ELSEVIER

THE TIME OF OVULATION IN RELATION TO ESTRUS DURATION IN GILTS

F.R.C.L. Almeida, S. Novak and G.R.Foxcroft[a]

Department of Agricultural, Food and Nutritional Science
University of Alberta, Edmonton, AB, Canada T6G 2P5

Received for publication: March 30, 1999
Accepted: October 8, 1999

ABSTRACT

The objective of this study was to determine time of ovulation, monitored by transcutaneous ultrasonography, relative to the duration of estrus in gilts. We exposed 92 cyclic gilts, Camborough x Canabrid terminal line, at Day 19 of their third estrous cycle to vasectomized boars every 6 h for the detection estrus. Transcutaneous ultrasonography was performed every 6 h, starting 24 h after the onset estrus, to determine time of ovulation. Estrus duration was, on average, 52.6 h (range: 30 to 72 h), and ovulation occurred between 30 and 60 h after the onset of estrus (mean: 44 h), about 85 % of the way through the estrus period. The time of ovulation during estrus was dependent on the duration of estrus (Time of ovulation = (duration of estrus) x 0.409 + 22.7; r = 0.57, P = 0.0001). Prediction of the time of ovulation in relation to duration of estrus is important for determining the optimal time for inseminating gilts. This knowledge would contribute to an improvement in the fertilization rate and in reproductive efficiency of the breeding herd.

Key words: gilt, ultrasonography, time of ovulation, estrus duration

INTRODUCTION

In pigs, high variation is seen in the duration of estrus and in the time of ovulation after the onset of estrus. This is one of a wide range of factors not related to semen quality, which possibly influences the results of field insemination trials (15). Earlier studies have estimated the time of ovulation using reproductive hormones (4) or data obtained on animals in which ovulation was induced by exogenous drugs (2). Additionally, the time of the LH surge has been used to predict the time of ovulation after onset of estrus in gilts and sows (13). However, these data exhibit great variation between individual animals and breeds. If the time of ovulation within the period of estrus varies considerably, the fertilization rate will be compromised if the number of matings per sow is restricted and related entirely to the onset of estrus (3). Transcutaneous ultrasonography of the ovaries as a noninvasive, stress-free technique may be

Acknowledgements
This research was financially supported by the Alberta Agriculture Research Institute, the Alberta Pork Producers Development Corporation and the Natural Sciences and Engineering Research Council.
[a] To whom correspondence should be addressed: Phone (780) 492-7661; fax (780) 492-9130; e-mail: george.foxcroft@ualberta.ca
F. Almeida was supported with a scholarship from CAPES (Brazil).

0093-691X/00/$–see front matter
PII S0093-691X(00)00281-8

used successfully in pigs to monitor follicular growth and the exact time of ovulation (16, 12). Moreover, this approach allows us to investigate the relationship between the duration of estrus and the time of ovulation. A positive correlation between the duration of estrus and the interval from the onset of estrus to ovulation has been found in sows, i.e., ovulation appears to occur approximately three quarters of the way (72 $\pm$ 15 %) through the estrus period (16, 12).

The objective of this experiment was 1) to determine when ovulation occurred in relation to the onset of estrus and estrus duration in gilts, and 2) to predict the optimal time of insemination in these animals.

MATERIALS AND METHODS

Animals

This study was conducted at the Swine Research Unit of the University of Alberta, in barns with a totally controlled environment, using 92 gilts from the Pig Improvement (Canada) Camborough x Canabrid terminal line. The gilts were in their third estrous cycle.

Estrus Detection and Monitoring of Ovulation

Estrus detection was carried out every 6 h starting on Day 19 of the cycle. Presence of a standing reflex during periods of good fence-line contact with a mature boar ("backpressure" test) was used to define occurrence of estrus. The onset of estrus was determined as the time when the standing reflex was first observed minus 3 h, and the end of estrus as the time when the last standing reflex was observed plus 3 h. In 39 gilts, the end of standing estrus was not observed before the gilts were moved to surgery for laparotomy as part of a second experiment. In these gilts, the end of estrus was estimated as the time that standing estrus was last recorded plus 3 h.

