Effects of Sperm Number and Semen Type on Sow Reproductive Performance in Subtropical Area

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ABSTRACT : The purpose of this study was to evaluate the effect of lower numbers of sperm (3×10^9) per dose liquid semen and type of semen used in artificial insemination (AI) on sow reproductive performance in subtropical area. Semen was supplied by two commercial AI centers. A total of 671 female pigs from seven farms were inseminated with either 3×10^9 or 5×10^9 sperm per dose. Two types of semen were used: heterospermic semen from two boars of the same breed and homospermic semen from a single boar. After insemination, conception rate, farrowing rate, total litter size, and number of dead piglets were recorded. The analysis of variance indicated that there was no significant effect of interactions between pig farm, type of semen, or number of sperm on any of the traits measured. There were significant differences in conception rate, farrowing rate, and total litter size among pig farms ($p<0.05$). The effect of number of sperm per dose liquid semen (3×10^9 or 5×10^9) was not significant. Sows inseminated with homospermic semen showed significantly higher conception and farrowing rates but significantly lower total litter size ($p<0.05$). In conclusion, the number of sperm per dose liquid semen for AI could be lowered to 3×10^9 without affecting reproductive performance in subtropical areas like Taiwan. *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 1 : 6-9)*

Key Words : Pig, Sperm Number, Semen Type, Artificial Insemination, Reproductive Performance, Subtropical Area

INTRODUCTION

Artificial insemination (AI) plays an important role in pig production. Production of high quality semen efficiently is the major mission of AI centers (Colenbrander and Kemp, 1990). Number of sperm per dose liquid semen can influence the efficiency of semen utilization and fertilization (Im et al., 1995; Langford and Marcus, 1982). Weitze (1990) and Kim et al. (1998) have tested the optimal number of sperm per dose for AI. They concluded that $2.0\text{-}2.5\times10^9$ sperm per dose is the minimal concentration for better reproductive performance. The number of motile sperm per dose of liquid semen currently used in most AI centers is 3×10^9 (Kim et al., 1998; Feitsma et al., 1996; Thibier and Malafosse, 1990; Colenbrander and Grooten, 1990; Johnson, 1990).

Heterospermic insemination has been used to evaluate the difference in fertilizing potential of spermatozoa in vivo (Beatty et al., 1969; Napier, 1961). Some reports indicated that heterospermic insemination could improve fertility (Beatty et al., 1969; Nelson et al., 1975; Revell, 1993). However, the improvement was usually not significant. The application of heterospermic insemination remains to be further elucidated.

In Taiwan, AI has been much more popular among pig producers in recent years. However, the number of sperm per dose liquid semen used for AI is still higher than 5×10^9 (Wu et al., 1972; Cheng, 1973). This makes the cost of per dose liquid semen much higher than in other countries, and lowers the utilizing efficiency of superior boars (Feitsma et al., 1996; Chiang et al., 1997). Whether the number of sperm per dose liquid semen used in AI can be lowered will have a major impact on the reduction of semen production cost, increase the utilization of superior boars, and extend the practice of AI in subtropical Taiwan. The purpose of this study was to evaluate the effects of lower number of sperm (3×10^9) per dose liquid semen and type of semen (homospermic and heterospermic) used in AI on sow reproductive performance in a field trial. The results will be used as reference for AI centers and pig producers in Taiwan.

MATERIALS AND METHODS

Farms involved and experimental animals

There were seven pig farms involved in the present study, three located in southern, two in central, and two in northern Taiwan. The semen used for AI was supplied by two commercial AI centers. The breed of boars included Landrace, Yorkshire and Duroc. A total of 671 female pigs, including gilts and sows, were used for AI. The semen of each boar was assigned to breed both gilt and sow as well as different number of sperm per dose.

Semen collection, quality control and artificial insemination

Semen was collected every 4-5 days or twice a week (Niwa, 1961) by gloved-hand technique

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(Hancock et al., 1959). Sperm-rich fraction of ejaculates was used for further examination.

After the semen was collected, semen samples were subjected to quality control examination by the method of Kuo et al. (1997). The items examined were as follows:

1. Sperm motility:
Fresh semen was dropped onto a warmed (37-38℃) slide and overlaid with a coverslip; the motility was examined under a phase contrast microscope (Niwa, 1961).

