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Artificial Insemination with Low-Dose Semen does not affect Swine Reproductive Performances

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ABSTRACT

Pig producers have been shown keen interest of the number of spermatozoa in a semen dose since pig artificial insemination introduce. However, determining the minimal number of spermatozoa need per AI without detrimental effect on overall reproductive performances is not an easy question to answer. To increase the efficiency of semen utilization in pig AI, optimum number of spermatozoa per dose needed to determine. The objective of this study was to determine the reproductive performance and factors that affect on-farm application of low-dose semen insemination in sows. Data were collected from Darby Genetics AI studs from 4th of June to 7th of July, 2012 (n=401). The numbers of parturition were 84, 234 and 83 in sows inseminated with doses of 1.5×10^9, 2.0×10^9 and 2.5×10^9 spermatozoa in 100ml extender, respectively. There were no significant differences on reproductive performances such as gestation period, total born, total born alive, stillbirth and mummy in sows inseminated with different semen doses. The average number of born alive was 10.5, 11.0 and 10.4 from sows inseminated with 1.5×10^9, 2.0×10^9 and 2.5×10^9 sperms, respectively. Also, number of spermatozoa per dose did not affect litter size (p>0.10). There were no significant differences of maternal genetic line difference on gestation period, total number born, number born alive, born dead and mummy. The estimated correlation coefficients of the different semen doses with total number born, number born alive, born dead and mummy were r=−0.00, −0.01, 0.02 and 0.02, respectively. Taken together, the result of this study suggested that when semen was appropriately inseminated after induced ovulation, insemination with low-dose (1.5～2.0×10^9) semen dose not adversely affect sow's fertility.

(Key words : Sperm concentration, Semen dose, Pig reproductive performances, Artificial insemination)

INTRODUCTION

Artificial insemination practice rate is over 90% and 1.8 million doses of semen were used annually in Korean swine industry (Kim *et al*., 2011). Most AI centers provide the semen dose of 3.0×10^9 per insemination to the farm (Kim *et al*., 2011). If semen dose could reduce as much as 50%, AI studs would possibly reduce the boar raising number to half, resulting in reducing the production cost. In previous study from RDA, 1.5×10^9 spermatozoa does not have detrimental effect on sow fertility, but there were some questions regarding management, individual sow used for AI, and other factors. Because artificial insemination applications take a huge part in swine industry worldwide, prior studies have been performed to enhance production efficiency (Diemer *et al*., 2003; Althouse *et al*., 2008), farrowing rate and litter size (Maroto Martí *et al*., 2010) by improving semen quality. Sows and gilts receive 2.4 to 3.0 inseminations (doses) with 3 to 5 billion motile spermatozoa per dose 2.4 times per year. When a single AI occurs within 24 h before ovulation, fertility rates can exceed 91%, making it seem that multiple inseminations are unnecessary and contribute to economic inefficiency in swine reproduction (Johnson *et al*., 2000). Sperm per dose and doses per mating affect the efficiency of semen utilization because a reduction of sperm per

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dose would result in more doses produced per boar and a considerable economic savings (Levis *et al*., 2002). Decreasing the number of doses per mating would mean more available doses for more mating. In both cases, the semen from a boar could be used to service more females.

The number of spermatozoa in a semen dose is important for the fertilization process. On the other hand, AI-centers tend to dilute the ejaculates as much as possible to maximize semen dose production. Variation in the number of spermatozoa in an ejaculate has been described between different pig breeds e.g. Landrace, Duroc and Yorkshire (Kommisrud *et al*., 2002), which is a first factor influencing semen dose production. Not only differences in sperm number but also in sperm volume, ranging from 100 to 300 ml (Kondracki, 2003), influence sperm concentration. Individual variation within a breed is also very important (Johnson *et al*., 2000). Xu *et al*. (1998) demonstrated a difference in litter size of 0.09 to 1.88 piglets when inseminating sows either with 2×10^9 or 3×10^9 spermatozoa. Differences in litter size between both semen doses were largely dependent on individual variations between boars. Another study (Alm *et al*., 2006) using 2×10^9 spermatozoa per dose mentioned not only a smaller litter size but also a lower farrowing rate at lower semen dose. In addition, several studies (Alm *et al*., 2006; Xu *et al*., 1998) described lower fertility results when lower semen doses were used in boars with suboptimal semen quality. Therefore, the objective of this study was to determine the reproductive performance and factors that affect on-farm application of low-dose semen insemination in sows.

