Original article

Farrowing Induction Practices for Periparous Sows and Reproductive Performance in Commercial Swine Herds

Hiroki ICHIKAWA* and Yuzo KOKETSU

School of Agriculture, Meiji University, Kawasaki, Kanagawa, Japan 214-8571

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Summary

The objective of the present study was to compare sow reproductive performance between induced-farrowing (IF) and natural farrowing (NF) sows in 'Early' or 'Late' farrowing herd groups, based on the proportions of IF records of sows in each herd. Nineteen herds were identified in a pig database to be herds commonly practicing IF, and were used in the present study. The individual records in the 19 herds included 18,792 farrowing records of 9,703 sows during 2008. The 19 herds were categorized into two groups by the proportion of IF records (less than 50%, or 50% or higher) with sow gestation length (GL) 116 days or more : 'Early Farrowing' (11 herds) and 'Late Farrowing' (8 herds) herds. Farrowed sows were categorized into two groups : IF or NF sows. Sows in 'Early Farrowing' and 'Late Farrowing' herds were analyzed separately by parity and GL groups to compare reproductive performance between the IF and NF sows. In the 'Early Farrowing' herds, there were no differences in pigs born alive between the IF and NF sows in any parity or GL group. In contrast, in the 'Late Farrowing' herds, the IF sows with GL 114 days in parity 6 or higher had 1.5 fewer pigs born alive than the equivalent NF sows ($P < 0.05$). Also, the IF sows with GL 115 days or more in parity 3 or higher had 0.9 or fewer pigs born alive than the equivalent NF sows ($P < 0.05$). There were no differences in pigs born alive between the IF and NF sows in any GL group in the parity 1 or 2 groups. Additionally, there were no differences between the IF and NF sows in either herd groups for adjusted 21-day litter weight, weaning-to-first mating interval or farrowing percentage in any parity or GL group. In order to improve the number of pigs born alive, such sows delayed farrowing should be carefully monitored, and IF should be practiced for these sows with assisted farrowing.

Keywords : gestation length, induced parturition, reproductive performance, sows

Introduction

Farrowing induction has been used by farrowing barn workers to assist sows with delayed farrowing, or to increase a proportion of daytime farrowing when it is more convenient for workers to supervise farrowing events. Effective supervision of farrowing with prostaglandin $F_{2\alpha}$ or its analogs administration can increase the number of pigs born alive, and reduce the number of stillborn piglets or nonviable piglets⁴⁾. The use and timing of farrowing induction in herds and the sow response to IF timing vary depending on gestation length (GL) of sows or herd schedules for batch-farrowing systems³⁾.

Some previous studies have compared farrowing performance of induced-farrowing (IF) and natural farrowing (NF) sows and found no differences in the number of pigs born alive^{3,12)}. How-

ever, these studies did not consider factors such as prolonged GL¹⁰⁾ and higher parity (i.e. parity 5 or higher)²⁾ that have been shown to be associated with fewer pigs born alive. Furthermore, there is little information about the effect of IF on lactational or post-weaning reproductive performance of sows in commercial herds. Therefore, this study is designed to compare farrowing, lactational or post-weaning reproductive performance between IF and NF sows in early and late farrowing herds by parity and GL groups.

Materials and methods

Database and herd selection

A database has been created and maintained by Meiji University (Meiji University, Kawasaki, Japan) based on data supplied by Japanese swine producers using PigCHAMP recording software (PigCHAMP Inc., Ames, IA, U.S.A.). All the Japanese producers (approximately 130 herds) are requested to mail their data files to Meiji University every time they renew their yearly maintenance contact. In February 2008, this PigCHAMP database comprised 2.1% of the 6,250 breeding herds and approximately

*Corresponding author :

Hiroki ICHIKAWA

Higashi-mita 1-1-1, Tama-ku, Kawasaki, Kanagawa, Japan 214-8571

Phone : +81-44-934-7826 ; Fax : +81-44-934-7902

E-mail : cf00202@meiji.ac.jp

5.6% of the 910,100 females in Japan⁷⁾.