2. Percentage of normal and abnormal sperm:
Percentage of normal sperm and abnormal sperm was examined under a phase contrast microscope.

3. Sperm concentration:
The sperm concentration was calculated by Haemacytometer method developed by Herrick and Self (1962).

Only semen with sperm motility higher than 70% and the percentage of sperm with distal plasma droplets less than 15% was used for further insemination (Waberski et al., 1994). The semen was adjusted to either 3×10^9 or 5×10^9 sperm per 80 ml liquid semen by PRIT extender (Kuo and Chiang, 1993). The types of semen used included heterospermic semen prepared by mixing semen from two boars of the same breed and homospermic semen from a single boar. The females were inseminated twice by aliquots of the same semen.

Traits measured

After insemination, the sows and gilts were recorded for the following traits:

1. Conception rate: The percentage of females which did not return to estrus after two estrus cycle observations.

2. Farrowing rate: The percentage of females farrowed.

3. Litter size: Total piglets born in a litter.

4. Number of dead piglets: The number of dead piglets at birth.

Statistical analysis

The effects of pig farm, number of sperm, and type of semen were analyzed by ANOVA. The statistical model was as follows:

$$Y_{ijkl} = \mu + F_i + SN_j + ST_k + (F \times SN)_{ij} + (F \times ST)_{ik} + (SN \times ST)_{jk} + e_{ijkl}$$

where Y_{ijkl}=reproductive traits of the l^{th} individual of the i^{th} farm inseminated with j^{th} sperm number and k^{th} sperm type; μ=overall mean, F_i=the effect of i^{th} farm, I=1, 2,..., 7; SN_j= the effect of j^{th} sperm number treatment, j=1, 2; ST_k=the effect of k^{th} semen type, k=1, 2; $(F \times SN)_{ij}$=the interaction of i^{th} farm by j^{th} sperm number treatment; $(F \times ST)_{ik}$=the interaction of i^{th} farm by k^{th} semen type treatment; $(SN \times ST)_{jk}$= the interaction of j^{th} sperm number by k^{th} semen type treatment; e_{ijkl}= random error.

We adopted the general linear model procedure (PROC GLM) in SAS package for the analysis of the above effects. The differences for main effects were tested by Duncan's Multiple Range test (SAS, 1996). The data are presented as mean ± standard error.

RESULTS

The analysis of variance indicated that there was no significant effect of interactions among pig farm, type of semen, or number of sperm on any of the traits measured. The differences of all main effects were further analyzed.

In none of the seven farms involved in this study was there a significant effect of number of sperm on reproductive performance within farm (p>0.05, data not shown). There were significant differences in conception rate, farrowing rate, and litter size among pig farms (table 1). The difference of number of dead piglets

Table 1. Farm effect on sow reproductive performance

Farm	No. of sows (head)	Conception rate (%)	Farrowing rate (%)	Litter size (head)	No. of dead piglets (head)
A	73	82.2 ± 4.5^{a}	80.8 ± 4.6^{abc}	10.7 ± 0.3^{ab}	0.8 ± 0.2
B	268	74.6 ± 2.7^{a}	69.4 ± 2.8^{bc}	10.2 ± 0.2^{bc}	0.7 ± 0.1
C	96	79.2 ± 4.2^{a}	78.1 ± 4.2^{abc}	9.2 ± 0.3^{c}	—
D	77	89.6 ± 3.5^{b}	85.7 ± 4.0^{ab}	11.7 ± 0.4^{a}	1.0 ± 0.3
E	26	88.5 ± 6.4^{ab}	88.5 ± 6.4^{a}	10.9 ± 0.6^{ab}	1.0 ± 0.2
F	100	87.0 ± 0.4^{a}	84.0 ± 3.7^{abc}	10.3 ± 0.3^{bc}	1.3 ± 0.2
G	31	77.4 ± 7.6^{a}	67.7 ± 8.5^{c}	10.7 ± 0.6^{ab}	1.2 ± 0.3

^{a,b,c} Means in the same column with different superscripts differed significantly (p<0.05).

was not significant among farms. Farms D and E showed better reproductive performance than the other farms.

The effect of number of sperm per dose liquid semen is shown in table 2. The result indicated that there was no significant difference in any reproductive performance between gilts or sows inseminated with 3×10^9 or 5×10^9 sperm ($p>0.05$).

