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THE INFLUENCE OF AN IMPROVED MICROCLIMATE DURING LACTATION ON THE REPRODUCTIVE PERFORMANCE IN SOWS IN THAILAND

Annop Suriyasomboon[3*] Nils Lundeheim[2] Annop Kunavongkrit[4] Stig Einarsson[1]

Abstract

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The aim of this study was to investigate the reproductive performance of lactating sows in Thailand kept in farrowing housing using an evaporative cooling system (EVAP) in comparison with conventional farrowing system (CONV). The study was based on data from one commercial sow herd, with four farrowing houses (one EVAP and three CONV) with sows of different parities, randomly circulating between these farrowing systems. In the herd, continuous farrowing and cross-fostering was practiced, and the litters were weaned at 18.7 ± 1.3 days of age. The data from 11,000 farrowings (between May 1999 to April 2002) were statistically analysed (ANOVA), to study the effect of present, as well as previous farrowing housing systems, on reproductive and production results. No significant effect of previous or present farrowing housing systems on litter size at birth were found. A significant effect of present farrowing housing systems was found on the average piglet weight at weaning (WPWT) and on the weaning-to-first-service interval (WSI). The WPWT ($P \leq 0.001$) in the EVAP system was higher than in the CONV system (5.8 vs. 5.6 kg) and the WSI ($P \leq 0.01$) in the EVAP system was shorter than in the CONV system (5.4 vs. 5.6 days). For both these traits, a significant interaction was found between the farrowing housing system and the two-monthly periods of results. The WPWT in the EVAP system was significantly higher than in the CONV systems in four out of six two-month periods (0.2-0.4 kg difference). These results suggest that keeping sows in the EVAP system during lactation might be beneficial for piglet production under tropical conditions.

Keywords : Sow, microclimate, reproductive performance, piglet production

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อิทธิพลของการปรับสภาพอากาศในช่วงระยะเลี้ยงลูกต่อสมรรถภาพการสืบพันธุ์ของแม่สุกรในประเทศไทย

วัตถุประสงค์ของการศึกษาครั้งนี้เพื่อเปรียบเทียบสมรรถภาพการสืบพันธุ์ของแม่สุกรที่เลี้ยงลูกระหว่างโรงเรือนระบบเปิด (conventional farrowing system) และโรงเรือนระบบปรับอากาศด้วยวิธีระเหยน้ำ (evapoarative cooling system) ในประเทศไทย การศึกษานี้ทำการเก็บข้อมูลจากฟาร์มสุกรแห่งหนึ่งที่มีโรงเรือนเลี้ยงลูกสุกรในระบบเปิด จำนวน 3 หลัง และในระบบปรับอากาศด้วยวิธีระเหยน้ำ จำนวน 1 หลัง ตั้งแต่เดือนพฤษภาคม 2542 ถึง เดือนเมษายน 2545 ในฟาร์มนี้มีระบบการเลี้ยงสุกรแบบต่อเนื่อง แม่สุกรมีการเข้าคลอดแบบสุ่มในระหว่างโรงเรือน 4 หลังนี้ มีการย้ายฝากลูกสุกรในระยะแรกคลอดและแม่สุกรมีระยะเวลาในการเลี้ยงลูกนาน 18 ± 1.3 วัน ทำการวิเคราะห์ข้อมูลทางสถิติบนฐานข้อมูลการคลอด 11,000 ท้อง โดยศึกษาผลกระทบของระบบโรงเรือนในท้องปัจจุบันและระบบโรงเรือนในท้องที่ผ่านมาต่อข้อมูลทางการผลิตและการสืบพันธุ์ ผลการศึกษาไม่พบความแตกต่างที่มีนัยสำคัญทางสถิติของระบบโรงเรือนในท้องปัจจุบันและระบบโรงเรือนในท้องที่ผ่านมาต่อขนาดครอกลูกสุกรแรกคลอด แต่พบความแตกต่างที่มีนัยสำคัญทางสถิติของระบบโรงเรือนในท้องปัจจุบันต่อน้ำหนักลูกสุกรหย่านมและระยะหย่านมถึงเป็นสัด โดยที่น้ำหนักลูกสุกรหย่านมในกลุ่มที่เลี้ยงในโรงเรือนระบบปรับอากาศด้วยวิธีระเหยน้ำ มีน้ำหนักมากกว่ากลุ่มที่เลี้ยงในโรงเรือนระบบเปิด (5.8 และ 5.6 กก) และระยะหย่านมถึงเป็นสัดในกลุ่มที่เลี้ยงโรงเรือนระบบปรับอากาศด้วยวิธีระเหยน้ำ มีระยะเวลาสั้นกว่ากลุ่มที่เลี้ยงในโรงเรือนระบบเปิด (5.4 และ 5.6 วัน) และพบความแตกต่างที่มีนัยสำคัญทางสถิติระหว่างระบบโรงเรือนในท้องปัจจุบันกับกลุ่มเวลาของการหย่านมทุกสองเดือนต่อน้ำหนักลูกสุกรหย่านมและระยะหย่านมถึงเป็นสัด โดยที่น้ำหนักลูกสุกรหย่านมในกลุ่มที่เลี้ยงในที่เลี้ยงในโรงเรือนระบบปรับอากาศด้วยวิธีระเหยน้ำมีน้ำหนักมากกว่ากลุ่มที่เลี้ยงในโรงเรือนระบบเปิด จาก 4 ใน 6 ของกลุ่มเวลาของการหย่านมทุกสองเดือน (ความแตกต่าง 0.2-0.4 กก) ผลการศึกษาพบว่าได้ว่าการให้แม่สุกรในระยะเลี้ยงลูกอยู่ในโรงเรือนระบบปรับอากาศด้วยวิธีระเหยน้ำให้ผลดีต่อการผลิตลูกสุกรภายใต้สภาพอากาศร้อนชื้น