In the present study, data were used from the 19 breeding herds commonly practicing IF, defined as those herds where IF records comprised 1% or more of all parity records. Two datasets were constructed: a mean value dataset for annual herd performance and a sow parity dataset for individual female pigs. Mean herd measurements during 2008 were collected from the selected 19 herds. The female pigs in these herds were mainly crossbreds between Landrace and Large White, either produced within the herds or replacement gilts purchased from breeding companies. The breeding stocks were originally imported from the United States or Europe and have been further improved in Japan.

Individual sow data

Reproductive data of the individual sows, such as pigs born alive, weaning-to-first mating interval and farrowing percentage, were obtained from the 19 selected herds. The overall data comprised 18,827 farrowing records of 9,711 sows during 2008. The records with missing data for GL (14 parity records) and weaning-to-first mating interval (15 parity records) were excluded from the study. Additionally, six records where weaning-to-first mating interval was ≥ 115 days were considered as extreme based on a previous study⁵⁾, and were excluded. This left a total of 18,792 parity records from 9,703 sows.

Definitions and calculations

The GL was defined as the number of days from the date of first mating during the conception service to the date of farrowing completion. The adjusted 21-day litter weight was defined as the weaning litter weight for a sow which was adjusted to 21 days of age, 3 to 6 parities and 10 piglets per litter⁸⁾. Farrowing percentage was defined as the number of farrowed females divided by the number of serviced females.

Sow and herd group categories

Two sow groups and two herd groups were made based on IF records in each parity. Farrowed sows were categorized as either IF or NF sows. The 19 herds were categorized into two groups based on the relative proportions of IF records with GL 116 days or higher: 'Early Farrowing (11 herds)' and 'Late Farrowing (8 herds)' herds. 'Early Farrowing' herds had 50% or less of IF records with GL 116 days or higher, and 'Late Farrowing' herds had more than 50% of IF records with GL 116 days or higher. Within each of these two sets of main groups, five GL groups (GL ≤ 113 , 114, 115, 116 or ≥ 117 days) and four parity groups (Parity 1, 2, 3-5 or ≥ 6) were formed.

Statistical analysis

All statistical analyses were performed using SAS software (SAS Inst. Inc., Cary, NC). Herd measurements were analyzed by one-way ANOVA, and the independent variable was the herd group ('Early Farrowing' and 'Late Farrowing' herds). In sow level analyses, sows in 'Early Farrowing' and 'Late Farrowing' herds were analyzed separately by parity and GL groups.

Two models were constructed to investigate an association be-

tween two sow groups (IF and NF sows) for pigs born alive, weaning-to-first mating interval, adjusted 21-day litter weight and farrowing percentage. The models included lactation length as a covariate when the dependent variable was either 'farrowing percentage,' or 'weaning-to-first mating interval.' For continuous variables, linear mixed-effects models using the MIXED procedure were performed in Model 1. For farrowing percentage (0 or 1), mixed-effects logistic regression models using the GLIMMIX procedure were performed in Model 2. A square root transformation was used on weaning-to-first mating interval to use as a dependent variable⁶⁾.

The Model 1 was :

$$Y_{ijkl} = \mu + \text{GRP}_i + \text{LL}_j + \text{P}_k + \text{H}_l + e_{ijkl}$$

where Y_{ijkl} was the reproductive performance (e.g. pigs born alive); μ is the overall mean; GRP_i was the fixed effect of the i th sow group ($i = \text{IF and NF sows}$); LL_j was a covariate; P_k was the fixed effect of k th period of four-month interval ($k = 1, 2, 3$); H_l was the random effect of l th herd ($l = 1$ to 11, or 12 to 19); and e_{ijkl} was the random error.

The Model 2 was :

$$\text{Logit}(p_{ijkl}) = a + \text{GRP}_i + \text{LL}_j + \text{P}_k + \text{H}_l$$

where p_{ijkl} was probability of a sow farrowing (farrowing percentage); a was the intercept; GRP_i , LL_j , P_k , and H_l were given as above.