Starting 24 h after the standing reflex was first observed, the ovaries of all gilts were examined by transcutaneous ultrasonography (Pie Medical Scanner 200, model 41480, Can Medical, Kingston, Ontario, Canada), using a 5.0 to 7.5 MHz multiple scan angle transducer for the presence of preovulatory follicles. Each gilt was scanned every 6 h until completion of ovulation. During each scanning, the follicle diameter was recorded. Time of ovulation was defined as the first scanning when no presumptive ovulatory follicles were seen minus 3 h. If fewer follicles were seen than at the time of the previous examination by ultrasonography but some preovulatory size follicles were still present, ovulation was assumed to have just begun. Ovulation was confirmed by a further scan 6 h later.

Statistics

Data were analyzed using the REG procedure of SAS (8) for the linear relationship between time of ovulation and duration of standing estrus. Individual means and standard deviations were determined using the UNIVARIATE procedure of SAS (8).

RESULTS

Using data from all 92 gilts studied, duration of standing estrus in gilts varied from 30 to 72 h, and ovulation occurred between 30 and 60 h after the onset of estrus (Table 1, Figure 1). A significant relationship was established between duration of standing estrus and standing estrus-to-ovulation interval (Figure 1): Time of ovulation = (duration of standing estrus) x 0.409 + 22.7 (r = 0.569, P = 0.0001).

Table 1. Estrus and ovulation in gilts examined by ultrasonographic scanning every 6 hours, beginning 24 hours after a standing reflex was first observed (n= 92)

Parameter	Means ± SD	Range
Estrus duration (hours)	52.58 ± 8.56	30 to 72
Onset of estrus to ovulation interval (hours)	43.93 ± 6.23	30 to 60
Time of ovulation during estrus (%)	85.74 ± 13.85	60 to 138

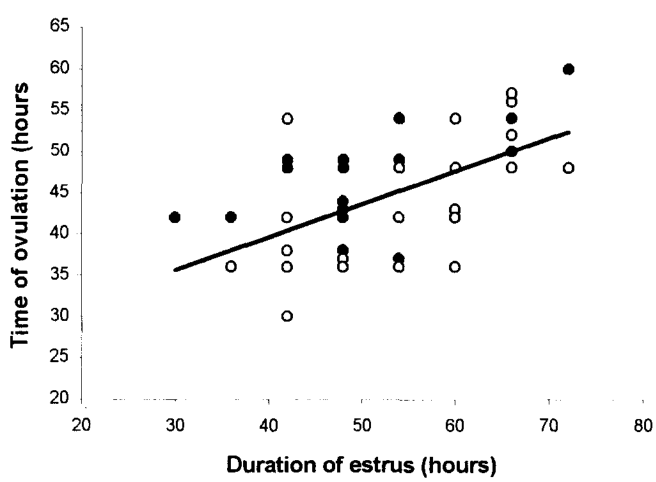

Figure 1. Relationship between standing estrus-to-ovulation interval and duration of standing estrus. Standing estrus-to-ovulation interval and duration of standing estrus are positively and highly correlated (Y = 22.70 + 0.409 x X, r = 0.57, P = 0.0001).
● Represents animals whose duration of standing estrus was known.
○ Represents animals whose duration of standing estrus was underestimated.
Each symbol may represent more than 1 animal.

These relationships were not different when the data set analyzed was restricted to the 53 gilts for which the duration of estrus was unequivocally defined (see Figure 1): Time of ovulation = (duration of standing estrus) x 0.407 + 23.3 (r = 0.563, P = 0.0001), the duration of estrus was 50.76 ± 8.25 h, and the interval from onset of estrus to ovulation was 43.82 ± 5.91 h (means ± SD). Ovulation occurred at about 85 % of the way through the estrus period.

DISCUSSION

High variation is seen in the duration of estrus and in the time of ovulation in pigs. Successful fertilization depends mainly on the time of insemination or mating relative to ovulation (14). If insemination is performed too late, which is possible in pigs since estrus may extend for up to 24 h after ovulation, a deleterious influence upon fertility is observed, including reduced conception, lower incidence of normal fertilization, and increased embryonic loss (6). In addition, although the lifespan of the oocyte in the Fallopian tubes is around 8 to 10 h, oocytes fertilized even at this short duration after ovulation appear less likely to develop into viable embryos. According to Hunter (5), approximately 40 % of embryonic deaths occur by Day 25 of gestation when fertilization takes place some 8 h after ovulation. Therefore, the conditions associated with fertilization of oocytes from gilts mated during or after ovulation are different from those of gilts mated early in estrus. Oocytes of gilts mated after the beginning of ovulation reach the oviduct before capacitation of sperm is completed, and some aging of the oocytes can occur before spermatozoa penetration. Hence, Cárdenas and Pope (1) demonstrated that delaying mating, relative to ovulation, decreased both the size and estradiol secretion of the blastocysts but did not affect their morphological diversity. Variability in the timing of the LH surge and the onset of behavioral estrus (-2 to + 22 h), as demonstrated by Tilton et al. (13), provides a physiological basis for fertilization failures. Delayed preovulatory LH surges associated with insemination early in estrus could result in ovulation up to 25 h after semen deposition into the uterus; in contrast, LH surges preceding the onset of estrus would result in aged oocytes at the site of fertilization.

