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Delayed age of gilts at first mating associated with photoperiod and number of hot days in humid subtropical areas

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ABSTRACT

The objective of the present study was to quantify the associations between age at first mating (AFM) in gilts and the climatic factors of photoperiod (PP; h), number of hot days (HD) and relative humidity for different herd productivity groups. This study used records of 37,362 gilts born in 2007 and 2008 in 101 Japanese herds, which were classified into high-performing and ordinary herds based on the pigs weaned per mated female per year. The climate data were obtained from 21 weather stations. The HD was defined as the number of days that achieved a maximum temperature >25 °C. Average values of daily PP, relative humidity and HD from day 91 to 150 after birth of a gilt were coordinated with the respective gilt performance data. Two-level mixed-effects models were applied to the data by using a herd at level 2 and a gilt at level 1. Mean AFM (ranges), PP, HD and relative humidity were 247.9 days old (152–364 days old), 12.2 h (9–15 h), 18.7 days (0–60 days) and 68.4% (48–87%), respectively. Delayed AFM was associated with decreased PP, more HD and being in an ordinary herd ($P < 0.05$), but not with relative humidity. As PP rose by an hour, the AFM in high-performing herds decreased by 1.13 days rather than that in ordinary herds. It is possible that AFM in replacement gilts could be hastened by improving light control and cooling management during hot days.

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1. Introduction

Age at first mating (AFM) in gilts is a key factor that determines herd reproductive efficiency (van Wettere et al., 2006) because delayed AFM is associated with low lifetime performance and low longevity of sows (Schukken et al., 1994; Le Cozler et al., 1998; Koketsu et al., 1999). The delayed AFM also results in increased nonproductive days from herd-entry to conception (Lucia et al., 2000), which is a major concern in commercial breeding herds. The increased nonproductive days of female pigs also have a negative effect on herd reproductive efficiency (Vargas et al., 2009), measured as pigs weaned per mated female per year (Dial et al., 1992).

It is now widely accepted that photoperiod (PP) and temperature are two of the environmental factors to seasonality in age at puberty in gilts (Love et al., 1993; Peltoniemi and Virolainen, 2006). The influence of PP on age at puberty, which is related to AFM, remains controversial. Some researchers have reported benefits of increased PP, such as earlier age at puberty (Hacker et al., 1976; Ntunde et al., 1979), but other studies have not shown similar benefits (Diekman and Hoagland, 1983; Paterson and Pearce, 1990). Using climate data (all measured at nearby meteorological stations), a Thai study showed that delayed age at first observed estrus was related to decreased average PP, decreased average temperature or lower relative humidity as a single fixed effect variable (Tummaruk, 2012). Additionally, another study has suggested that PP

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and number of hot days (maximum temperature > 25 °C) are related to seasonal infertility of sows (Auvigne et al., 2010). However, no research has attempted to explain the relative roles of PP, temperature and relative humidity by quantifying the associations between AFM in gilts and PP, the number of hot days or relative humidity in the same model.

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 associations between delayed AFM and climate data probably differ between high-performing herds and ordinary herds. The objective of the present study was to quantify the associations between AFM and the climatic factors of PP, the number of hot days and relative humidity for different herd productivity groups in Japan, where there is a wide range of climatic conditions throughout the Japanese archipelago.

2. Materials and methods

2.1. Herds and herd category

Approximately 110 Japanese pig producers that use the PigCHAMP® recording system (PigCHAMP®, Ames, IA, U.S.A.) were requested to mail their data files to Meiji University each time they renewed their yearly maintenance contract. By August 31, 2010, data files were received from 105 breeding herds. Of the 105 herds, four were excluded from the present study: two because they were producing only purebred pigs, one that had no records of gilts and one that did not record birth dates of females. The remaining 101 commercial breeding herds were located throughout the Japanese archipelago from Northern to Southern areas. Gilts in most of these herds had been developed in barns having side curtains or glassed windows. Also, the gilts 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 in Japan. Breeding stocks in the national breeding companies were originally imported from the U.S.A. or Europe. In addition, long distance transportation of gilts across regions is not commonly practiced in Japan.

Mean herd measurements, i.e. herd size and pigs weaned per mated female per year, were collected from the 101 herds for three 1-year periods from 2007 to 2009. Mean (±SEM) herd size was 448 ± 59.9 females with a range between 49 and 3640 females. Herds were classified into two herd productivity groups on the basis of the upper 25th percentile of pigs weaned per mated female per year: high-performing herds (mean = 24.9 ± 0.16 pigs; range = 24.1–27.7 pigs) and ordinary herds (mean = 21.8 ± 0.18 pigs; range = 15.8–24.0 pigs). Mean herd sizes for high-performing and ordinary herds were 603 ± 144.7 and 392 ± 62.0 females, respectively.

2.2. Gilt performance data and exclusion criteria

Reproductive performance data of the gilts born between January 2007 and December 2008 in the 101 herds were extracted from the PigCHAMP® recording system. The initial dataset contained 37,470 gilts with AFM records. Gilt records where AFM was 150 days or lower or 365 days or higher (108 records) were considered as extreme (Tummaruk et al., 2001; Babot et al., 2003) and these data were excluded. Hence, a total of 37,362 gilt records from 101 herds were used for further analysis.

2.3. Climate data and season

Climate data were obtained from data gathered at 21 weather stations located in the cities in the 21 prefecture cities where the 101 herds were located. The PP data was downloaded from the National Astronomical Observatory of Japan (NAOJ, 2012) and temperature and humidity data from the Japan Meteorological Agency (JMA, 2012). 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 101 herds were located in either humid subtropical climate zones (96 herds) or humid continental climate zones (5 herds).

Average values of daily PP, relative humidity and number of hot days, which was defined as the number of days that achieved a maximum temperature >25 °C (Auvigne et al., 2010), from day 91 to 150 after birth of a gilt were coordinated with the respective gilt performance data. The value of >25 °C was selected for the definition of hot days because it has been shown to be the critical upper temperature for sows (Quiniou and Noblet, 1999). Also, this period was chosen because it covers the period just before most gilts are entered into herds (mean ± SEM: 177.5 ± 0.20 days old) and also because a previous report has suggested that LH secretion and pulse frequency increase from this period (70–135 days old) in prepubertal gilts (Halli et al., 2008). Additionally, gilts were classified into four season groups on the basis of the date on which they were 91 days old: January to April (91–150 days old age period in months with increasing PP), May to June (transitional period 1), July to October (91–150 days old age period in months with decreasing PP) and November to December (transitional period 2).

2.4. Statistical analysis

All statistical analyses were conducted using SAS software (SAS Inst. Inc., Cary, NC). Two-level analysis was applied by using a herd at level 2 and an individual gilt at level 1, to take account of the hierarchic structure of the individual gilts within a herd (Singer, 1998). A linear mixed-effects model using the MIXED procedure with a Tukey–Kramer multiple comparisons test was applied for continuous AFM data.

A model was constructed to quantify the associations between AFM and either PP, the number of hot days or relative humidity. The fixed effect variables in the model were PP, the number of hot days, relative humidity, herd productivity groups and season groups. Herds in both humid subtropical climate zones and humid continental climate zones were used in the model because the climatic factors could explain the difference between the zones. Both

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