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Quantitative associations between outdoor climate data and weaning-to-first-mating interval or adjusted 21-day litter weights during summer in Japanese swine breeding herds

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ABSTRACT

The objective of the present study was to quantify the associations between climate data and either weaning-to-first-mating interval (WMI) or adjusted 21-day litter weights of sows during summer for different herd productivity groups. This study was conducted using 87,428 parity records of 61,558 sows farrowed between June and September in 2007, 2008 and 2009, in 103 Japanese herds mostly located in humid subtropical areas. The 103 herds were classified into high-performing herds and ordinary herds by the basis of the upper 25th percentile of pigs weaned per mated female per year, averaged over the three years. The climate data were obtained from 21 weather stations of the Japan Meteorological Agency. Average values of the daily maximum temperatures (HT), average daily relative humidity (RH) and temperature-humidity index (THI) for 21 days after the farrowing date of a sow were coordinated with sow performance data from a recording system. Two-level mixed-effects models were applied to the data by using a herd at level 2 and an individual record at level 1. Mean values (ranges) of HT, RH and THI were 27.8 °C (17.3–36.0 °C), 74.6% (57.3–90.9%) and 22.2 °C (13.0–27.4 °C), respectively. Higher HT, RH and THI were associated with higher WMI and lighter adjusted 21-day litter weights ($P<0.05$). High-performing herds had lower WMI and heavier adjusted 21-day litter weights than ordinary herds at any HT, RH and THI ($P<0.05$). The WMI of sows in high-performing herds did not increase as much as those in ordinary herds when HT or THI increased. For example, as HT increased from 25 to 35 °C, WMI of sows in high-performing herds increased by 0.3 days, whereas those in ordinary herds increased by 0.8 days. Also, when HT, RH or THI increased, parity 1 sows showed greater increase in WMI than parity 2 or higher sows ($P<0.05$). For instance, as THI increased from 15 to 25 °C, WMI in parity 1 sows increased by 0.9 days, whereas those in parity 2 or higher sows increased by only 0.3 days. In conclusion, high-performing herds alleviate the negative effects of humid subtropical summer climates on WMI or adjusted 21-day litter weight more than ordinary herds. The parity 1 sows were more sensitive to such summer changes in climate than parity 2 or higher sows. Therefore, it is recommended in particular for parity 1 sows that producers practice cooling management during summer.

1. Introduction

High temperature in summer is one of the environmental factors which explain the reduction of sow performance (Prunier et al., 1996). The suboptimal sow performance during summer including prolonged weaning-to-first

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-mating interval (WMI) and lighter weaning litter weights is a major concern in swine breeding herds (Anil et al., 2005; McGlone et al., 1988). The prolonged WMI and lighter weaning litter weights lead to low farrowing rate of sows and low growth performance of weaned pigs, respectively (Klindt, 2003; Koketsu et al., 1997a). Parity 1 sows also have less mature endocrine systems and consume less feed during lactation in summer than parity 2 or higher (parity 2+) sows (Koketsu et al., 1996). In tropical areas, a higher temperature combined with high humidity was reportedly associated with lower feed intake and higher body weight loss during lactation (Renaudeau et al., 2003). Additionally, climate data in Meteorological stations near the herds have been used to investigate delayed puberty of gilts in tropical areas (Tummaruk, 2012). However, no research has yet quantified an association between climate data and either WMI by parity or adjusted 21-day litter weight in humid subtropical areas.

Herd management in high-performing herds, based on pigs weaned per mated female per year, differs from that in ordinary herds (Koketsu, 2007). Therefore, the association between climate data and sow performance would likely differ between high-performing herds and ordinary herds. The objective of the present study was to quantify the associations between summer climate data and the performance of lactating sows by parity and herd productivity groups in humid subtropical areas.