Results

The proportions of the IF sows in the 'Early Farrowing' and the 'Late Farrowing' herds were 33.8 and 35.0%, respectively. In the 'Early Farrowing' herds, the proportions of the IF and NF sows with GL 115 days or less were 26.2 and 56.3%, respectively, whereas in the 'Late Farrowing' herds, the proportions were 8.4 and 35.9%, respectively (Figure 1).

Table 1 shows comparisons of annual herd performance between the two herd groups. The 'Early Farrowing' herds had 1.1 days shorter GL than the 'Late Farrowing' herds ($P < 0.05$). There were no differences between the two herd groups for number of pigs born alive per litter, number of pigs weaned per litter, average female inventory and lactation length ($P > 0.05$).

In the 'Early Farrowing' herds, there were no differences in pigs born alive between the IF and NF sows in any parity or GL group ($P > 0.05$; Table 2). In contrast, in the 'Late Farrowing' herds, when GL was 114 days the IF sows in parity 6 or higher had 1.5 fewer pigs born alive than the equivalent NF sows ($P < 0.05$; Table 3). Also, when GL was 115 days or more, the IF sows in parity 3 or higher had 0.9 or fewer pigs born alive than the equivalent NF sows ($P < 0.05$). There were no differences in pigs born alive between the IF and NF sows in any other parity or GL groups ($P > 0.05$). Additionally, no differences between the IF and NF sows were found in any parity or GL group of either herd group for adjusted 21-day litter weight, weaning-to-first mating interval or farrowing percentage ($P > 0.05$).

Fig. 1 Relative frequency (%) of gestation length group by 'Early Farrowing' or 'Late Farrowing' herds. Proportions in each figure add up to 100%. Herds were categorized into two groups by the proportion of IF records (less than 50%, or 50% or higher) with gestation length 116 days or higher : 'Early Farrowing' (11 herds ; n = 8,869 farrowing records) and 'Late Farrowing' (8 herds ; n = 9,923 farrowing records) herds.

Table 1 Comparisons of annual herd performance (Mean $\pm$ SEM) between two herd groups¹

Measurements	Herd groups	
	Early Farrowing	Late Farrowing
Number of herds	11	8
Reproductive performance		
Gestation length, days	114.7 $\pm$ 0.14 ^b	115.8 $\pm$ 0.16 ^a
Number of pigs born alive per litter	11.0 $\pm$ 0.18	10.8 $\pm$ 0.25
Number of pigs weaned per litter	9.9 $\pm$ 0.16	9.8 $\pm$ 0.22
Population and management		
Average female inventory	423 $\pm$ 106	678 $\pm$ 220
Lactation length, days	23.4 $\pm$ 0.64	24.0 $\pm$ 0.92

¹ Herds were categorized into two groups by the proportion of IF records (less than 50%, or 50% or higher) with gestation length 116 days or higher : 'Early Farrowing' and 'Late Farrowing' herds.

^{a-b} Values with different superscripts within a row differ significantly ($P < 0.05$).

Discussion

This is the first report to study the relationship between farrowing induction practice and reproductive performance in Japanese commercial herds. Our study clearly examines that IF practice had no negative association with lactation performance or post-weaning reproductive performance in either the 'Early Farrowing' or 'Late Farrowing' herds.

Using limited numbers of mixed parity sows (111 or 413 sows)^{3,12)}, previous studies showed IF sows had shorter GL and lower piglet birth weights than NF sows, but there was no difference between the IF and NF sows for pigs born alive. However, these previous studies did not examine an association between IF

practices and post-weaning reproductive performance by parity and GL groups. For parity 6 or higher and GL 114 days or higher groups in the 'Late farrowing' herds, our study shows that the IF sows had lower pigs born alive than the NF sows. Farrowing induction in the 'Late Farrowing' herds appeared to be used in order to induce high parity sows that had problems with delayed farrowing. The occurrence of delayed farrowing has been shown to increase at higher parity and this is related to more stillborn piglets¹⁾. Additionally, the IF sows with prolonged GL may have included litters that were farrowed by sows with dystocia. Therefore, earlier timing of IF is recommended for herds practicing 'Late Farrowing' in order to improve the number of pigs born alive.