คำสำคัญ : แม่สุกร ไมโครไครเมต สมรรถภาพการสืบพันธุ์ การผลิตลูกสุกร

Introduction

The influence of season is regarded as an important environmental component affecting swine reproductive efficiency. Seasonal variations in swine reproduction/production in tropical areas, such as Thailand, with high temperatures and high humidity, have been reported (Tantasuparuk et al., 2000). Several studies have shown the adverse effects of high ambient temperatures, humidity, and changes in the photoperiod, on the reproductive efficiency of gilts and sows (Peltoniemi et al., 1999; Tantasuparuk et al., 2000; Tummaruk et al., 2000), and also boars (Colenbrander et al., 1993; Suriyasomboon et al., 2004).

In hot conditions, the feed intake and, to a smaller extent, milk production, decline in order to avoid excessive increases in body temperature (Renaudeau et al., 2001). The reduction of milk yield in hot conditions might be related to a decrease in voluntary feed intake and the associated reduction in nutrient availability, for milk production. In a recent study, Renaudeau et al. (2003) showed that an increase in ambient temperature from 20 to 28 °C, with a constant feed allowance, did not directly affect milk production in multiparous sows.

In Thailand, there are three seasons: A hot summer one from March until June, a hot rainy one from July to October and a winter season from November until

February. Most swine production in Thailand takes place in conventional housing systems (CONV) which are open air systems with no walls. In recent years, an evaporative cooling housing system (EVAP), has been introduced in order to improve the microclimate. EVAP is a system aiming to reduce ambient temperatures by a humidification process. In the EVAP system water is sprayed on to cooling pads at one end of the closed stable. Hot outdoor air is drawn through the pads, by using the exhaust fan at the other end of the building, and air temperatures are cooled as the water evaporates. This process reduces the temperature but increases the relative humidity of the air (Simmons and Lott, 1996).

The objective of this study was to investigate the reproductive performance of sows in one herd in Thailand having farrowing housing which used both the CONV and the EVAP systems.

Materials and Methods

The study was based on data from one sow herd located in the central part of Thailand, having four farrowing houses (one EVAP and three CONV) and using PigCHAMP((Version 4.0, Farms.com, LTD) for herd recording. The herd was established in 1992 and started to use the EVAP system, in one farrowing house, in May 1999. The data analyzed covers the farrowing period for the 3 years from May 1999 to April 2002. The herd size was approximately 1,800 sows (mainly Landrace x Yorkshire crosses). A low proportion of sows of other breed combinations were excluded from the analyses. Duroc boars were mainly used for insemination.