MATERIALS & METHODS

Semen Preparation

For this study, semen from Duroc boar proven fertility was used. Semen samples were prepared from the boars in Midwest region of swine AI stud from June 4 ～July 7, 2012 in Korea. Boar semen was extended using Modena and semen was delivered into the farms. Artificial insemination was performed using 2-day old semen (day of semen collection=d1, semen was delivered to the designated farms=d2). Sperm's motility was examined before AI and only over 75% motile sperm were used.

Data Collection and Definition of Terms

Data of reproductive performances was obtained from electronically submitted data from farms. Obtained data were total number of born, total live born (live until 1 wk postpartum), mummy and still birth and natural selection (body weigh below 700 g at birth were selected and discard).

Statistical Analyses

Data were analyzed using the Generalized Linear Model procedure (PROC-GLM) of the Statistical Analysis System (SAS Institute, Cary, NC, USA). Differences among treatment means were determined by using the Duncan's new multiple range tests. A probability of $p<0.05$ was considered statistically significant.

RESULTS

The number of parturition were 84, 234 and 83 in sows inseminated with doses of 1.5×10^9, 2.0×10^9 and 2.5×10^9 spermatozoa in 100 ml extender, respectively. There were no significant differences on reproductive performances such as gestation period, total born, total born alive, stillbirth and mummy in sows inseminated with different semen doses (Table 1, $p>0.05$). The average number of born alive is 10.5, 11.0 and 10.4 from sows inseminated with 1.5×10^9, 2.0×10^9 and 2.5×10^9 sperms, respectively. Also, number of spermatozoa per dose did not affect litter size ($p>0.10$). There were no significant

Table 1. Reproductive performances from sows inseminated with 1.5, 2.0, or 2.5×10^9 spermatozoa

No. of spermatozoa ($\times10^9$/ml)	N	Gestation period	Total born	Mummy	Born dead	Total born live	Natural* selection
1.5	84	114.88±0.16	11.48±0.354	0.36±0.09	0.61±0.11	10.51±0.33	0.33±0.09
2.0	234	114.85±0.10	12.22±0.21	0.55±0.06	0.66±0.07	11.01±0.20	0.48±0.56
2.5	83	115.22±0.16	11.47±0.36	0.42±0.10	0.66±0.11	10.39±0.33	0.45±0.09
F-value		1.99	2.45	1.42	0.08	1.70	0.92
Pr > F		**0.13**	**0.09**	**0.24**	**0.92**	**0.18**	**0.40**

* Body weigh below 700 g at birth were selected and discard.

differences of maternal genetic line difference on gestation length, total number born, number born alive, stillbirth and mummy (Table 2, $p>0.05$). However, LB breed line showed higher abandon rate at birth compared to other breed lines. (data not shown). Total number of born dead was lowest in parity of 1～2 group compared to other parity groups and it was highest in parity of 5～6 group (Table 3, $p>0.05$). The natural se-

Table 2. Reproductive performances from sows of different genetic lines[1]

Genetic* line	N	Gestation period	Total born	Mummy	Born dead	Total born live	Natural[2] selection
LL	196	115.21±0.11	11.74±0.23	0.56±0.06	0.69±0.07	10.49±0.22	0.54±0.06[b]
YY	198	114.64±0.10	12.02±0.23	0.39±0.06	0.59±0.07	11.04±0.22	0.31±0.06[b]
F-value		5.67	0.56	2.20	0.46	1.60	7.64
Pr > F		**0.08**	**0.63**	**0.087**	**0.71**	**0.19**	**0.0001**

[a,b] Means±SE was significantly differ within the same column.
* LL: Landrace×Landrace.
YY: Yorkshire×Yorkshire.
[1] 2.0×10^9 spematozoa were used as a semen dose.
[2] Body weigh below 700 g at birth were selected and discard.