Table 2 Comparisons of number of pigs born alive (Mean $\pm$ SEM) between two sow groups by gestation length and parity groups in 'Early Farrowing' herds

Parity ³	Sow groups ¹			
	n	Induced-farrowing sows	n	Natural farrowing sows
Gestation length $\leq$ 113 days ²				
1	13	12.3 $\pm$ 0.75	229	10.9 $\pm$ 0.17
2	10	12.8 $\pm$ 0.79	236	11.8 $\pm$ 0.18
3-5	53	11.8 $\pm$ 0.43	531	12.7 $\pm$ 0.11
$\geq$ 6	30	11.8 $\pm$ 0.50	404	11.5 $\pm$ 0.12
Gestation length 114 days				
1	92	10.5 $\pm$ 0.26	250	10.9 $\pm$ 0.15
2	122	11.1 $\pm$ 0.27	232	11.3 $\pm$ 0.18
3-5	323	12.0 $\pm$ 0.16	660	12.2 $\pm$ 0.10
$\geq$ 6	264	12.0 $\pm$ 0.18	490	11.6 $\pm$ 0.11
Gestation length 115 days				
1	223	10.4 $\pm$ 0.19	333	10.6 $\pm$ 0.14
2	221	10.8 $\pm$ 0.21	316	11.4 $\pm$ 0.16
3-5	549	11.9 $\pm$ 0.13	813	11.6 $\pm$ 0.10
$\geq$ 6	430	11.5 $\pm$ 0.14	493	11.4 $\pm$ 0.12
Gestation length 116 days				
1	108	9.7 $\pm$ 0.33	137	10.4 $\pm$ 0.25
2	91	9.8 $\pm$ 0.32	113	10.8 $\pm$ 0.30
3-5	196	11.6 $\pm$ 0.23	213	11.7 $\pm$ 0.19
$\geq$ 6	138	10.4 $\pm$ 0.28	128	11.1 $\pm$ 0.24
Gestation length $\geq$ 117 days				
1	44	9.5 $\pm$ 0.49	74	10.0 $\pm$ 0.34
2	18	9.8 $\pm$ 1.02	54	10.4 $\pm$ 0.42
3-5	51	10.3 $\pm$ 0.50	100	10.7 $\pm$ 0.35
$\geq$ 6	30	9.3 $\pm$ 0.55	57	11.0 $\pm$ 0.41

¹ Two sow groups were formed on the induced-farrowing and natural farrowing sows.

² Five gestation length groups were formed on gestation length $\leq$ 113, 114, 115, 116 and $\geq$ 117 days.

³ Four parity groups were formed on parity 1, 2, 3-5, and $\geq$ 6.

In the 'Early Farrowing' herds, our results showing no association between IF practices and pigs born alive are consistent with the previous studies^{3, 12)}. There were no differences in pigs born alive between the IF and NF sows in any parity or GL group in the 'Early Farrowing' herds. Additionally, the 'Early Farrowing' herds had a high proportion of the IF sows with GL 115 days or lower. Producers of the 'Early Farrowing' herds may have a management practice to induce at a certain GL or they may have identified sows with potential problems with delayed farrowing and made a quick decision to treat these sows.

The lack of any differences in weaning-to-first mating interval

is probably due to the fact that weaning-to-first mating interval is more related to a function of hypothalamus-pituitary-ovary axes²⁾. The IF sows in the 19 herds were induced with prostaglandin F_{2 α} or its analogs. These would have been delivered locally from the uterus to the adjacent ovary, not through the hypothalamus or pituitary and caused luteolysis in late gestation so induced farrowing¹³⁾. Additionally, farrowing percentage appears to be more associated with other management practices, such as that estrus detection and timing of multiple inseminations are related to ovulation^{9, 11)} than farrowing induction practice.