Herd Management

The sows were housed and kept in individual stalls in a conventional open air system during gestation, while lactating sows were kept in individual farrowing pens in either an EVAP or a CONV system. The sows were randomly circulating between these two systems.

The sow feed contained 17% crude protein and 3,100 kcal of digestible energy per kilogram. Feed ingredients included broken rice, rice bran, soybean meal, fishmeal, dicalciumphosphate, salt, vitamins, and mineral concentrate. All sows received the same diet at all stages of the reproductive cycle. Antibiotics were added to the sow feed when needed to control mastitis, metritis, agalactia, and dysentery. Sows were fed 1.8 kg feed/day, from mating to week 12 of gestation and thereafter 3 kg feed/day until 7 days before their expected farrowing, when the amount was reduced to 2 kg feed/day. Lactating sows were fed 2.5, 4.5, and 6 kg feed/day during weeks 1, 2 and 3 of lactation, respectively. After weaning when the sows were moved to the mating/gestating area and until mating, the sows were fed 3 kg feed/day. All gestating and lactating sows had free access to water via nipple drinkers.

Replacement gilts were penned in groups of 5. Before expected estrus, they were moved into the mating area to allow boar contact, where they were kept in individual stalls. Estrous detection was performed twice a day, in the morning and evening, by experienced staff, in the presence of boar(s). Sows who were detected with standing heat in the morning, were mated in the evening; sows where of standing heat was detected in the evening, were mated in the morning. All matings were performed by AI, collected within the herd, and matings were recorded both on sow cards and by mating reports, which were transferred into the computer.

After mating, a backpressure test in the presence of a boar (control of repeat breeding) was performed, from the second through to the third week after mating and after 5 weeks, pregnancy was tested using A-mode ultrasound. Farrowings were supervised during working hours (6.00 to 18.00 h), and farrowing events were recorded twice a day. Liveborn piglets were weighed, and the total litter weight was recorded. Cross fostering was performed within a few days after farrowing. Creep feed was provided from day 7 after farrowing. The lactation period was approximately 3 weeks. Weaning was practiced every 3 days. At weaning, the sows were moved to the mating area and penned in individual stalls, adjacent to boars. Sows that did not show estrus within 7 days were stimulated to come into estrus by relocation to another individual stall, or sometimes by a combination of relocation and grouping of 3 to 4 sows together, and introducing them into a boar pen for 10 min, twice a day. The sows that had not shown estrus at the end of the second week after weaning were treated with hormones using a combination of PMSG and HCG (PG600®, Intervet, The Netherlands).

The herd showed no clinical findings of foot-and-mouth disease or swine fever during the period studied. Antibodies against porcine reproductive and respiratory syndrome (PRRS) were found, but no clinical outbreaks were observed. Culling due to small litter size from the first to third parity and due to conception failure after the third mating was practiced. Culling due to old age was done after parity 7.

Editing of data

Data were extracted from PigCHAMP® (Version 4.0, Farms.com, LTD) and handled using the SAS program (Ver. 8, SAS Institute Inc., Cary, NC, USA). The records consisted of sow identity, breed, parity number, mating date, farrowing date, farrowing house, number of total piglets born per litter (NTB), number of piglets born alive per litter (NBA), average piglet weight at birth (PBWT), weaning date, number of weaned piglets per litter (WPIG), and average piglet weight at weaning (WPWT). Variables such as lactation length (LL), gestation length (GEST), weaning-to-first-service interval (WSI), and service within 7 days after weaning (WSI7), were calculated from the data, where GEST is the number of days from the mating to farrowing, which took place from 107 to 122 days after mating, WSI is the number of days from weaning to first service, and recorded for 30 days after weaning; the day of weaning being defined as day zero, and WSI7 is an all-or-none trait, defined for records with the WSI in the range 0-30 days as 1: 0-7 days, and 0: 8-30 days. Records with a PBWT lower than 0.9 kilograms or higher than 2.4 kilograms, a WPIG higher than 14 piglets, a WPWT lower than 3 kilograms or higher than 9 kilograms, and a GEST longer than 122 days or WSI longer than 30 days were all disregarded. Sows with incomplete records, or records with obvious errors, were regarded as missing values in the analyses. The edited data contained 11,811 farrowing records from 3,179 sows, obtained from May 1999 to April 2002 (Table 1).

