135 days of age, LH increased transiently but was not associated with estrous until ~170 days of age (Kingsbury and Rawlings, 1993). Similarly, van de Wiel and Booman (1993) observed an LH surge but did not observe estrous any time soon after the occurrence. Yet is logical to assume that these subtle hormonal changes may have some impact on reproduction. For example, the role of LH in stimulating follicular development, steroidogenesis, and ovulation is well established. If the boar does increase LH release, then it is likely that an increase in ovarian activity and estrogen will result. It is also possible that any increase in LH could reduce variation in the time of ovulation and also improve the ovulatory response. There is also new evidence to show that LH binds in the uterus and to uterine myometrium, which has lead to speculation involving its role in controlling contractile function. Similarly, the reports of Prolactin increase resulting from boar exposure could also be associated with enhanced luteotrophic activity in pigs, while the observed increases in oxytocin resulting from boar exposure could impact uterine contractility through prostaglandin release or could even have some impact at the level of the ovary of the pig.

■ Puberty

For puberty induction, it has been reported that physical contact is advantageous when compared to fence-line exposure (Pearce and Paterson, 1992). However, this point remains unclear since when comparing signaling or priming pheromone effects since fence-line exposure has been shown to induce an immediate rise in cortisol but not physical boar exposure. Part of this response may involve the age of the boar since immature boars (<8 months) have fewer cells that synthesize pheromones when compared to older boars, and androgens do not accumulate until about 1 year of age (reviewed by Hughes et al. 1990). This would clearly explain why immature boars are less effective for reducing age at puberty and inducing estrous.

■ Effect of Boar Exposure on Weaned Sows

Wean to service intervals (Pearce and Pearce, 1992) can be impacted by boar exposure and even exposure to estrous sows. It was suggested that this effect is most likely due to pheromonal cues and also to some of the physical behaviors of the estrous sow as she interacts with other females. The ability of either the boar or sow to induce estrous was dependent upon both parity and season. This would suggest that some cases of lowered fertility could be alleviated by boar exposure but exposure should be controlled since excessive

exposure results in shorted estrous (Hemsworth and Hansen, 1990) and lower detection rates.

■ Detection of Estrous

Signoret (1970) reported that there are certain aspects of boar exposure that are essential for eliciting the estrous response in females. By applying back-pressure alone in the absence of the boar, approximately 48% of females will exhibit the standing response, and the proportion of sows standing may increase to 60% as estrous progresses toward ovulation. When back-pressure and boar vocalizations are used together, 70% of females are detected standing and when "odor" is used in place of boar vocalizations, 80% are detected in estrous. When all stimuli are applied together with visual stimulation from the boar, 97% of all females in estrous are detected. These data indicate that boar vocalizations, visualization, and odor are critical components for accurate detection of estrous and should be optimized in any direct or fence-line estrous detection regimen.

Determining onset of estrous is essential for ensuring insemination within 24 hours before ovulation. It has been shown (Nissen et al., 1997) that this determines farrowing rate and litter size. To date, the only marker that helps determine the optimal time to inseminate is the onset of estrous. Methods to improve AI results by improved timing have had limited success and breeding success based on predicted estrous duration has not been reported. However, Knox et al. (2002) found no significant advantage with increased detection frequencies, but twice and three time daily estrous detection resulted in 5% higher farrowing rates and litter sizes increasing by >0.5 pig compared to once daily detection. Although this is thought to result from improved AI timing, it is not clear whether increased exposure to boar factors also had some effect.

■ Boar Effects on Successful AI

Soede et al. (2002) reviewed the impact of the boar at mating and suggested that the boar could improve fertility through centralized oxytocin release, which altered uterine contractility. Boar exposure has no impact on time of ovulation (Knox et al., 2002) but does increase the percent of primiparous sows that ovulate by 21%. This is interesting, since boar contact has no effect on follicle growth (Langendijk et al., 2000). Although uncertain, perhaps this could be related to the previously reported effects of the boar for inducing LH release.