It is recommended that producers still record information about

Table 3 Comparisons of number of pigs born alive (Mean $\pm$ SEM) between two sow groups by gestation length and parity groups in 'Late Farrowing' herds

Parity ³	Sow groups ¹			
	n	Induced-farrowing sows	n	Natural farrowing sows
Gestation length $\leq$ 113 days ²				
1	30	10.3 $\pm$ 0.58	122	11.1 $\pm$ 0.22
2	18	10.9 $\pm$ 0.60	91	11.9 $\pm$ 0.26
3–5	56	12.2 $\pm$ 0.41	309	11.9 $\pm$ 0.18
$\geq$ 6	22	11.9 $\pm$ 0.64	101	11.7 $\pm$ 0.28
Gestation length 114 days				
1	34	10.9 $\pm$ 0.51	234	10.6 $\pm$ 0.17
2	26	10.8 $\pm$ 0.70	208	11.7 $\pm$ 0.19
3–5	80	12.0 $\pm$ 0.37	536	12.2 $\pm$ 0.12
$\geq$ 6	39	10.2 $\pm$ 0.51 ^b	202	11.7 $\pm$ 0.19 ^a
Gestation length 115 days				
1	81	10.1 $\pm$ 0.28	383	10.6 $\pm$ 0.11
2	99	10.8 $\pm$ 0.31	332	11.0 $\pm$ 0.15
3–5	215	11.3 $\pm$ 0.22 ^b	773	12.1 $\pm$ 0.11 ^a
$\geq$ 6	127	10.9 $\pm$ 0.24 ^b	269	11.7 $\pm$ 0.18 ^a
Gestation length 116 days				
1	353	10.3 $\pm$ 0.15	340	10.1 $\pm$ 0.15
2	315	10.5 $\pm$ 0.18	295	11.1 $\pm$ 0.17
3–5	755	11.1 $\pm$ 0.11 ^b	711	11.8 $\pm$ 0.12 ^a
$\geq$ 6	411	10.6 $\pm$ 0.15 ^b	203	11.5 $\pm$ 0.21 ^a
Gestation length $\geq$ 117 days				
1	189	9.1 $\pm$ 0.23	274	9.0 $\pm$ 0.19
2	164	10.2 $\pm$ 0.24	306	10.4 $\pm$ 0.18
3–5	349	10.1 $\pm$ 0.19 ^b	595	11.0 $\pm$ 0.13 ^a
$\geq$ 6	109	9.3 $\pm$ 0.29 ^b	167	10.2 $\pm$ 0.22 ^a

¹ Two sow groups were formed on the induced-farrowing and natural-farrowing sows.

² Five gestation length groups were formed on gestation length $\leq$ 113, 114, 115, 116 and $\geq$ 117 days.

³ Four parity groups were formed on parity 1, 2, 3–5, and $\geq$ 6.

^{a-b} Values with different superscripts within a row differ significantly ($P < 0.05$).

IF or NF, because the NF sow records will enable producers to recognize the natural GL of their herds. Predicting the farrowing date from record of the previous natural GL of sows is useful for producers because the repeatability of GL is high as 50%¹⁰⁾, and such knowledge will help them to determine the induction day for gestation and when to practice farrowing supervision.

In conclusion, in order to improve the number of pigs born alive, such sows delayed farrowing should be carefully monitored, and IF should be practiced for these sows with assisted farrowing.

One of the limitations of this study is that our analyses did not take account of herd health, genetics or aspects of farrowing barn management including farrowing assistance and oxytocin administration. Additionally, the studied herds were not randomly selected; therefore, the findings in this study may not apply to all swine herds in Japan. Even with these limitations, the present study provides veterinarians and producers with useful information of the farrowing management for periparous sows in commercial swine herds.