Statistical analyses

The data were statistically analyzed using the SAS program (Ver. 8, SAS Institute Inc., Cary, NC, USA). The parameters analysed were: NTB, NBA, PBWT, GEST, WPIG, WPWT, WSI and WSI7. Parity number was grouped into 3 classes (1, 2-3 and 4-12). Two-monthly periods of farrowing (mf) and two-monthly periods of weaning (mw), were grouped into 6 classes; each class having two months (January/February, March/April, May/June, July/August, September/October, and November/December). To reduce the impact of non-normal distribution, natural log transformation was applied to the WSI. Results from the analyses were transformed back to an ordinary scale in this presentation.

Analysis of variance was applied to the data using PROC MIXED and twelve statistical models were applied to the parameters (Table 2). Two subsets of data were analysed: to determine the effect of the present farrowing system on litter size, PBWT, GEST, WPIG, WPWT, WSI and WSI7. The data set comprised of records on farrowings from May 1999 to April 2002. For analysing the impact of the previous farrowing system on litter size at birth, PBWT and GEST, the data set comprised of farrowing records (from parity 2-3 to 4-12), from September 1999 to April 2002.

For analysing the effect of the present farrowing system on NTB, NBA, PBWT and GEST, the model included the fixed effects of the present farrowing system (system), year of farrowing (yf), two-monthly periods of farrowing (mf), parity and two-way interactions between the system and parity, the system and mf, and mf and parity.

Table 1 Descriptive statistics of the data after editing

	n	Means	SD	Min	Max
Parity	11,811	3.9	2.2	1	12
Gestation length (days)	11,805	115.7	1.6	107	122
Number of total born piglets per litter	11,810	11.5	3.1	1	24
Number of live born piglets per litter	11,810	10.5	3.1	0	21
Number of weaned piglets per litter	10,998	9.0	1.4	1	14
A verage piglet birth weight (kg)	11,629	1.56	0.27	0.9	2.4
A verage piglet weaning weight (kg)	10,985	5.9	0.9	3	9
Lactation length (days)	11,164	18.7	1.3	16	21
Service within 7 days	10,199	91.3	-	-	-

For analysing the effect of the present farrowing system on WPIG, WPWT, WSI and WSI7, records with LL less than 16 or longer than 21 days were excluded from the analyses. The model included the fixed effects of the system, the year of weaning (yw), the two-monthly periods of weaning (mw), parity, LL and two-way interactions between the system and parity, the system and mw, and mw and parity. A regression on WPIG was included in the model, when analysing WPWT, WSI and WSI7. PROC GLIMMIX was applied for WSI7.

For analysing the effect of both the previous and the present farrowing system on NTB, NBA, PBWT and GEST, litters resulting from remating, litters where previous LL was shorter than 16 or longer than 21 days, and litters where the previous WSI was longer than 30 days, were excluded from the analyses. The fixed effects of the previous farrowing system (p_system), the present farrowing system (system), yf, mf, parity, and the two-way interactions between p_system and system, p_system and mw, p_system and parity, system and mf, system and parity, and mf and parity, were included in the model. The random effect of sows was included in all models. Multiple comparison t-test of least-squares means were performed using Bonferroni correction, to reduce the risk of getting false significances.

