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COMPARATIVE PERFORMANCE OF SOWS HOUSED WITH AND WITHOUT EVAPORATIVE COOLING SYSTEM AT TEMPERATURE HUMIDITY INDEX OF 73-83

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ABSTRACT

A study was conducted to assess the effect of evaporative cooling system (ECS) on the performance of sows during summer season and to determine the temperature-humidity index (THI). Ninety one sows were used in the study, 49 sows were housed with ECS throughout gestation (T1) and 42 in conventional housing system all throughout gestation period (T2). The THI in T1 and T2 ranges from 73.31-80.47 and 75.23-82.66 respectively. Results showed that ECS significantly affects the birth weight, back fat thickness at weaning, and weaning to estrous interval of sows but did not have a significant effect on the gestation period, weaning weight, back fat thickness at farrowing, litter size born alive, litter size at weaning, total pigs born, and number of born dead. There was also a 0.75-day difference in the weaning to estrus interval from T1 was also observed. Partial budget analysis revealed that 25, 634.33 per year per house was added to the net profit of the farm due to the reduction in feed and water costs. Therefore the use of evaporative cooling system to counter the negative effects of summer heat stress on the performance of the gestating sows was economically feasible in a commercial swine production enterprise.

Key words: evaporative cooling system, swine, temperature-humidity index

INTRODUCTION

Environmental conditions, such as extreme temperatures, greatly affect the overall performance of livestock. For instance, heat stress brought by high temperature and relative humidity negatively affects the reproductive efficiency of the farm including its production and profitability. Since swine have lower heat tolerance due to their lack of sweat glands (Fuquay, 1981), they have a lower range for thermo neutral zone. For pregnant sows, the range is only 12-20°C (Botto *et al.,* 2014). Alarmingly, the usual temperature during summer in the Philippines (March-June) is 30-35°C, which already falls within their critical temperature zone. When heat stress is experienced, consequences in efficient performance, production, and reproduction, feed conversion, health and welfare of animals can be severe (Lucas *et al.,* 2000).

The increase in the environmental temperature as a result of climate change especially during summer season is inevitable. However, modern types of ventilation systems are available which can be used to counteract the negative effects of heat stress on the production and profitability of a swine production enterprise. The use of evaporative cooling pads in livestock housing can be considered a feasible solution to the problems caused by extreme heat conditions.

Lally (1999) observed superior performance of pigs housed in houses with ECS in terms of daily feed consumption and feed conversion. Kiefer *et al.* (2012) on the other

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hand, was able to observe increased in feed intake, reduced total percent of weight loss, and increased weight of piglets and litters at weaning and improved daily milk production of sows because of air-cooling.

To validate the above claims in a tropical environment, this study aimed to determine the effects of evaporative cooling system (ECS) and thermal humidity index (THI) in the reproductive performance of sows and its economic feasibility for commercial farm in the Philippines.

MATERIALS AND METHODS

The experiment was conducted at an accredited breeder farm in Rizal province from February to June 2014. The breeding period was from January to February 2014, gestation period was from March to May 2014 and the sows farrowed on June 2014 (Figure 1).

There were two treatments for the experiment. Treatment 1 (T1) sows (n=49) were confined in gestating houses with evaporative cooling system (ECS) throughout gestation while Treatment 2 (T2) sows (n=42) were from the conventional housing system or the non-ECS housing. The feeding and other management practices were similar for both treatments.

1. Breeding→→→→→Gestation→→→→→Farrowing and Lactation→→→Weaning
(7d Non-ECS) (107d ECS) (28d ECS) (4-8d Non-ECS)

2. Breeding→→→→→Gestation→→→→→Farrowing and Lactation→→→Weaning
(7d Non-ECS) (107d Non-ECS) (28d ECS) (4-8d Non-ECS)

Figure 1. Diagram of management scheme for treatments 1 and 2.