Table 3 shows the effect of types of semen on reproductive performance. There was no significant effect of number of sperm per dose on reproductive performance within each type of semen (data not shown). Gilts or sows inseminated with homospermic semen showed higher conception and farrowing rates ($p<0.05$) than with heterospermic semen. However, the number of dead piglets was higher and litter size was lower in gilts or sows inseminated with homospermic semen than in those inseminated with heterospermic semen ($p<0.05$).

DISCUSSION

The first AI center in Taiwan was established in 1958 (Koh, 1977). Since then the AI technique has been broadly extended to farmers. However, under the influence of AI experts from Japan, the number of sperm per dose followed that used in Japan, that is, above 5×10^9 sperm (Niwa, 1977). The number of sperm per insemination still remains above 5×10^9 sperm (Cheng, 1973; Chiang et al., 1997), higher than that in other temperate countries (Steverink et al., 1997; Weitze, 1990; Colenbrander and Grooen, 1990; Feitsma, 1996; Kim et al., 1998). The present study was designed to evaluate the effect of lower number of sperm (3×10^9) per dose liquid semen used in AI on sow reproductive performance in subtropical areas like Taiwan. The result indicated that reproductive performance was not adversely affected by number of sperm per dose on the same farm. However, there was significant farm effect on reproductive performance (table 1). The differences might result from the variation in the technical level of AI (Paquignon et al., 1980).

Johnson et al. (1988) reported that when sows were inseminated with semen stored for 1 to 3 days, 3×10^9 sperm per dose could give satisfactory reproductive performance. A recent study showed that when inseminated with semen with 85% motile sperm, the number of sperm per dose can be lowered to 1.5×10^9 without affecting reproductive performance (Kim et al., 1998). In this study, we used 70% motile sperm and percentage of normal sperm as criteria of quality control; the reproductive performance of gilts or sows inseminated with 3×10^9 was similar to those inseminated with 5×10^9 (table 2). The results were comparable to those in earlier reports which studied insemination with 5×10^9 sperm (Chiang et al., 1997). The results indicated that even in subtropical area, the number of sperm per dose liquid semen could be lowered to 3×10^9 sperm without affecting reproductive performance. The non-significant effect of interaction between farm and sperm number also suggested that by applying semen quality control, reproductive performance can be maintained with lower sperm number insemination in farms with different levels of AI technique.

Some reports indicated that heterospermic insemination could improve fertility (Beatty et al., 1969; Nelson et al., 1975; Revell, 1993). In cows inseminated with heterospermic semen from 3 bulls, the conception rate was 2.1% higher than for those inseminated with homospermic semen (Revell, 1993), but the difference was not significant. Sows inseminated with heterospermic semen from more than one boar did not significantly improve reproductive performance compared to those inseminated with homospermic semen (Godet et al., 1996). In this study, we found that gilts or sows inseminated with

Table 2. Effect of sperm number on sow reproductive performance

Semen number	No. of sows (head)	Conception rate (%)	Farrowing rate (%)	Litter size (head)	No. of dead piglets (head)
3×10^9	326	81.0 ± 2.2	78.5 ± 2.3	10.5 ± 0.2	1.1 ± 0.1
5×10^9	345	79.7 ± 2.2	74.8 ± 2.3	10.2 ± 0.2	0.8 ± 0.1

Table 3. Effect of semen type on sow reproductive performance

Semen type	No. of sows (head)	Conception rate (%)	Farrowing rate (%)	Litter size (head)	No. of dead piglets (head)
Heterospermic	371	77.4 ± 2.2^b	72.8 ± 2.2^b	10.6 ± 0.2^a	0.8 ± 0.1^b
Homospermic	300	84.0 ± 2.3^a	81.3 ± 2.3^a	10.0 ± 0.2^b	1.2 ± 0.1^a

[a,b,c] Means in the same column with different superscripts differed significantly ($p<0.05$).

homospermic semen showed a significantly higher conception rate and farrowing rate but significantly lower litter size (table 3). The result was inconsistent with that in cows but consistent with that in sows reported by Godet et al. (1996).

In conclusion, based on the application of quality control, the number of sperm per dose liquid semen for AI could be lowered to 3×10^9 without affecting reproductive performance in subtropical areas like Taiwan. The application of this result will be of great help in reducing semen production cost, increasing the utilization of superior boars, and extending the practice of AI in subtropical areas.

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