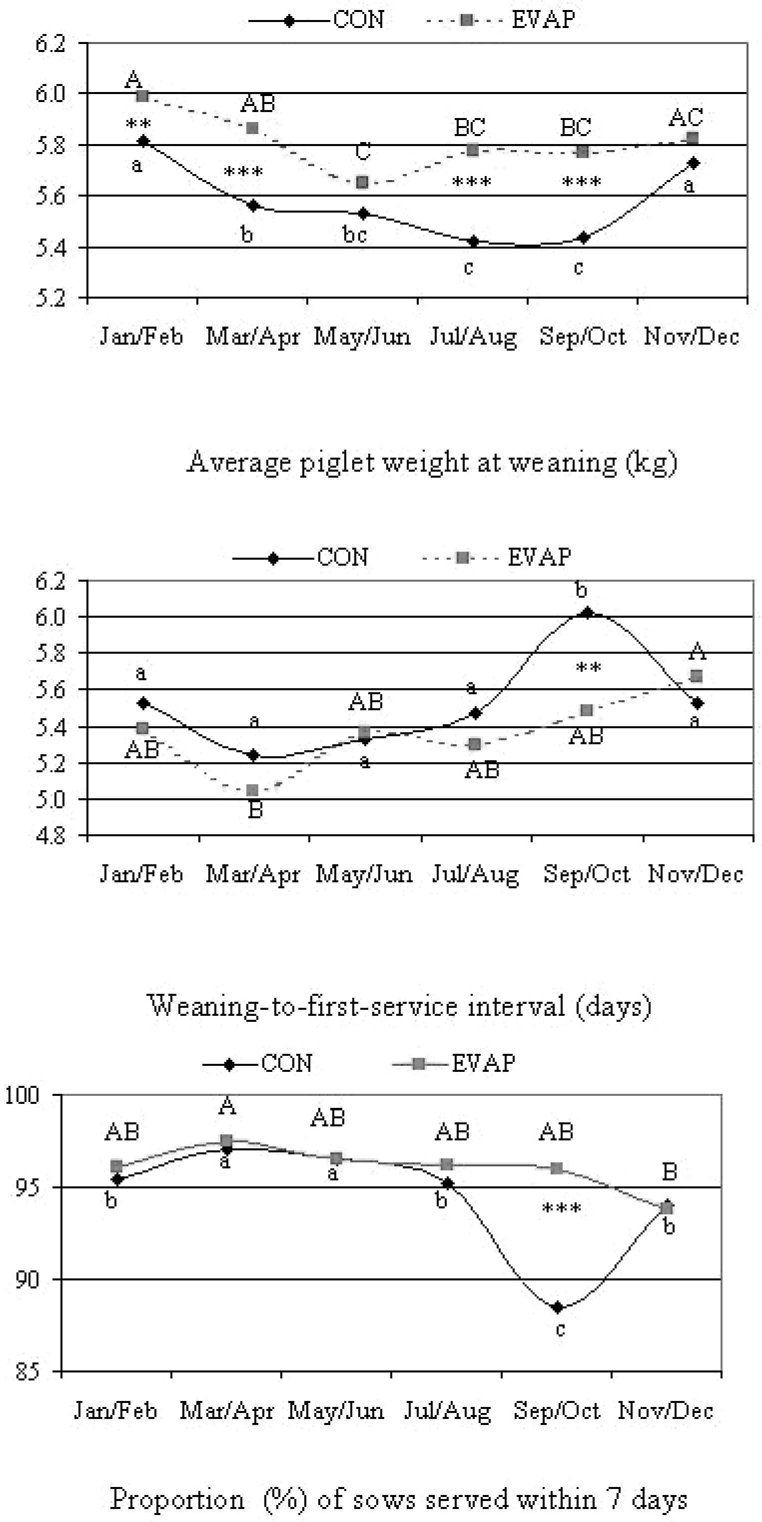

Figure 1 Combined effect of farrowing system and two-month period of weaning on average piglet weight at weaning, weaning-to-first service interval and service within 7 days

Least-squares means without any letter in common (within line, $p \leq 0.05$), and**, *** (between lines), are significantly different ($p \leq 0.01$, $p \leq 0.001$, respectively).

Table 2 The level of significence for the values included in the statistical models