Two types of gestating houses were used in this experiment, with and without ECS. The main material for both houses was concrete, with galvanized iron sheets for the roof while the stalls were made with steels. The ECS houses were just converted from the conventional houses. Stall dimension for ECS houses is 0.7m x 2.2m, while for non-ECS houses is 2.5m x 1.5m. Ventilation fans are located on one end, opposite the two cooling pads at the left and right corners of ECS houses.

Relative humidity and temperature (RHT) in each house was obtained using Humidity & Temperature Data loggers (Model RHT20) from EXTECH® Instruments (Massachusetts, USA) that were installed in houses with and without evaporative cooling systems. RHT obtained was used to compute for Temperature Humidity Index (THI) using the formula recommended by NOAA (1976), as stated by Botto, *et al*. (2014):

$$THI = 0.8T_a + (RH/100) \times (T_a - 14.3) + 46.4$$

Where:
T_a - ambient temperature (°C)
RH – relative humidity (%)

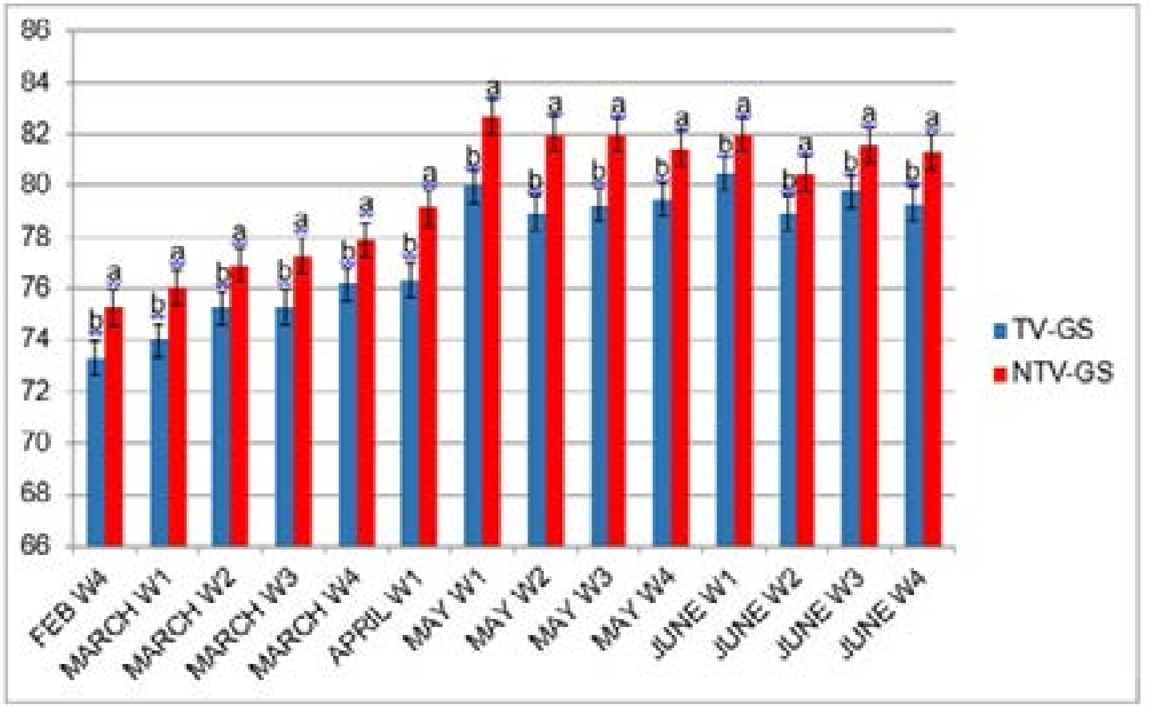
Computed THI was compared for each month in relation with the performance of the sows. A temperature-humidity index is defined as a single value that represents the combined effects of the temperature and humidity in the environment associated with the level of thermal stress (Bohmanova *et al.* 2007).