2. Materials and methods

2.1. Herds

Approximately 110 Japanese pig producers, that use the PigCHAMP recording system (PigCHAMP Inc., Ames, IA, USA), were requested to mail their data files to Meiji University each time they renewed their yearly maintenance contract. By August 31, 2010, data files had been received from 105 breeding herds. Two of these herds were excluded from the present study because the herds were producing only purebred pigs. The remaining 103 commercial breeding herds were located throughout Japan from Northern and Southern areas. Mean herd reproductive productivity measurement, i.e. pigs weaned per mated female per year, in the three-year period from 2007 to 2009 was collected from the 103 herds. Natural or mechanical ventilation was used in the lactation barns of these herds, and eight herds had cool cell ventilation systems. Females in the studied herds were mainly crossbreds between Landrace and Large White, either produced within the herds or were replacement gilts purchased from national or international breeding companies. Breeding stocks in the national breeding companies were originally imported from the USA or Europe. Approximately 90% of Japanese commercial herds using PigCHAMP use artificial insemination.

2.2. Sow performance data

Performance data, including WMI and adjusted 21-day litter weight, were extracted from the recording system for sows farrowed between June and September in 2007, 2008 and 2009. The present study contained 95,308 parity records of 65,620 sows in the 103 herds. Records of sows in parities when lactation length was 0–13 days were not used in the analysis (3009 records) because the sows in these parities were likely to have poor reproductive performance (Xue et al., 1993). Furthermore, records of sows in parities with lactation length 30 days or higher (1829 records), or sows with 16 or more pigs weaned (2218 records) were excluded because the sows might have been used as nurse sows. Sows with three or fewer pigs weaned were also excluded because such sows typically do not have strong enough suckling intensity to suppress the resumption of estrus during lactation (824 records; Stevenson and Britt, 1981). Finally, records of sows with WMI 120 days or higher were regarded as missing values (Le Cozler et al., 1997). Therefore, 87,428 parity records of 61,558 sows in the 103 herds were used for further analyses. Additionally, one herd had no records of adjusted 21-day litter weights. Therefore, the data integrity of weaning litter weight records was evaluated in the remaining 102 herds by their normality using either the Shapiro–Wilk test ($W>0.95$) or the Kolmogorov–Smirnov test ($D<0.05$). These tests showed that weaning litter weight records of sows in 14 herds were not normally distributed and their records were thought to be inaccurate, so the adjusted 21-day litter weight records in these herds were regarded as missing observations. In preliminary analysis, there was no difference in adjusted 21-day litter weights between the datasets of the original 102 herds and the 88 herds remaining after the normality tests.

2.3. Climate data

Climate data from 2007 to 2009 were downloaded from climate statistics uploaded in 21 weather stations of the Japan Meteorological Agency (JMA, 2012). The weather stations were located in the cities having local government offices in the 21 prefecture districts where the 103 studied herds were located. The 21 stations were located between latitude 20–45°N and longitude 136–148°E. Based on the Köpper climate classification (Peel et al., 2007), the 103 herds were located in either humid subtropical climates (98 herds) or humid continental climates (5 herds). Average values of daily maximum temperatures (HT), average daily relative humidity (RH) and temperature–humidity index (THI; see definition below) for 21 days from the farrowing date for individual sows were coordinated with sow performance data from the PigCHAMP recording system. The 21-day period was chosen because mean lactation length in the 103 herds was approximately 21 days. In addition, luteinizing hormone secretion during lactation is critical for quick resumption of estrus (King and Martin, 1989). The THI incorporates the effects of both temperature and humidity, and has been used in previous studies to examine the association between female reproductive performance and the climate (Tantasuparuk et al., 2000; Tummaruk, 2012). The THI was calculated for each day using the following formula: $\mathrm{THI}\ (^\circ\mathrm{C}) = T\ (^\circ\mathrm{C}) - [0.55 - (0.0055 \times H)] \times [T\ (^\circ\mathrm{C}) - 14.5]$ where T is the average daily temperature and H is the average daily humidity (NOAA, 1976). Minimum temperatures were not used for the present study, because a high correlation was found