The time of ovulation during estrus is highly correlated to duration of estrus. In the present study, ovulation occurred at about 85 % of the way through the estrus period. The time of ovulation relative to the estrus period has been described in a number of recent studies on sows, in which ultrasonography was used to determine the time of ovulation (11,10, 9, 12, 16, 7). Soede et al. (12), Weitze et al. (16) and Nissen et al. (7) all reported that ovulation occurred at approximately 70 % of the estrus period. Our findings suggest that gilts ovulate later in the estrus period than sows. Because fertilization results are strongly related to the interval between insemination and ovulation, our data suggest that different breeding strategies should be adopted for sows and gilts. The ability to predict the time of ovulation is a major advantage in determining the optimal time for insemination (7). According to Soede et al. (12), the period between 24 and 0 h before ovulation yields optimal fertilization results in sows, whereas Waberski et al. (15) found the period between 12 to 0 h before ovulation to be optimal for gilts.

In practice, the optimal time for insemination would depend on the frequency and accuracy of detection of estrus. In our present study, gilts were checked for estrus every 6 h, however, if estrus detection is performed less frequently, at 12-h intervals or just once a day, the variation for both the duration of standing estrus and the time of ovulation would be increased (see Figure 2).

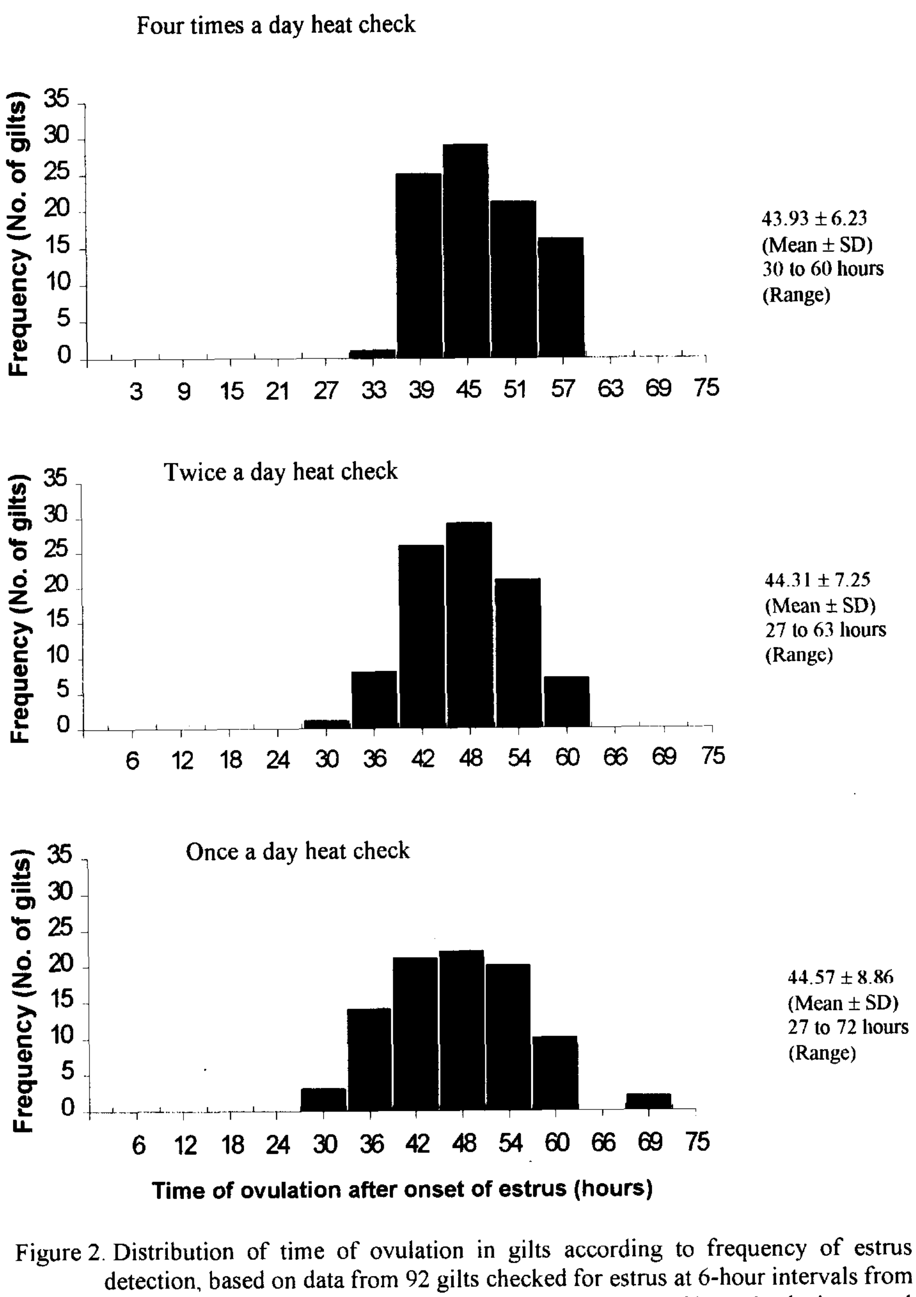