Effects in the model	Analyses of the present farrowing system: Litter size NTB	Litter size NBA	Average birth weight	Gestation length	Analyses of both present and previous farrowing systems: Litter size NTB	Litter size NBA	Average birth weight	Gestation length	Weaned piglets per litter	Average weaning weight	Weaning-to first-service interval	Service within 7 days
p_system[1]	-	-	-	-	ns	ns	ns	ns	-	-	-	-
system[2]	ns	ns	ns	ns	ns	ns	ns	ns	ns	***	**	***
yf[3]	***	***	***	***	***	***	***	***	-	-	-	-
mf[4]	ns	*	*	***	***	ns	**	***	-	-	-	-
yw[5]	-	-	-	-	-	-	-	-	***	***	***	***
mw[6]	-	-	-	-	-	-	-	-	***	***	***	***
parity	***	***	***	**	***	***	***	ns	***	***	***	***
lactation length	-	-	-	-	-	-	-	-	*	***	**	***
Interactions												
p_system x system	-	-	-	-	ns	ns	ns	*	-	-	-	-
system x mf	ns	ns	ns	ns	ns	ns	ns	ns	-	-	-	-
parity x mf	**	**	*	**	ns	ns	ns	ns	-	-	-	-
p_system x mw	-	-	-	-	ns	ns	ns	ns	-	-	-	-
p_system x parity	-	-	-	-	ns	ns	ns	ns	-	-	-	-
system x parity	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	*
system x mw	-	-	-	-	-	-	-	-	**	***	***	***
parity x mw	-	-	-	-	-	-	-	-	***	***	ns	**
Regression on the number of weaned piglets	-	-	-	-	-	-	-	-	-	ns	***	***
Number of observations	11259	11259	11099	11258	6217	6217	6156	6217	10478	10467	9559	9559

*p• 0.05
**p• 0.01
***p 0.001
ns $p > 0.05$
[1]previous farrowing system
[2]present farrowing system
[3]year of farrowing
[4]two-monthly periods of farrowing
[5]year of weaning
[6]two-monthly periods of weaning

Results

The overall mean values of the reproductive performance variables analysed, after editing, are shown in Table 1. Mean parity number was 3.9. Means of NTB, NBA, and WPIG were 11.5, 10.5, and 9.0 piglets per litter, respectively. The average piglet weight at birth and the average piglet weight at weaning were 1.6 and 5.9 kg, respectively, and ranged from 0.9 to 2.4 kg and 3 to 9 kg, respectively. The weaning-to-first-service interval was, on average, 5.8 days. Mean gestation length was 115.7 days, and the lactation length was, on average, 18.7 ± 1.3 days.

The levels of significance for all fixed effects included in the statistical models, are presented in Table 2. No significant effects of the present or the previous system were found on NTB, NBA, PBWT, GEST or WPIG. However, there was a significant effect of the present system on WPWT ($p \leq 0.001$), WSI ($p \leq 0.01$) and WSI7 ($p \leq 0.001$). There were, on average, higher WPWT, WSI7 and shorter WSI in the EVAP system (5.8 kg, 96.2% and 5.4 days, respectively) than in the CONV system (5.6 kg, 95.0% and 5.6 days, respectively). There was a significant effect of parity on all variables ($p \leq 0.001$), except on GEST, in the analyses of both the previous and the present farrowing systems (i.e. when the first parity farrowings were not included). Also, when lactation length increased, there was a significant decrease in WPIG ($p \leq 0.05$) and WSI ($p \leq 0.01$) (least-squares means: 9.1 piglets and 5.6 days [16 days]: 8.9 piglets and 5.3 days [21 days]) and a contemporary significant increase in WPWT and WSI7 ($p \leq 0.001$), (least-squares means: 5.2 kg and 94.7% [16 days]: 5.9 kg and 97.0% [21 days]). There was a significant positive regression of WSI ($p \leq 0.001$) and WSI7 ($p \leq 0.001$) on WPIG. Also, there was a significant interaction between the previous and the present system for GEST ($p<0.05$), although of small numeric magnitude.

There was a significant interaction between the present farrowing system (system) and the two-monthly periods of weaning (mw) for WPIG ($p \leq 0.01$), WPWT ($p \leq 0.001$), WSI ($p \leq 0.01$) and WSI7 ($p \leq 0.001$). Fig. 1 shows the combined effect of the system and mw on WPWT, WSI and WSI7. In the CONV system, WPWT decreased from January/February to July/August but gradually increased thereafter to November/December reaching the same level as in January/February. In the EVAP system, WPWT decreased from January/February to May/June, but gradually increased thereafter to November/December, and then remained at the same level, as before in March/April. WPWT was highest in both systems in January/February, and lowest in May/June in the EVAP system and in July/August in the CONV system. WSI increased significantly in the CONV system from July/August to September/October, after which it decreased again to November/December, reaching the same level as in January/February. In the EVAP system, WSI increased gradually from March/April to November/December. WSI was shortest, in both systems, in March/April, and longest in September/October in the CONV system and in November/December, in the EVAP system. From these figures, it can be concluded that WSI7 is almost a mirror of WSI. In the EVAP system, there was a significantly higher WPWT ($p \leq 0.001$) during January/February, March/April, July/August and September/October, than in the CONV system (0.2, 0.3, 0.4, and 0.3 kg higher WPWT, respectively), and a significantly shorter WSI ($p \leq 0.01$) and higher WSI7 ($p \leq 0.001$) during September/October (5.5 vs. 6.0 days; 96% vs 88%, respectively).