Litter size born alive (LSBA) and at weaning (LSW) were compared in the study. Factors that influence the said parameters were also considered such as total pigs born (TPB), birth weight (BW), weaning weight (WW), and number of born dead (BD) which includes stillbirth and mummified.

Back fat thickness of sows was measured one week before farrowing (BFTBF) and at weaning (BFTW) to compare the performance of the animals from both treatments. Renco Lean-Meter® Series 12 (Minneapolis, USA) was used to measure back fat thickness of pigs.

The duration of gestation period and weaning to the subsequent estrous interval was measured (in days) in relation to the comparison of the reproductive performances of animals in houses with and without evaporative cooling systems.

All the values were analyzed using PROC GLM of SAS (Cary USA). To satisfy the requirement for ANOVA, some of the values were transformed using square root transformation. The experimental design was Completely Randomized Design (CRD). The values obtained in the measurement were presented in Mean ± SEM and comparison of means between and within different factors was done using Least Significant Difference (LSD).



a,b-superscripts with different labels represent significance
TV: tunnel ventilated (ECS); NTV: non-tunnel ventilated (non-ECS)

Figure 2. Average Temperature-Humidity Index per Week from February to June2014.

RESULTS AND DISCUSSION

Temperature humidity index (THI)

THI during summer season was calculated and evaluated to relate the effects of heat stress on reproductive performance of sows. The summary of the weekly average THI from February 26 to last week of June was presented in Figure 2. However, due to problems encountered with the data logger there were missing data from 2nd to 4th week of April.

The graph shows that the average THI throughout observation was consistently lower in T1 than T2 (P<0.05). The average THI value for T1 is 77.52, 2.15 lower than that of in T2 which has an average value of 79.67. The lowest THI values occurred in week 1, which fell on the last week of February, with values of 73.31 and 75.23, for T1 and T2 respectively. The highest values occurred in first week of June for T1 with of 80.47 and first week of May for T2 with 82.67.

According to Botto *et al.* (2014), the range of the safest THI values for pigs must be 74 below (THI≤74). THI value within the range of 74 to 79 is considered critical, while a value 79 to 84 is considered to be dangerous for pigs. If the THI value reaches and or exceeds the value of 84 (THI≥84), emergency situation for pigs is declared.

Based on computed THI, only the first two weeks of observation for the house with ECS could be considered to have a safe THI value (73.31 and 73.97) for sows. The average THI values (73.31-80.47) in T1 were in the range of safe to critical condition, while these values (75.2-82.67) in T2 are considered to be critical to dangerous stages. Thus it could be concluded that sows during their gestation period experienced heat stress.

Gestation period (GP) and weaning to estrous interval (WEI)

The effect of ECS on the estrous cycle of sows, specifically the length of gestation period and the weaning to estrous interval was presented on Table 1.

Results showed that GP was not significantly affected by the treatments. This was supported by several studies, which observed that non-environmental factors affect the length of gestation period. Garnett *et al.* (1978) reported that litter size could affect the length of gestation by its relationship to the level of fetal corticoid that may serve as a precursor to estrogen.

On the other hand, significant difference was observed in WEI. T1 sows had shorter WEI compared with T2 sows, which could be attributed to heat stress experienced by T2 sows. According to Boma *et al.* (2006) the change in ambient temperature and photoperiod influenced the weaning to service intervals through its effects on the hypothalmohypophyseal-ovarian axis. Additionally, the delay in the WEI of sows during summer season reflects reduced ability of the sow to resume its ovarian activity (Greer 1983).

Birth weight (BW) and weaning weight (WW)

T1 sows produced significantly higher BW of piglets compared to T2. Results suggested that T1 sows were able to conserve their body reserves and reduced the incidence of weight loss due to heat stress. For sows in T2, due to their early exposure to heat stress since the beginning of their gestation period, the body weight they incurred was caused by heat-induced reduction in feed intake. Liao (2006) also observed significant higher birth weight of piglets from sows raised in water pad cooled barn compared with those raised from conventional air barn.

