The Effect of Wet Pad and Forced Ventilation House on the Reproductive Performance of Boar

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ABSTRACT : There were two trials involved in the experiment. Trial 1: the trial was conducted on two Taiwan Sugar Corporation (TSC) pig farms. One was located in the north of Taiwan and the other was located in the south. Both farms had wet pad and forced ventilation (WPFV) and conventional open design (COD) boar and sow houses. There were 12 Duroc boars, age ranging from 12-24 months. Half of them (6 boars) were raised in a WPFV pig house, and the other half were kept in a COD house. Semen was collected at 5-day intervals from May 1st to the end of October. Sixteen sows (2-8 parity) were served by artificial insemination each week from the beginning of May to the end of Oct. These sows were checked for heat from 18 days to 25 days after insemination. Trial 2: there were four MPFV boar houses involved in the test. Two houses were located in the north of Taiwan, and the other two houses were located in the south. The test was conducted from January 2000 to December 2001. The total number of serviced sows by MPFV-housed boars was 35,105 head and for COD-housed boars 103,065 head. The results showed that the total semen volume, density of sperm, total sperm per ejaculate, sperm motility and morphological abnormality were significantly better ($p<0.01$) for boar raised in WPFV house than for COD houses. Average sperm motility in June and July was lower than for the other months. Morphological abnormality was higher during May, June and July. Although the results did not reach a significant level, the average value showed that the total volume of boar semen was higher in the north than for the south. The total semen volume production of boar raised in WPFV was higher than for boars raised in COD house, reaching a significant level only in summer. Boars kept in WPFV house had higher total sperm number than boars kept in COD house, reaching a significant level in spring ($p<0.05$), summer ($p<0.01$), and fall ($p<0.05$) but not in winter ($p>0.05$). Boars raised in WPFV house had significantly higher sperm motility than boars in COD house during spring ($p<0.001$), summer ($p<0.001$), fall ($p<0.01$) and winter ($p<0.05$). The average farrowing rate and piglets born alive were higher for boars in WPFV house than for boars in COD house, but neither reached a significant level ($p>0.05$). The present experiment shows that WPFV house can improve the reproduction performance of boars. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 1 : 96-101)***

Key Words : Boar, Sow, Reproduction, Improvement

INTRODUCTION

Heat stress causing lower reproductive performance in pigs has been reported everywhere of the world (Wallace and Comb, 1962, Florida, USA; Okauchi and Hirakata, 1962, Kyushu, Japan; Corteel et al., 1964, France; Thiboult et al., 1966, France; Minin, 1967, Ukraine, USSR; Steinbach, 1968, 1971, 1972, Nigeria; Mikitas, 1969, Ukraine, USSR; Rasbech, 1971, Denmark; Lawrence et al., 1970, Oklahoma, USA; Omtvedt, 1972, Oklahoma, USA; Cheng and Wung, 1974, Taiwan, ROC; Stone, 1981, Australia; Paterson et al., 1977, Australia; Enne et al., 1979, Italy; Hurtgen and Leman, 1980, Minnesota, USA; Hutgen et al., 1980, Minnesota, USA; Hsia, 1990a, Taiwan, ROC; Borg et al., 1993, Nebraska, USA; Ciereszko et al., 2000, Olsztyn, Poland; Park and Yi, 2002, Daejeon, Korea). This lower reproductive performance was caused by either boars or sows or a combination of both. The following reports showed that lower reproductive performance could be contributed by boars. High environmental temperatures caused lower fertility in boars (Thibault et al., 1966; Wettemann et al., 1978). High environmental temperatures resulted in a decrease in sperm concentration and motility and abnormal sperm within 6-8 weeks. The change usually started after 2 weeks of heat stress (Mazzarri et al., 1968; McNitt and First, 1970; Steinbach, 1972; Christenson et al., 1972; Wettemann et al., 1976; Wettemann et al., 1977; Wettemann et al., 1979; Cameron and Blackshaw, 1980). The most significant change started after 3 weeks of heat stress and might be due to the sperm in epididymides being more resistant to heat stress. Wettemann and Desjardins (1979) reported that heat stress resulted in a decrease in plasma testosterone concentration, which caused suppression in spermatic maturation. McNitt et al. (1972) suggested that evaporative moisture heat loss from the scrotal surface was an important source of heat loss, in spite of the lack of thermal response. Winfield et al. (1981) reported that severe heat stress caused the boar to exhibit less courting behaviour. However, the courting behaviour might not be damaged by moderate heat stress. Steinbach (1972) reported that the number of refused mountings

