Reproductive management in pigs: emphasis on the different roles of the boar and on optimal insemination management

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Summary

Boars have different roles in the reproductive management in pigs. Boar contact can stimulate follicle development and thereby induce oestrus, both in gilts and sows. Boar contact during oestrus is essential for good oestrus expression, which is essential for the correct timing of insemination and the proper use of boar contact during insemination can stimulate sperm transport and thereby fertilisation. Stimulation by boars clearly has an olfactory component (the boar smell), but can also have an auditory, visual and evn tactile component. The background of the different roles and some of these different components of the boar are discussed.
To enable a good farrowing rate and litter size, sows should be inseminated between 0 and 24h before ovulation. However, it is not possible to accurately predict the time of ovulation in sows. Although ovulation takes place at a relatively fixed 60-75% of the duration of oestrus, the duration of oestrus varies considerably between sows and between farms, resulting in a variable ovulation time from onset of oestrus. Therefore, most farmers inseminate their sows every day of oestrus to ensure insemination within the optimal period. Since post-ovulation inseminations should be avoided, it is adviced to only inseminate sows while they still show an optimal standing response.

Introduction

Optimal reproductive management in pigs holds many different aspects, including optimal housing (e.g. group size, temperature), optimal feeding (e.g. amount, composition) and optimal management in the different phases of the reproductive cycle (e.g. gilts, mating barn, pregnancy, lactation). In the current paper, only two aspects can be considered, the first one being the roles that boars have in optimal reproductive management (largely based on: Kemp et al., 2005; Langendijk et al., 2005) and secondly, partly related to the boar, aspects to be considered in optimal insemination strategies. Although gilts constitute an important part of the animals on the farm and the proper management of gilts is essential for good reproductive performance during their life time, the current paper focuses on the management of sows.

Role of the boar

<u>In oestrus induction</u>
Older research demonstrated that in weaned sows daily exposure to boars results in shorter weaning to estrus intervals and a higher percentage of sows showing estrus within e.g. 10 or 16 days after weaning (Hemsworth et al., 1982; Walton, 1986 and Pearce and Pearce, 1992). Average weaning to estrus intervals in the control groups in these studies are quite long (more than 10 days) and effects of boar exposure are quite substantial: about 3 (0.4 to 4) days reduction in weaning to estrus interval. More recently, Hughes (1998) failed to find an effect of one to three times daily boar contact after weaning on the rebreeding interval in mostly multiparous sows. However, rebreeding intervals were short in this study (4.9 to 5 days). Langendijk et al. (2000) performed an experiment to validate the effect of boar contact after weaning on weaning to ovulation interval in 94

primiparous sows. Half of the sows received boar contact three times daily from Day 2 after weaning onwards, the other half did not receive any boar contact. Boar contact resulted in an increased number of sows ovulating within 10 days after weaning: 51 vs 30 % ($P<0.05$) for boar contact group and control groups, respectively. This increase was due to an increased percentage of sows ovulating between 6.5 and 9d from weaning.

Collectively, these data suggests that boar stimuli may be particularly important in sows with longer weaning to estrus intervals like e.g. primiparous sows. Boar exposure during the last week of lactation may have an additive effect (Walton, 1986), but increases the risk that lactational estrus occurs. The stimulatory role of the boar on the onset of estrus after weaning can be explained by a stimulatory effect on LH release from the pituitary gland. Van der Wiel and Booman (1993) showed that boar introduction to anestrous sows after weaning resulted in a sustained increase in pulsatile LH release from from three to at least seven hours after boar introduction onwards. The function of this increased pituitary LH release is to stimulate follicle growth, leading to ovulation. It appears, therefore, that sows producing sufficient LH after weaning have sustained follicle growth and therefore a short weaning to estrus interval. In these sows no additional effect of boar stimulation is found. However, a number of the sows that have low LH release after weaning benefit from the triggering of LH release by boar contact, resulting in sustained follicle growth and ovulation. In some sows, LH release can not be triggered sufficiently by boar contact. These sows will remain anestrous.
It is still unclear how much boar contact should be given daily to get the best responses. In gilts it is shown that continuous boar contact may result in habituation to the boar (e.g. Tilbrook and Hemsworth, 1990), resulting in reduced oestrus induction. However, the period in which sows and boars are housed together is usually much shorter in weaned sows and therefore habituation effects may be of limited importance.