Evidence that the boar may impact uterine contractions comes from Langendijk et al. (2003) who showed that the boar increased oxytocin and Mattioli et al. (1986) who showed that androgen spray alone also induced an oxytocin

release. However, it was reported that uterine contractions and increases of oxytocin appeared unrelated, except in cases of low uterine activity. The linking of oxytocin with uterine contractions is important, since it is purported to be related to movement of sperm to the site of fertilization. Sperm transport typically takes between 2-6 hours following AI. During this time, sperm are moved primarily by uterine contractions and not due to their inherent motility. Some sperm move through the tract in minutes during the rapid phase of transport, while the remainder move in the slower phase of transport (hours). The sperm arriving within minutes are not fertile, since capacitation (ability to fertilize an egg) occurs as sperm travel through the uterus during a 2-hour time period. Most of the sperm inseminated are not transported up the uterus but are lost to backflow through the cervix and vagina. An even smaller percentage of the sperm are moved through the uterotubal junction to the oviduct to establish sperm reservoirs. Many sperm not in the reservoirs are engulfed by white blood cells in the uterus within 24 hours following AI. Willenburg et al. (2003a) reported that 50% of the sperm are lost in the backflow over an 8-h period, while at the same time, white blood cells increase from less than 5% to 98% of the total cells in the uterus during this period. Results indicate that when 3 billion sperm cells are deposited intracervically, only ~0.01% of the inseminated sperm remain at 8 hours following AI.

It has been postulated that much of the fertilizing sperm in the reservoirs survive in deep folds of the uterine and oviductal tissue where they are protected from destruction by the white blood cells, and their viability can be maintained for extended periods of time. Steverink et al. (1998) measured semen and sperm loss from backflow following insemination of different semen doses. The average loss was 70% of the volume and 25% of the sperm by 2.5 hours. The authors observed that with low dose insemination, a 5% loss of semen at the time of insemination negatively impacted fertility, but overall backflow had no impact. Willenburg et al. (2003a) showed that exposure to a boar at time of mating did not impact duration of insemination (~3.5 minutes) but did reduce the amount of semen lost at the time of insemination. Despite the differences in leakage at insemination due to movement of the gilts receiving no boar exposure, there was no effect on total volume lost or on total sperm lost and no effect on pregnancy rate (100%) or on total numbers of embryos (11.5). This indicated that lack of boar exposure at mating did not have any detrimental effects on fertility.

To evaluate the impact of the boar, it is important to link the effect of hormones and uterine contractions, to sperm movement or fertility. Since there have been reports of the boar causing release of LH and oxytocin, and these could theoretically be associated with changes in estrogen or prostaglandin, it is important to determine how these might influence sperm movement. Uterine muscle contraction is dependent upon estrogen, prostaglandin, and oxytocin. Estrogens increase the number of oxytocin receptors, alter sensitivity to oxytocin and cause prostaglandin release. Prostaglandin and oxytocin (which

also causes prostaglandin release) are both known muscle contractants. If these hormones are influenced by the boar and do impact fertility, then the addition of these hormones could give a clue as to how they might act. In the review by Willenburg et al. (2003b) there were reports that addition of prostaglandin and oxytocin to sows or semen before AI, improved fertility. The hormones were thought to improve farrowing and litter size through enhanced sperm transport in cases of reduced fertility, such as occurs in summer, parity 1, and with low quality semen. Willenburg et al. (2003b) used a low fertility model and reported that hormone addition did not significantly reduce the total semen volume lost (85%) compared to controls (90%), nor was there any significant effect on sperm lost (38%) compared to controls (54%). There was only a transient increase in the frequency and amplitude of uterine contractions with prostaglandin for a 2-hour period but not for the other treatments. Hormone treatment increased the numbers of sperm in the uterine reservoir (22,000) compared to controls (13,000 sperm) but not in the oviduct. Although there was no effect on pregnancy rate, there was an increase of 1.5 to 3.0 total fetuses in the hormone treated group compared to controls. Collectively these data suggest that hormone addition does have a positive effect on fertility following AI when fertility is compromised, although the mechanism remains unclear. If the boar does in fact have some impact on oxytocin and therefore prostaglandin release, then in cases of lowered fertility, supplying boar exposure at time of mating could prove beneficial. However, in a commercial field test in the summer months, and involving insemination of 240 weaned sows, AI without a boar had no detrimental impact on either farrowing rate (82.5%) or on liveborn pigs (10.3, Knox unpublished) when compared to AI with a boar present.

It would appear that use of boar exposure at time of mating would serve as added insurance against excessive leakage at insemination, and might actually increase LH pulses, Prolactin, and oxytocin release. Under the assumption that any of these factors could improve the low fertility conditions of certain females, supplying boar exposure could serve as insurance. However, there appears to be limited evidence for fertility improvement from providing boar exposure. Therefore, what appears evident is that while providing hormone supplementation can improve cases of low fertility, it also appears that performing AI in the absence of a boar can result in fertility similar to that when mating in the presence of a boar.

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