There was a significant interaction effect of the present farrowing system (system) and parity on WPIG. Least-square means for the combination of system and parity show that WPIG increased from parity 1 to 2-3 in both systems, however with higher means in the EVAP system than in the CONV system. There was a significant interaction between parity and the two-monthly periods of weaning for WPIG ($p \leq 0.001$), WPWT ($p \leq 0.001$) and WSI7 ($p \leq 0.01$). There was a numerically lower WPIG and WPWT in parity 1 than in parity 2-3 and 4-12, and higher WSI in parity 1 than in parity 2-3, for all two-month periods (least-squares means: 0.5-1.0 piglets, 0.3-0.6 kg, and 0.7-1.2 days difference, respectively).

Discussion

The present study investigated the effect of the two farrowing housing systems (CONV system and EVAP system), on the reproductive performance of crossbred sows under tropical conditions. There was a significant effect of present farrowing systems on WPWT and WSI. A significant interaction between present farrowing systems and the two-monthly periods of weaning, on WPWT and WSI, was also found.

The results from the present study did not show any effect of the present or previous farrowing housing systems on litter size at birth or at weaning, piglet birth weight or gestation length. This might be due to the fact that all sows weaned from both the EVAP and the CONV farrowing housing systems were exposed to the same ambient temperatures and humidity from weaning until late gestation when housed in the CONV gestation houses.

In this study there was a significant influence by the farrowing housing systems on both WPWT and WSI. The WPWT was highest in January/February (winter) in both systems, and lowest in July/August (rainy) in the CONV system, and lowest in May/June (summer) in the EVAP system. This might be explained by the difference in microclimate during lactation with lower temperatures in the winter, than the rainy and summer seasons, respectively. A reduction in piglet weight gain, as a consequence of reduced feed intake by lactating sows (low appetite), under high environmental temperatures was demonstrated by Schoenherr et al. (1989) and Quiniou and Noblet (1999). Furthermore the WPWT in the CONV system was significantly lower than in the EVAP system during four out of six, two-month periods. This might also be explained by differences in the microclimate between the CONV and the EVAP systems. In the CONV system, the average daily maximum temperature and the variations in temperature, is higher, while and the average minimum humidity is lower, than in the EVAP system (Suriyasomboon et al., 2004). One reason for the lower WPWT in the CONV system might be that sows, kept at higher temperatures, have a lower feed intake and consequently, decreased milk production and litter growth rates, than the sows kept at lower temperatures. Another contributing factor might be a combined effect of high temperature and high humidity under tropical conditions (Renaudeau et al., 2003). To our knowledge, no studies are available on the effect of relative humidity on lactating sows kept in hot conditions. This possible effect should be investigated further.

The results from the present study also showed a combined effect of the farrowing system and the weaning-month on WSI, being significantly shorter in the EVAP system than in the CONV systems, during September/October (rainy). One reason for this might be a difference in sow condition and/or sow appetite during lactation, due to the differences in microclimate. The present study also showed that WSI was shortest and WSI7 was highest during March/April (summer) in both systems. Tantasuparuk et al. (2000) on the other hand showed, in three purebred sow herds in Thailand, that WSI was longest during March/April, and WSI7 was lowest during May/June. The present results were obtained from one herd only, using crossbred sows. Therefore, no explanation can be given for the short WSI and high WSI7 during the summer in the present study. Further investigations on the combined effect of the farrowing system and the weaning-month on WSI and WSI7, based on data from several herds, are needed.

Conclusion

The average piglet weight at weaning, and proportion of sows served within 7 days after weaning was higher and the weaning-to-first-service interval was shorter in the EVAP system than in the CONV system, during some periods of the year. These results suggested that keeping sows in the EVAP system during the lactation period, might be beneficial for piglet production under tropical conditions.

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