<u>In oestrus expression</u>
Oestrus expression is of importance, because it determines the time of insemination (see further). Normally, a sow is defined to be in estrus when she shows a standing response to back pressure (BP). During BP, a technician mimics the tactile stimulation of a boar by pushing the sow in the flanks and rubbing and pressing the sow's back. A standing response is positive when the sow reacts with a frozen stance, arched back and cocked ears. Boar stimuli have substantial effects on estrus expression of sows. Soede et al. (1996) found that of 18% of the sows that had an estrus duration of on average 50h (24-88h) had an 8 or 16h estrus duration (14%) completely failed to show oestrus (4%) with BP in absence of a boar. Although the exact physiological mechanism of how boar stimuli affect expression of estrus is still unknown, especially olfactory and tactile stimuli of the boar are involved (e.g. Signoret, 1970).
Usually boars are brought in front of the sow or sows are taken to the boar pen to allow fence line contact for estrus stimulation and detection. In some systems sows are led into a detection mating area (DMA), which is an area surrounded by 4 to 6 boars in crates designed to maximize boar stimuli during estrus detection Langendijk et al (2000) found that fence line contact with boars during BP resulted in sufficient boar stimuli to maximize the sows' oestrous responses; an oestrus duration of 52±18 in 91% of the sows vs 55±17h in 94% of the sows in the DMA. However, in cases when individual boars used for fence line contact are less effective in inducing estrous behavior, the DMA may compensate for less effective boars.
Sows will only show full expression of estrus at the maximum stimulation level applied to them (Langendijk et al. (2000). At lower levels of boar stimuli the expression of estrus was found to be suppressed. This implies that combination of different estrus detection protocols during estrus detection (e.g. BP in front of boar in the morning and no boar presence in the afternoon) can be sub-optimal for optimal oestrus expression and thus may influence the decision to inseminate the sow.

Further, to maximize expression of estrus it does not seem advisable to house sows adjacent to boars, since data on gilts, but also on sows indicate that the duration of estrus is shorter in sows housed adjacent to boars as compared to daily boar exposure for restricted periods (e.g. Dyck, 1998).

At insemination

After insemination, sperm cells have to be distributed over both horns and to be rapidly transported to the sperm reservoir in the utero-tubal-junction to prohibit their phagocytosis in the uterine lumen. This transport of sperm cells through the uterine horns is believed to be a passive process, driven by uterine contractility. Sows vary considerably in the level of spontaneous uterine activity during oestrus (Langendijk et al., 2002), which may be one of the reason for different fertilization results between sows. A boar can stimulate uterine activity in several ways. During natural mating, oestrogens in the ejaculate of a boar can trigger prostaglandin release by the endometrium and thus increase uterine activity (Claus, 1990). Further, the presence of a boar at artificial insemination induces central oxytocin release in the sow and thereby increases uterine activity during at least 1 hour (Langendijk et al., 2003), but only in sows with a below average uterine activity prior to boar stimulation (see Figure 1; BOAR treatment). Tactile stimulation of the back and flanks of the sow by man during artificial insemination does not cause a release of oxytocin (Langendijk et al., 2003), although it stimulates uterine contractions to some extent (see Figure 1; BP treatment). Effects of boar spray on uterine contractions are similar to that of the BP treatment (see Figure 1); thus, the effect of boar presence on uterine contraction activity is not only caused by olfactory stimulation. It is unclear for how long uterine contractions are increased after boar presence and it is also unclear for how long uterine contractions should be at a high rate for optimal filling of the sperm reservoir. Further, since sows need at least 20 min from the first oxytocin peak to be able to generate a second oxytocin peak (Mathiasen, 2001) it is advised to give sows boar contact from the time of insemination onwards and not before. In practice, this means that the boar should be locked up in front of sows that are being inseminated, preferably out of sight from the sows still to be inseminated.

Several studies have investigated the use of exogenous hormones to stimulate uterine contractions, but variable results have been found. Langendijk et al. (2002) showed that uterine infusion of prostaglandins indeed stimulated uterine contractions, but also increased the duration of infusion and the level of vaginal back flow, and also decreased subsequent fertilisation results. Thus, it seems more safe to appropriately use a boar at the time of insemination to ensure controlled increase in contraction activity.

Boar characteristics

Since the olfactory stimulation plays a major role in the boar effects on oestrus induction, oestrus expression and uterine contractions, it is essential that the boars are mature and sufficiently active and 'smelly'. If a boar looses its active behaviour in front of the sows, he should be replaced to ensure optimal stimulation.