Figure 2. Distribution of time of ovulation in gilts according to frequency of estrus detection, based on data from 92 gilts checked for estrus at 6-hour intervals from Day 19 of the estrous cycle. Reduction in the frequency of heat checks increased the variation in the interval between onset of estrus and time of ovulation.

In turn, the time of onset of estrus would provide a less accurate prediction of when ovulation occurs, as shown in Figure 2 by changes in the distribution curve and the increase in range and standard deviation of the interval from onset of estrus to ovulation. Therefore, the timing of insemination in these cases would differ slightly to improve the fertilization rate. We therefore hypothesize that when estrus detection is performed at 12-h intervals, the first insemination should be done 24 h after the onset of estrus and the second 12 h later. A third insemination could be justified for gilts that remain in estrus 12 h after the second insemination (Figure 3).

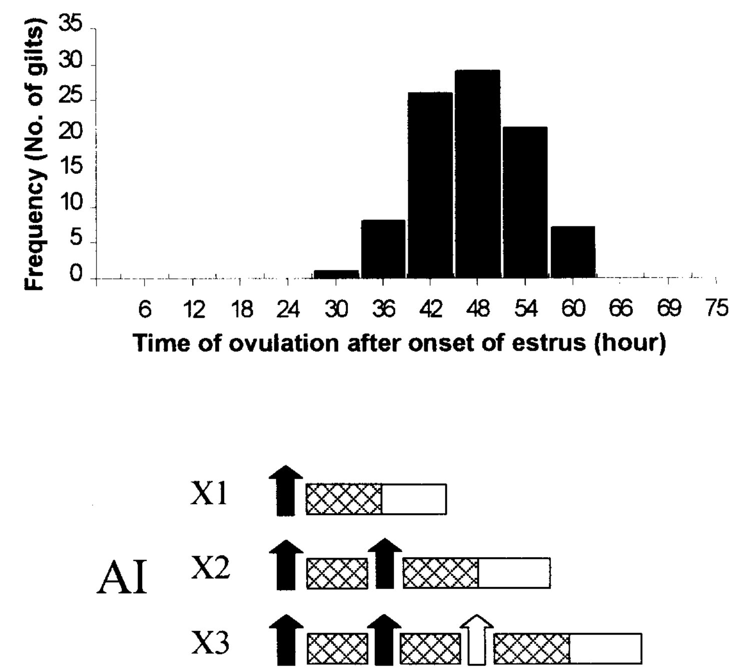

Figure 3. Suggested timing of insemination using estrus detection at 12-hour intervals. Cross-hatched bars on the AI area represent the period over which fresh semen should maintain optimal viability (approximately 12 hours), and the blank bars represent the additional 12-hour period during which semen may continue to maintain acceptable levels of fertilizability. Arrows indicate suggested times for inseminations under different AI protocols. The open arrow represents the timing of a possible third insemination, which may be cost effective in gilts with longer durations of estrus.