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increased during the summer. Mazzarri et al. (1968) reported that spermatogenesis was influenced when the testicular temperature increased to 40°C by local heating of the scrotum (3 h, 48°C). The ability to tolerate high environmental temperatures might vary considerably between individual boars (Winfield et al., 1981) and between breeds (McNitt and First, 1970). Heat stress also caused less courting activity in boars (Winfield et al., 1981). Larsson and Einarsson (1984) reported that the highest abnormal sperms of boar were found during the 4th week after exposure to high environmental temperature. Mauget and Boissin (1987) found that plasma testosterone levels were significantly higher in winter than during summer months. Malmgren and Larsson (1984) reported that high environmental temperature caused poor quality of boar semen; consequently, semen used for insemination produced a low rate of fertility. Ninomiya et al. (1988) reported that the number of spermatozoa and spermatids in seminiferous tubules was slightly decreased under heat stress. A progressive decrease in seminiferous tubule diameter and increase in the amount of perituhla connective tissue were also noted in response to heat. Stone (1981) reported that sperm returned to pretreatment values 5 weeks after exposure to high environmental temperature. Trudeau et al. (1988) reported that the blood concentration of 16-ondrostenes was generally comparable to that of testosterone concentration and fluctuated very little with season. In contrast, testosterone concentration varied with season.

However, there have been very few reports showing how to solve the problem. In practice, many farms in Taiwan and Southeast Asian countries have tried to use ventilation of fan and/or sprinkling of water to solve the problem; despite this, little or no improvement in the reproduction performance of boar has been reported. This experiment was designed to find out whether wet pad and forced ventilation (WPFV) cooling system could improve boar reproductive performance or not.

MATERIAL AND METHODS

There were two trials involved in the experiment.

Trial 1 : The trial was conducted on two Taiwan Sugar Corporation (TSC) pig farms. One was located in the north of Taiwan and the other was located in the south of Taiwan. Both farms had WPFV and conventional open design (COD) boar and sow houses. There were 12 Duroc boars, age ranging from 12-24 months, used on each farm. The boars had been selected based on the same size of testicle and good quality of semen (motility above +++ 70%). Half of them (6 boars) were raised in a WPFV pig house and the other half were kept in a COD pig house. Semen was collected at 5-day intervals from May 1st to the end of October. The following semen characteristics were evaluated.

i) Total semen volume: The semen was collected every five days with a 500 cc-scale glass jar. The unit of scale was ml.

ii) Total and density of spermatozoa per ejaculate: Total and density of spermatozoa counting was measured by Bűrker Chamber. Sperm motility was evaluated by a microscope at 100 magnification and given a scoring from highest to lowest score: +++ ++ + −. The present experiment was conducted with a percentage of +++.

iii) Morphological abnormalities: The abnormality rate was evaluated at 5 points by a microscope at 400 magnification. The definition of abnormality was according to the method, which was reported by Cheng and Weng (1974).

Sixteen sows (2-8 parity) were served each week from the beginning of May to the end of Oct. Eight head of sow were artificially inseminated with mixed semen collected from the WPFV boar house. The other eight head of sow were inseminated with semen collected from the COD boar house. The semen was diluted by Kiev extender. Each dose of semen contained about 3 billion sperm in 80 ml. The following measurements would be taken:

Sows were checked for heat from 18 days to 25 days after insemination. The other measurements included farrowing rate and total born alive piglets. Temperature and relative humidity of WPFV and COD boar houses were recorded by automatic recorder.

Trial 2 : There were four WPFV boar houses involved in the test. Two houses were located in the north of Taiwan, and the other two houses in the south. Thirteen pig farms with COD boar houses were involved in the trial. Seven of them were located in the north of Taiwan, and the other 6 were located in the south. The test was conducted from January 2000 to December 2001. The total number of serviced sows by MPFV-housed boars was 35,105 head and by COD-housed boars 103,065 head.