Table 1. Mean ± SEM Values of Lengths of Gestation Period and Weaning to Estrous Interval *of sows in houses with and without ECS.*

Parameters	Treatments	
	ECS (n=49)	Non-ECS (n= 42)
Gestation period, days^{ns}	114.41 ± 0.36	115.12 ± 0.41
Weaning to estrous interval, days**	4.53 ± 0.09	5.29 ± 0.22

ns -not significant (P≤0.05)
***-statistically significant*

On the other hand, there was no significant difference seen between the WW of the animals for both treatments. This could be attributed to the ability of the sows to recover after their transfer to houses with ECS, done for both treatments. The recovery lasted from last week of gestation to lactation period where the sows were able to make up for the loss in their body weights and energy reserves.

Backfat thickness before farrowing (BFTBF) and after weaning (BFTW)

Back fat thickness in pigs is an important factor to consider in swine reproduction because it affects reproductive performance of sows namely puberty attainment, total piglets born, farrowing rate, and weaning to estrous interval (Gourdine *et al.,* 2006; Roongsitthichai *et al.,* 2014)

Average back fat of sows from T1 were thicker as compared to the sows from T2 both at farrowing and weaning measurements (Table 2). A greater change in back fat thickness was seen in sows from T2 while the change in back fat thickness of sows in treatment 1 was higher by 0.6803.

Table 2. Mean ± SEM Values of Weights of the Litter and Back Fat Thickness (BFT) of Sows from Farrowing to Weaning in housed with and without ECS.

Parameters	Treatments	
	ECS	Non-ECS
	n=49	n=42
Birth weight, kg**		
Weaning weight, kg^{ns}	7.86 ± 0.19	7.52 ± 0.21
BFTBF,mm^{ns}	20.51 ± 0.82	18.88 ± 0.69
BFTW, mm**	17.86 ± 0.58	15.55 ± 0.53
ΔBFT, mm^{ns}	2.65 ± 0.53	3.33 ± 0.44

^{ns}- not significant (P>0.05)
***-statistically significant*

BFTBF was not significantly different but the BFTW of T1 sows were significantly higher than T2 sows. It could be claimed that sows from T2 were not able to recover their body weight loss caused by heat stress in terms of body reserves, resulting to thinner BFTW. Likewise, it could also be assumed that sows in T1 were able to conserve their energy and body reserves better than T2 sows since significant difference was only yielded at BFTW with a non-significant difference BFTBF.

The result of this study agreed with the claim of Trezona*, et al.* (2004), which states that heat stressed pigs have thinner back fat as compared to pigs raised in a normal condition. Gourdine *et al.* (2006) reported that sows with higher body weight and back fat thickness at farrowing period have a lower incidence of delayed weaning to estrous interval since adipose and muscle tissues at farrowing is essential for normal ovarian activity after weaning.

Reproductive parameters (LSBA, LSW, TPB, BD)

The comparisons on the effect of ECS on different reproductive parameters of sows that have farrowed during the summer season were presented on Table 3.

Table 3. Mean ± SEM values of reproductive performance of sows in houses with and without ECS.

Parameters	Treatments	
	ECS (n=49)	Non-ECS (n=42)
Litter size born alive[ns]	9.49 ± 0.45	9.40 ± 0.39
Litter size at weaning[ns]	8.63 ± 0.30	8.69 ± 0.21
Total pigs born[ns]	10.02 ± 0.51	10.26 ± 0.37
Mortality[ns]	0.38 ± 0.05	0.66 ± 0.07

[ns]- *not significant (P>0.05)*

Results exhibited a non-significant effect on LSBA, LSW, TPB and BD This could be attributed to the management system performed on the animals. In the study, weaned sows were housed in conventional pens. Once their pregnancy was confirmed, they were randomly selected to transfer to either a conventional or houses with ECS. It was possible that during the breeding period and estrus to conception days, the sows already experienced heat stress. This could be seen as a factor leading to the insignificant difference yielded by the results since heat stress was not possible during farrowing.