Table 3. Effect of numbers of parity on reproductive performances[1]

Parity	N	Gestation period	Total born	Mummy	Born dead	Total born live	Natural[2] selection
1-2	168	115.13±0.11[ab]	11.83±0.25	0.41±0.07	0.45±0.08[b]	10.98±0.23	0.31±0.07[b]
3-4	159	114.63±0.12[ab]	12.18±0.26	0.47±0.07	0.72±0.08[ab]	10.98±0.24	0.47±0.07[ab]
5-6	49	115.04±0.21[ab]	11.38±0.47	0.61±0.13	0.97±0.14[a]	9.79±0.43	0.69±0.12[a]
< 7	25	115.32±0.29[a]	11.56±0.66	0.72±0.18	0.76±0.19[ab]	10.08±0.61	0.68±0.17[a]
F-value		3.63	0.89	1.32	4.56	2.61	3.46
Pr > F		**0.013**	**0.45**	**0.26**	**0.003**	**0.05**	**0.02**

[a,b] Means±SE was significantly different within the same column.
[1] 2.0×10^9 spematozoa were used as a semen dose.
[2] Body weigh below 700 g at birth were selected and discard.

Table 4. Correlation coefficient of sperm concentration with reproductive performance

	Sperm conc.[1]	Parity	Gestation period	Total born	Mummy	Born dead	Total born alive	Natural[2] selection
Sperm conc.		0.02	0.07	−0.00	0.02	0.02	−0.01	0.04
Parity			−0.03	−0.06	0.07	0.11*	−0.12*	0.14**
Gestation period				−0.17***	0.14**	−0.04	−0.21***	−0.02
Total born					0.28***	0.25***	0.91***	0.34***
Mummy						0.07	−0.01	0.06
Still birth							−0.07	0.05
Total born live								0.32***

*$p<0.05$, **$p<0.01$, ***$p<0.001$.
[1] 1.5×10^9, 2.0×10^9, or 2.5×10^9 spematozoa were used as a semen dose.
[2] Body weigh below 700 g at birth were selected and discard.

lection rate at parturition was higher in groups of over parity of 5 compared to parity of 1～2 group (Table 3, p>0.05). In this study, there was a low correlation coefficient values between number of parity with total number of born dead, number born alive and natural selection (Table 4, r=0.11, −0.12, 0.14, respectively). Total number of born had a medium correlation with number of mummy, born dead and natural selection (Table 4, r=−0.17, 0.14, −0.21, respectively, p>0.001). There was a high correlation between total number of born and total number of born alive (Table 4, r=0.91, p>0.001). The estimated correlation coefficients of the different semen doses with total number born, number born alive, still birth and mummy were r=−0.00, −0.01, 0.02 and 0.02, respectively.

DISCUSSION

Swine AI is widely practiced and is a very useful tool to introduce superior genes into sow herds, with minimal risk for disease transmission. In practice, fresh diluted semen (3 billion spermatozoa in 80-100 ml) is mostly used for intracervical insemination .The success of AI is largely determined by the semen quality and the insemination procedure. Different parameters and techniques can be used to assess semen quality. Although more advanced technologies offer more accurate information, in commercial AI centers, semen quality is assessed based predominantly on concentration, morphology and motility using simple, cheap and practically easy-to-perform techniques. Critical issues for AI involve estrus detection in the sow, timing of insemination and applying strict hygiene measures.

This brings up the interesting question of sperm dose - how many sperm are required to produce the most pregnancies with the most piglets. This is not an easy question to answer, as semen from different boars responds differently, and many other factors (timing of insemination, age of the female, etc) affects the success of the fertilization. In this study, however; weaned sows inseminated with 1.5, 2, or 2.5×10^9 sperm at a variety of times before ovulation had similar pregnancy rates, but Steverink *et al*. (1997) reported that there was a trend to bigger litters with more spermatozoa in a dose. In this study, reproductive performances of sows of different genetic lines (LB, LD, LL, YY) were not affected by different insemination doses but LB line showed significantly higher natural selection rate (data not shown) compared to other breeds. Gestation period was longer in parity of 7 sows compared to parity of 3～4 sows. Total number of born dead was higher in parity of 1～2 compared to other parities. Although AI technician experience differed from farm to farm, summary data of Table 1 of this study suggested that insemination with low-dose ($1.5～2.0\times10^9$) semen with 75 % motile spermatozoa dose not adversely affect sow's fertility. However, one should consider that highly variable results from other investigators may still exist in a commercial farm environment. But we should realize that sow's reproductive performances shows inconsistencies and depend on the factors such as improper semen handling, inadequate sanitation, days of semen preservation and person's AI experience in.

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