Aspects of optimal insemination strategies

Optimal timing of insemination relative to ovulation

For sperm cells, the minimum time from insemination to fertilisation is determined by the time it takes a sufficient number of capacitated sperm cells to reach the site of fertilization (halfway the oviduct) and the maximum time by the survival of a sufficient number of sperm cells in the sperm reservoir (at the utero-tubal-junction). For oocytes, the minimum time from ovulation to fertilization is determined by the time it takes the oocytes to reach the site of fertilization and the maximum time by the fertile life span of the oocytes. Studies focusing on these individual processes took place in

the 1970's and did not reveal clear answers to the optimal timing of insemination relative to ovulation. In the early 1990's repeated cutaneous and rectal ultrasound were used to study ovulation time in gilts and sows (e.g. Waberski et al., 1994; Soede et al., 1995). From these and subsequent studies, it became clear that insemination should take place between 0 and 24h before ovulation for optimal fertilization results. If older or lower quality semen [e.g. frozen semen] is used, this optimal period shortens and may become as short as 0 to 8h before ovulation. Figure 2 shows effects of the interval between insemination and ovulation on fertilization rate. It clearly shows the high fertilization rates for sows inseminated between 0 and 24h before ovulation. However, even some of the sows that are inseminated more than 40h before ovulation or more than 8h after ovulation can have complete fertilization. Unfortunately, little is known about the causes of this variability in fertilization results between sows that are inseminated at similar moments relative to oestrus.

Timing of ovulation during oestrus

Since farmers do not know ovulation time of their sows, but have to rely on oestrus, it is important to know the timing of ovulation during oestrus. A large number of studies in many countries of the world that have studied the time of ovulation using ultrasound have found similar results; ovulation takes place at on average 60-75% of the oestrous period in the majority of sows, although sows with a short duration of oestrus tend to ovulate more towards the end of oestrus (reviewed by Soede and Kemp, 1997). Thus, if it would be possible to predict the duration of oestrus, it would be possible to predict ovulation and therewith the best period of insemination.

Factors affecting the duration of oestrus

The duration of estrus varies considerably between sows; Weitze et al. (1994) found that the duration of estrus varied between 35 and 96 h (60±15 h). Several studies have searched for factors that influence the duration of oestrus (reviewed by Soede et al., 1997). Although a large part of the variation in duration of oestrus remains unexplained, the following factors play a role: oestrus detection procedure, boar stimulation, housing conditions [stress levels], gilt vs sow [often, gilts have a shorter oestrus than sows, which may be related to different housing or oestrus detection]; and very importantly the weaning-to-oestrus interval [sows with a short WOI have a longer oestrus; this effect was significant on 80% of the 55 farms studied by Steverink et al., 1999]. The latter means that sows with a longer WOI (~6 days) should be inseminated sooner after onset of oestrus. The average duration of estrus also varies between farms; Steverink et al. (1999) found an average duration of 48 h, ranging from 31 to 64 h between the 55 farms; this means that optimal insemination strategies should be tailored for a farm.

Timing of insemination during oestrus

Despite the knowledge of factors that influence the duration of oestrus, ovulation time is still quite unpredictable, which means that most sows are inseminated according to strategies in which the moment of first insemination depends on the weaning to oestrus interval and inseminations are repeated at 12h to 24h intervals.. Based on the 24h period of optimal fertilization results for one insemination (see Figure 2), double inseminations can take place at 24h intervals. Several studies have been performed to study effects of inseminations at either 12h or 24h intervals, but no consistent differences have been reported (e.g. Castagna et al., 2003). However, post-ovulatory inseminations should be avoided, since these may result in (sub-clinical) endometritis, related with the redcued 'possibility' of the uterine clearance (e.g. Rozeboom et al., 1997). Thus, inseminations should only take place as long as sows show a good quality standing response.

Future developments

Opmerking [s1]: Nog een beetje van alles wat…

To deal with the issue of variable ovulation timing and its consequences for double and triple inseminations, pharmaceutical companies are currently evaluating the use of ovulation-inducing drugs (GnRH analogues and LH) in combination with fixed-time AI (e.g. Zak et al., 2009;).
For farmers, it would be of interest to have a semen dosage that would allow optimal fertilization results for a longer period after insemination, preferably 48h instead of 24h, which would allow single inseminations. However, if at all possible, this does not seem feasible in the near future.
In many countries of the world, current AI doses still consist of 3 to 3.5 billion live sperm cell of mixed origin. In the Netherlands, where more than 98% of the 1.2 million sows are artificially inseminated, the average number of sperm cells per dose has decreased to only 1.8 billion total sperm cells per dose, while reproductive performance has remained on a constant high level (Hanneke Feitsma, research coordinator of the Dutch AI centers, oral communication). The current focus of the Dutch AI-centres is on long term storage (up to 7 days) and on early detection of 'low quality' ejaculates. For breeding companies, also further optimizing the fertility of frozen semen is of interest, to facilitate the spread of genetic material over the world.