Similar study conducted by Liao (2006) found insignificant difference on LSBA, and LSW between sows raised in conventional open air barn and water pad cooling barn. The findings were strongly supported by Bloemhof *et al.* (2013) who suggested that heat stress during two weeks post-mating has a negative effect on conception rate and the number of viable embryos. It was also stated that stress incurred on 10th day post-mating negatively affects the total number of pigs born and the litter size born alive. This stage is considered critical since it is the period when pregnancy recognition and embryo implantation occur.

Budget analysis

Based on the results of this study, the use of ECS during summer season has a significant effect on WEI, BW, and BFTW. For this analysis, only the effect on WEI was the parameter that can be economically valued. Partial budget analysis of using ECS during summer season was summarized in Table 4.

Electric cost was based on farm's existing record while reduced cost was based on the estimated feed and water cost that could be saved from 0.75 days shorter WEI from T1 sows throughout the experiment. Assuming that these sows consume about 3 kg/day, and the cost of the regular commercial ration is about 23.0Php/kg. The total reduction in feed cost for 74 sows in one ECS house will amount to 3,829.50Php per sow productive cycle. Reduced water cost on the other hand was computed from the 75% savings from regular usage of water in a conventional pen according to the farm manager. In one

Table 4. Partial budget analysis of using evaporative cooling systems in one building per sow productive cycle[a].

Added return: None	Added cost: *Electric cost* *133.20/ day* *15,984.00/ cycle* *ECS Installation cost (D)* *(300,000.00[c])* *10,000.00/ year* Total added cost (B) 15,984.00
Reduced cost: *Feed cost* *3,829.50/ cycle* *Water cost* *26,640.00/ cycle* Total reduced cost (A) 30,469.50	Reduced return: None
Net change in profit (A-B) = 14,485.50/cycle 14,485.50 x 2.46[b] = 35,634.33/year (C) Total net change in profit (C-D): 35,643.33 - 10,000.00 = 25,643.33/year	

[a] *sow productive cycle: 148days;* [b]*2.46= sow index;* [c]*30 years lifespan*

cycle the computed reduced cost was 26,640PhP. If we subtract the additional electric cost (15,984/cycle) that was incurred from using ECS, there can be a total of 14,485Php increase in profit per cycle, for one house containing 74 sows. This is also equivalent to 35, 643.33Php additional profit per year in one gestating house with ECS. Meanwhile, considering the installation cost for ECS which was 300,000 Php and with a lifespan of 30 years, there was a 10,000 Php installation cost per year. The computed additional profit (35,643.44/year) was deducted with 10,000 Php for the installation cost. Therefore, the total net change in profit per year was 25,643.33.

CONCLUSION AND RECOMMENDATION

THI from last week of February to June were calculated and assessed to relate the effects of heat stress to the performance of the animals. Only the first two weeks of observation was considered to have a safe THI value for sows. Safe to critical condition (73.31-80.47) and critical to dangerous stages (75.2-82.67) were observed from THI values from T1 and T2 respectively. Thus it could be concluded that sows during their gestation period experienced heat stress.

Significant effect of ECS was observed only in WEI, BW and BFTW. Through the economic analysis performed, it was concluded that the use of ECS was economically feasible in a commercial type of swine production enterprise. Thus it is recommended to use to counter the negative effects of heat stress on the performance of swine, especially the breeder animals, in a commercial scale of production. Further studies can also be done to assess if transfer of breeder sows in houses with ECS prior to the onset of estrus or before mating can improve the reproductive efficiency of sows specifically the litter size born alive and total pigs born. This is based from the claims that heat stress negatively affects the ovulation rate and conception rates of the sows.

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