All the measurements were the same as for Trial 1. Data were analyzed by least squares analysis of variance using the GLM procedure of SAS 8.0 (2000). The model included main effects of month, house, location, and their interaction. The test of significant was by Duncan's multiple range test.

RESULTS AND DISCUSSION

Trial 1

These results showed that the total semen volume, density of sperm, total sperm per ejaculate, sperm motility, and morphological abnormality were significantly better ($p<0.01$) for boars raised in WPFV house than COD boar houses (Table 1). Semen character on total semen volume,

Table 1. Effect of WPFV and COD houses on boar semen characteristics (Trial 1)

Item	WPFV	COD	SE	Significance
Semen volume (ml)	261.1	222.1	1.1	***
Sperm density ($\times10^8$/ml)	3.5	3.1	0.009	***
Total sperm (10^8)	915.9	697.1	5.5	***
Sperm motility ($^{+++}$%)	77.6	70.2	0.2	***
Morphological abnormality (%)	9.2	13.1	0.1	***

*** p<0.001.

Table 2. Effect of different regions on boar semen characteristics (Trail 1)

Item	North	South	SE	Significance
Semen volume (ml)	252.8	230.4	1.1	***
Sperm density ($\times10^8$/ml)	3.4	3.2	0.009	***
Total sperm (10^8)	861.8	751.1	5.5	***
Sperm motility ($^{+++}$%)	74	74	0.2	NS
Morphological abnormality (%)	11	11	0.1	NS

*** p<0.001; NS: not significant.

density of sperm, and total sperm per ejaculate were significantly higher (p<0.01) in north than in south but without a significant difference on sperm motility or abnormality (Table 2). Total semen volume, sperm density, and total sperm per ejaculate were higher in September and October than in May, June or August. The lowest month for semen volume production was in July. Average sperm motility of June and July were lower than for the other months. Morphological abnormality was higher during May, June, and July (Table 3).

The results showed that the boars raised in WPFV house had better semen characteristics than those raised in COD house. The max temperature in two houses differed only 3-5°C. This difference should not have caused such a difference in semen characteristics, but the fast wind speed (1 m-1.5 m/sec) could remove both sensible and latent heat production of pigs (Hsia, 2002). This removal could reduce the heat load of the pigs; consequently, these animals' physiology and performance could be kept normal. It was very clear that environmental temperature was highest in June and July. This might be the reason that semen characteristics of boars was worst in these months. Reproduction performance of sows was also higher when kept in WPFV than in COD pig house (Table 4). There was no significant difference between TSC north and south farms on sow's reproduction performance (Table 5). The hottest months had the lowest farrowing rates (Table 6).

Table 4. Effect of WPFV and COD houses on sow reproduction (Trial 1)

Item	WPFV house	COD house	SE	Significance
Mating (%)	90.3	84.5	1.7	*
Farrowing rate (%)	89.3	83.5	1.7	***
Total piglets	8.94	8.59	0.05	***
Born alive	8.68	8.25	0.05	***
Born dead	0.25	0.34	0.03	NS

* p<0.05; *** p<0.001; NS: not significant.

Table 5. Effect of different regions on sow reproduction (Trial 1)

Item	North	South	SE	Significance
Mating (%)	84.6	90.2	1.7	NS
Farrowing rate (%)	84.4	88.4	1.7	NS
Total piglets	8.72	8.82	0.05	*
Born alive	8.42	8.51	0.05	NS
Born dead	0.28	0.30	0.03	NS

* p<0.05; NS: not significant.

Trial 2

Table 7 shows total semen volume of boars kept in north and south. Although the results did not reach a significant level (p>0.05), the average value shows that the total volume for boars was higher in the north than the south. The total semen volume production of boars raised in WPFV was higher than for boars raised in COD house. A significant level was reached only in summer. The average

Table 3. Effect of different months on boar semen characteristics (Trail 1)