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References

- 1) Borges, V.F. et al. : Risk factors for stillbirth and foetal mummification in four Brazilian swine herds. *Prev. Vet. Med.*, **70**, 165-176, 2005.
- 2) Dial, G.D. et al. : Reproductive failure: differential diagnosis. In: Leman AD, Straw BE, D'Allaire S, Mengeling WL, Taylor DJ, eds. *Diseases of Swine*. 7th ed. Ames, Iowa: Iowa State University Press, 88-137, 1999.
- 3) Gunvaldsen, R.E. et al. : Effects of farrowing induction on suckling piglet performance. *J. Swine Health Prod.*, **15**, 84-91, 2007.
- 4) Holyoake, P.K. et al. : Reducing pig mortality through supervision during the perinatal period. *J. Anim. Sci.*, **73**, 3543-3551, 1995.
- 5) Hoshino, Y. and Koketsu, Y. : A repeatability assessment of sows mated 4-6 days after weaning in breeding herds. *Anim. Reprod. Sci.*, **108**, 22-28, 2008.
- 6) Kleinbaum, D.G. et al. : Regression diagnostics. Applied regression analysis and other multivariable methods. 2nd ed. Ames, North Carolina : North Carolina University, 220-221, 1988.
- 7) MAFF statistics. Ministry of Agriculture, Forestry and Fishery Statistics in Japan (in Japanese). Available at: <http://www.e-stat.go.jp/SG1/estat/Xlsdl.do?sinfid=000002949008> (Accessed on 13 December 2010).
- 8) National Swine Improvement Federation. Guidelines for Uniform Swine Improvement Program. National Pork Producers Council, Ds Moines.
- 9) Nissen, A. K. et al. : The influence of time of insemination relative to time of ovulation on farrowing frequency and litter size in sows, as investigated by ultrasonography. *Theriogenology*, **47**, 1571-1582, 1997.
- 10) Sasaki, Y. and Koketsu, Y. : Variability and repeatability in gestation length related to litter performance in female pigs on commercial farms. *Theriogenology*, **68**, 123-127, 2007.
- 11) Soede, N. M. et al. : Effects of time of insemination relative to ovulation, as determined by ultrasonography, on fertilization rate and accessory sperm count in sows. *J. Reprod. Fertil.*, **104**, 99-106, 1995.
- 12) Straw, B. et al. : Influence of method of administration of prostaglandin on farrowing and relationship between gestation length and piglet performance. *J. Swine Health Prod.*, **16**, 138-143, 2008.
- 13) Weems, C. W. et al. : Prostaglandins and reproduction in female farm animals. *The Veterinary Journal*, **171**, 206-228, 2006.

原 著

生産農場における妊娠豚への分娩誘発剤の使用とその繁殖成績

市川大樹*・瀬瀬雄三

〒214-8571 神奈川県川崎市多摩区東三田 1-1-1, 明治大学農学部

要旨

本研究の目的は、分娩誘発剤の使用記録を基に農場を2グループに分け、各農場グループで誘発分娩の母豚（IF母豚）と自然分娩の母豚（NF母豚）の繁殖成績を比較することとした。データベースより、19農場を分娩誘発剤を常用している農場として抽出した。生産記録は、2008年における母豚9,703頭の18,792回の分娩記録を含んだ。19農場を妊娠期間（GL）が116日以上であるIF母豚の割合（50%以下または50%より多い）を基に、‘Early Farrowing’農場（11農場）と‘Late Farrowing’農場（8農場）の2グループに分類した。母豚はIF母豚またはNF母豚の2グループに分類した。繁殖成績の比較は、各農場グループ、産次および妊娠期間毎に分析した。‘Early Farrowing’農場において、生存産子数は、全ての産次および妊娠期間でIF母豚とNF母豚間で差がなかった。しかし、‘Late

Farrowing’農場ではGL114日である6産次以上のIF母豚は、NF母豚と比べ生存産子数が1.5頭少なかった（ $P<0.05$ ）。また、GL115日以上であるIF母豚は、3産次以上でNF母豚と比べ生存産子数が0.9頭またはそれよりも少なかった（ $P<0.05$ ）。他の産次および妊娠期間では、生存産子数はIF母豚とNF母豚間で差がなかった。両農場グループにおいて、補正21日齢一腹体重、離乳後初回交配日数、分娩割合は、全ての産次と妊娠期間でIF母豚とNF母豚間で差がなかった。母豚の生存産子数を改善するために、分娩が遅れている母豚は注意深く観察し、介助分娩を伴った分娩誘発が行われるべきである。

キーワード：妊娠期間，分娩誘発，繁殖成績，豚

連絡先：市川大樹*
明治大学農学部農学科
〒214-8571 神奈川県川崎市多摩区東三田 1-1-1
Phone : 81-44-934-7826 ; Fax : 81-44-934-7902
E-mail : cf00202@meiji.ac.jp