Opmerking [s2]: Klopt??

In conclusion

Opmerking [s3]: Nodig??

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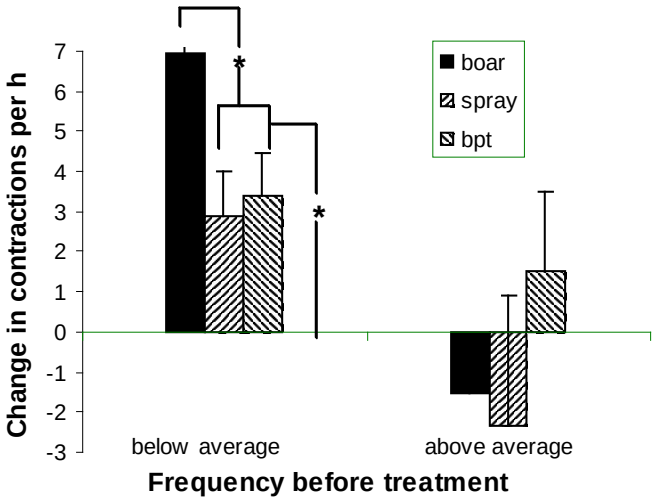

Figure 1 Change in frequency of uterine contractions (mean±SEM) after one of three different stimuli, for sows that had either a below average or above average frequency of contractions before treatment. Average frequency of contractions before treatment was 25/h. The three different stimuli were: 1. BP (n=15); back pressure to the sows; 2. SPRAY (n=12); BP combined with boar pheromone spray; 3. BOAR (n=15); BP in presence of a boar. * $P<0.05$. [from: Langendijk et al., 2003]

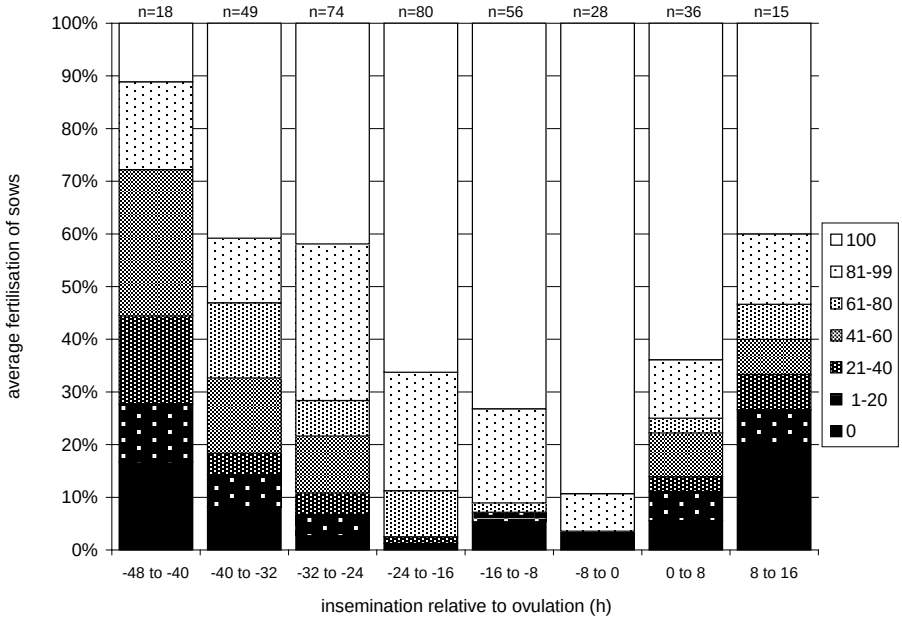

Figure 2 Percentage of sows with variable percentages of fertilization (classes between 0% and 100%) at Day 5 after ovulation depending on the interval between insemination and ovulation (h) for sows that were all inseminated only once. The time of insemination is shown in 8h classes relative to ovulation (n=356). [adapted from: Steverink, 1999]