Item	May	Jun.	Jul.	Aug.	Sep.	Oct.	SE	Significance
Semen volume (ml)	243.2^{b}	240.5^{b}	224.4^{c}	242.4^{b}	249.8^{a}	249.3^{a}	1.1	***
Sperm density ($\times10^8$/ml)	3.32^{c}	3.24^{d}	3.21^{d}	3.33^{bc}	3.38^{ab}	3.41^{a}	0.009	***
Total sperm (10^8)	812.3^{b}	788.7^{b}	728.1^{c}	811.3^{b}	845.3^{a}	853.1^{a}	5.5	***
Sperm motility ($^{+++}$%)	73.5^{b}	72.1^{c}	72.3^{c}	74.8^{a}	75.3^{a}	75.4^{a}	0.2	***
Morphological abnormality (%)	11.3^{b}	11.9^{a}	11.5^{b}	10.5^{d}	10.8^{cd}	10.9^{c}	0.1	***

Different letters in the same row show significant difference. *** p<0.001.

Table 6. Effect of different months on sow reproduction (Trial 1)

Item	May	Jun.	Jul.	Aug.	Sep.	Oct.	SE	Significance
Conception rate (%)	87.5^{a}	86.9^{a}	87.3^{a}	87.2^{a}	87.4^{a}	87.8^{a}	1.7	NS
Farrowing rate (%)	85.4^{b}	86.9^{b}	85.1^{b}	86.5^{b}	86.9^{b}	87.3^{a}	1.7	***
Total piglets	8.77^{b}	8.68^{b}	8.62^{bc}	8.78^{b}	8.60^{c}	9.89^{a}	0.05	**
Born alive	8.41^{bc}	8.44^{b}	8.38^{cd}	8.42^{cd}	8.41^{d}	8.64^{a}	0.05	**
Born dead	0.30^{abc}	0.24^{c}	0.36^{ab}	0.32^{a}	0.29^{bc}	0.30^{abc}	0.03	*

Different letters in the same row show significant difference.
* p<0.05; ** p<0.01; *** p<0.001; NS: not significant.

Table 7. Effect of different regions on semen characteristics (Trial 2)

Season	North	South	SE	Significance
		Total volume of boar semen		
Spring	212	199	11.6	NS
Summer	204	189	8.7	NS
Autumn	211	193	6.7	**
Winter	214	199	10.0	NS
		Density of boar semen		
Spring	4.20	3.60	0.17	**
Summer	3.55	3.51	0.17	NS
Autumn	4.16	3.82	0.15	NS
Winter	4.25	3.97	0.17	NS
		Total sperm of boar		
Spring	840	763	66.7	NS
Summer	726	674	63.8	NS
Autumn	802	801	44.1	NS
Winter	849	845	63.0	NS
		Boar sperm motility		
Spring	77	75	0.61	**
Summer	75	72	0.72	*
Autumn	77	76	0.83	NS
Winter	79	78	0.70	NS

* p<0.05; ** p<0.01; NS: not significant.

Table 8. Effect of WPFV and COD houses on semen characteristics (Trial 2)

Season	WPFV	COD	SE	Significance
		Total volume of boar semen		
Spring	216	200	11.6	NS
Summer	212	189	8.7	*
Autumn	212	196	6.7	NS
Winter	213	202	10.0	NS
		Density of boar semen		
Spring	4.44	3.74	0.17	*
Summer	3.55	3.51	0.17	NS
Autumn	4.16	3.82	0.15	NS
Winter	4.25	3.97	0.17	NS
		Total sperm of boar		
Spring	950	750	66.7	*
Summer	912	609	63.8	**
Autumn	894	764	44.1	*
Winter	946	807	63.0	NS
		Boar sperm motility		
Spring	78	75	0.61	***
Summer	77	72	0.72	***
Autumn	78	75	0.83	**
Winter	80	78	0.70	*

* p<0.05; ** p<0.01; *** p<0.001; NS: not significant.

Table 9. Effect of different regions on farrowing rate and piglets of sow (Trial 2)

Jan. ~ Dec.	North	South	SE	Significance
Farrowing rate (%)	78.4	77.9	42.5	NS
Piglets born alive	8.27	8.21	0.09	NS

NS: not significant (p>0.05).