Our data also suggest that for gilts with a short estrus duration only a single insemination may be sufficient when detecting estrus once a day. For gilts with a longer duration of estrus, a second insemination could be justified 24 h later.

In conclusion, estrus duration in gilts as well as in sows is variable, whereas the time of ovulation during the estrus period is more constant and strongly correlated with the duration of estrus. By accurately predicting the time of ovulation relative to the onset of estrus, it was possible to suggest the optimal time for insemination of gilts in our study using different frequencies of estrus detection and insemination. Although it is necessary to verify these suggestions with extensive AI trials, the application of the data presented in this study on the timing of ovulation in gilts, offers the opportunity to improve fertilization rate and the reproductive efficiency of the breeding herd.

REFERENCES

1. Cárdenas H, Pope WF. Effect of time of mating relative to ovulation on morphological diversity of swine blastocysts. Biol Reprod 1993; 49:1015-1018.
2. Dziuk P. Estimation of optimum time for insemination of gilts and ewes by double mating at certain times relative to ovulation. J Reprod Fertil 1970; 22:277-282.
3. Foxcroft GR, van de Wiel. Endocrine control of the oestrus cycle. In: Cole DJA, Foxcroft GR (eds), Control of Pig Reproduction. London: Butterworths, 1982;161-177.
4. Helmond F, Aarnink A, Oudenaarden C. Periovulatory hormone profiles in relation to embryonic development and mortality in pigs. In: Sreenan JM, Diskin MG (eds), Embryonic Mortality in Farm Animals. Dordrecht: Martinus Nijhoff, 1986; 119-125.
5. Hunter RHF. The effects of delayed insemination on fertilization and early cleavage in the pig. J Reprod Fertil 1967; 13:133-147.
6. Hunter RHF. Physiological factors influencing ovulation, fertilization, early embryonic development and establishment of pregnancy in pigs. Br Vet J 1977; 133:461-470.
7. Nissen AK, Soede NM, Hyttel P, Schmidt M, D'Hoore L. The influence of time of insemination relative to time of ovulation on farrowing frequency and litter size in sows, as investigated by ultrasonography. Theriogenology 1997; 47:1571-1582.
8. SAS. SAS User's Guide: Statistics (Version 6.06). Cary NC: SAS Institute Inc, 1990.
9. Soede NM, Helmond FA, Kemp B. Periovulatory profiles of oestradiol, LH and progesterone in relation to oestrus and embryo mortality in multiparous sows using transrectal ultrasonography to detect ovulation. J Reprod Fertil 1994; 101:633-641.
10. Soede NM, Kemp B. In synchronized pigs, the duration of ovulation is not affected by insemination and is not a determinant for early embryonic diversity. Theriogenology 1993; 39:1043-1053.
11. Soede NM, Noordhuizen JPTM, Kemp B. The duration of ovulation in pigs, studied by transrectal ultrasonography, is not related to early embryonic diversity. Theriogenology 1992; 38:653-666.
12. Soede NM, Wetzels CCH, Zondag W, de Koning MAI, Kemp B. Effects of time of insemination relative to ovulation, as determined by ultrasonography, on fertilization rate and accessory sperm count in sows. J Reprod Fertil 1995; 104:99-106.

13. Tilton JE, Foxcroft GR, Ziecik AJ, Coombs SL, Williams GL. Time of the preovulatory LH surge in the gilt and sow relative to the onset of behavioral estrus. Theriogenology 1982; 18:227-236.
14. Waberski D, Weitze KF, Gleumes T, Schwarz M, Willmen T, Petzoldt. Effect of time of insemination relative to ovulation on fertility with liquid and frozen boar semen. Theriogenology 1994 ; 42:831-840.
15. Waberski D, Weitze KF, Lietmann C, Lübbert zur Lage W, Bortolozzo FP, Willmen T, Petzoldt R. The initial fertilizing capacity of longterm-stored liquid boar semen following pre- and post-ovulatory insemination. Theriogenology 1994; 41:1367-1377.
16. Weitze KF, Wagner-Rietschel H, Waberski D, Richter L, Krieter J. The onset of heat after weaning, heat duration, and ovulation as major factors in AI timing in sows. Reprod Dom Anim 1994; 29:433-443.