Table 10. Effect of WPFV and COD houses on farrowing rate and piglets of sow (Trial 2)

Jan. ~ Dec.	WPFV	COD	SE	Significance
Farrowing rate (%)	78.8	78.0	42.5	NS
Piglets born alive	8.27	8.23	0.09	NS

NS: not significant (p>0.05).

figure for total sperm number was higher in the north than in the south, but there was no significant difference between north and south farms (p>0.05). Boars kept in the WPFV house had a higher total sperm number than boars kept in COD house, reaching a significant level in spring (p<0.05), summer (p<0.01), and fall (p<0.05) but not in winter (p>0.05). Sperm motility was significantly higher in the north than in the south during spring (p<0.01) and summer (p<0.05). Boars raised in the WPFV house had significantly higher sperm motility than for boars in COD house during spring (p<0.001), summer (p<0.001), fall (p<0.01) and winter (p<0.05) (Table 8). The average farrowing rate and total born alive piglets were higher in the north than in the south but did not reach a significant level (p>0.05) (Table 9). The average farrowing rate and piglets born alive were higher for boars in the WPFV house than for boars in the COD house, but neither reached a significant level (p>0.05) (Table 10). The effect of month on farrowing rate and piglets born alive for sows reached a significant level (p<0.05) (Table 11).

Table 12 shows the significant differences between experimental farms (p<0.001). This result might indicate why the reproduction performance of the first trial being small in number of boars and sows could reach a significant level, but not Trial 2 which used a very large number of boars and sows. The result of Trial 2 might have been influenced by management and other factors on individual farms. The results of the present experiment show that wet pad and forced ventilation cooling system can improve boar semen characteristics and sow performance under a heat stress environment.

The effect of high environmental temperature on the performance of growing and finish pigs had different results. The pigs had better performance when pigs fed restricted (Hsia and Lu, 2004). However, the pigs had worse performance when pigs fed *ad lib.* (Hsia and Lu, 1988,1989). The boars in the present experiment were fed restricted and kept in COD house but had lower semen quantity. The COD house temperature was higher than WPFV's. Hsia (1990b) found that boars scrotal size could not enlarge when environmental temperature over 25-27.5°C. The boar scrotum might increase blood circulation to dissipate heat. When boar could not dissipate enough heat out, then the scrotum temperature increased. This might cause lower quality and quantity of semen. The WPFV house not only had lower environment temperature but also had higher speed wind which carried convection and evaporation heat away from scrotum. This might be the reason to improve semen quality and quantity.

Table 11. The effect of pig farms on farrowing rate and piglets of sow

Farm No.	Farrowing rate (%)	Piglets born alive
1	74.5^{def}	8.38^{cd}
2	79.3^{abc}	8.49^{abc}
3	80.2^{ab}	8.67^{a}
4	73.6^{ef}	8.18^{de}
5	76.6^{bcde}	7.57^{f}
6	80.9^{ab}	8.38^{cd}
7	81.9^{a}	8.24^{d}
8	79.0^{abc}	8.02^{e}
9	79.6^{abc}	8.48^{bc}
10	72.8^{ef}	7.59^{f}
11	71.5^{f}	8.63^{ab}
12	76.7^{bcde}	8.33^{cd}
13	75.4^{cdef}	8.30^{cd}
14	78.0^{abcd}	8.38^{cd}
15	78.3^{abcd}	8.06^{e}
16	82.1^{a}	8.30^{cd}
17	82.5^{a}	8.30^{cd}
SE	42.5	0.09
Significance	***	***

Different letters in the same column show significant difference.
*** $p<0.001$.

Table 12. Effect of different months on farrowing rate and piglets of sow

Month	Farrowing rate (%)	Piglets born alive
1	80.3^{ab}	8.43^{a}
2	80.2^{a}	8.35^{ab}
3	81.2^{a}	8.26^{bcd}
4	81.4^{a}	8.17^{cde}
5	75.1^{cd}	8.11^{de}
6	75.7^{cd}	8.17^{cde}
7	72.8^{d}	8.06^{e}
8	74.5^{d}	8.29^{abc}
9	81.7^{a}	8.17^{cde}
10	73.2^{d}	8.24^{bcd}
11	81.5^{a}	8.30^{abc}
12	77.9^{bc}	8.38^{ab}
SE	42.5	0.09
Significance	***	***

Different letters in the same column show significant difference ($p<0.01$).
*** $p<0.001$.

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