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SHORT COMMUNICATIONS

Lifetime reproductive performance and survival of English Berkshire female pigs raised in commercial herds in subtropical Japan

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Abstract The objective of the present study was to compare lifetime reproductive performance and survival probability of English Berkshire female pigs and crossbred females in a subtropical region of Japan. We analyzed records of 20,417 females entered into the 12 herds in Southern Japan from 2003 to 2007. Generalized linear mixed-effects models were conducted to compare the lifetime reproductive performance of the Berkshire and crossbred females. Multilevel mixed-effects models were conducted to compare the lifetime reproductive performance of the Berkshire and crossbred females. Also, a multilevel proportional hazard model was used to examine the survival probabilities for the two breeds. Berkshire gilts were 39.8 days older at first-mating than crossbred gilts ($P=0.05$). The pigs born alive (PBA) in Berkshire and crossbred gilts increased from 5.8 to 6.9 pigs and from 10.7 to 11.1 pigs, respectively, as age at first-mating increased from 220 to 310 days old ($P<0.05$). More Berkshire gilts were culled for reproductive failure than crossbred gilts (7.5 vs. 3.8 %; $P<0.05$). Also, Berkshire females had 2.7 lower parity at removal, 224.4 days lower reproductive herd-life, and 4.2 pigs fewer average lifetime PBA than crossbred females ($P<0.05$) and tended to have a lower survival probability ($P=0.05$). In summary, Berkshire females had later puberty, were more sensitive to age at first-mating for increasing PBA, and had lower fertility and a lower survival probability than crossbred females in commercial herds.

Keywords Berkshire pigs · Reproductive performance · Survival analysis · Swine

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Introduction

Approximately 57,000 Berkshire breeding females are reared for pure Berkshire production in Japan, mainly in the southern subtropical region, Kyushu, comprising approximately 6.4 % of the sow inventory of Japan (MAFF 2005), although three-way crossbred breeding is common in Japanese pork production. Berkshire pigs were originally imported from the UK or USA, and the breed has been maintained in Japan.

Measuring parameters associated with lifetime reproductive performance, including gilt age at first-mating, longevity, and culling risk, is critical for producers to optimize herd productivity and profitability (Sasaki and Koketsu 2011). Additionally, increased gilt age at first-mating, which is highly associated with pubertal age in female pigs, has been associated with increased number of pigs born alive (PBA) in parity 1 (Tummaruk et al. 2009). However, no studies have compared differences between Berkshire and crossbred females in subtropical Japan on the impact of gilt age at first-mating on PBA, lifetime performance, survival probability, and culling risk. Therefore, the objective of the present study was to compare the impact of gilt age at first-mating on PBA, lifetime performance, and survival in English Berkshire and crossbred females reared in the same subtropical region of Japan.

Materials and methods

The manuscript does not contain human patient data. Also, the data in this manuscript were obtained from an existing database.

Farms, data, and definitions

Records of 12 Japanese swine herds located between latitude 31–33° N and longitude 130–132° E in the same subtropical

region (Kyushu, southern Japan) were abstracted from the PigCHAMP database at Meiji University; it has been maintained using the PigCHAMP software (PigCHAMP, Ames, IA, U.S.A.). Two of the herds were raising only purebred English Berkshire females. The English Berkshire pigs were originally imported from the UK and have since been maintained in these two herds in Japan (KDF 2014). The remaining 10 commercial breeding herds comprised crossbred females between Landrace and Large White from national or international breeding companies. The breeding stocks in the national breeding companies were originally imported from the USA or Europe.

Mean values (ranges) of daily average temperature and relative humidity in the southern region from 2003 to 2009 were 17.7 (−2.5 to 32.0)°C and 68.1 (23.0 to 96.0)%, respectively (JMA 2014). Mean (±SEM) herd sizes for the Berkshire and crossbred breeding herds were 2357±245 and 457±110 females, respectively, and mean pigs weaned per mated female per year were 16.8±0.33 and 22.6±0.33 pigs, respectively.

Lifetime data of females entered between 2003 and 2007 were extracted from the database. The dataset contained records of 20,417 gilts having age at first-mating of 160–400 days, and 92,218 parity records of 15,537 sows in the 12 herds.

Females included gilts and sows; a gilt was defined as a female pig that had entered a herd but had not farrowed, and a sow was a female pig that had farrowed at least once. A service included one or more matings in a 10-day period of the estrus. Culling risk was defined as the number of culled females at each parity divided by the number of surviving females, multiplied by 100. Three categories of culling reasons were established (Engblom et al. 2007): "reproductive failure", "locomotor problems", and "others". Reproductive herd-life was defined as the number of days from the date of first-mating to removal date. Average lifetime PBA and pigs weaned were defined as the sum of PBA or pigs weaned in lifetime, respectively, divided by the number of parity at culling.

Statistical analysis

Generalized linear mixed-effects models were used to account for the clustering of females within a herd or the correlations among repeated measures in the same sow (SAS Int. Inc., Cary, U.S.A.). Two statistical models were constructed: Model 1 was applied for the comparisons of lifetime performance between the two breed groups. Model 2 was created to examine an interaction between the breed groups and age at first-mating in relation to PBA for gilts. A quadratic expression was examined in Model 2 for age at first-mating. Both the models included the herd as a random intercept. The normalities of the residuals in the final models were evaluated by using normal probability plots (Littell et al. 2006). Estimate statements were used for whether the slope of each variable was different from 0 or not.

A multilevel proportional hazard model in MLwiN software (MLwiN 2.26, University of Bristol, Bristol, UK) was used to examine the associations between the hazard of removal for a Berkshire female and a crossbred female. Removed females with a reproductive herd-life of less than 1000 days were treated as uncensored subjects, whereas surviving females and removed females with a reproductive herd-life of 1001 days or more were treated as censored subjects. Additionally, the herd was included as a random intercept in the model. As a limitation, herd health and nutrition were not taken into account.

Results

Berkshire gilts were 39.8 days older than crossbred gilts at first-mating ($P=0.05$), and had 17.6 % lower farrowing rate at second-service ($P<0.05$; Table 1). Also, more Berkshire gilts were culled for reproductive failure than crossbred gilts ($P<0.05$). Berkshire sows had a 19.2 % lower farrowing rate than crossbred sows at first-service ($P<0.05$). Additionally, Berkshire females had 2.7 lower parity at removal, 224.4 days lower reproductive herd-life, and 4.2 pigs fewer average lifetime PBA than crossbred females ($P<0.05$).

There was a two-way interaction between breed groups and gilt age at first-mating for PBA ($P<0.05$). The PBA in Berkshire gilts increased from 5.8 to 6.9 pigs as age at first-mating increased from 220 to 310 days old ($P<0.05$; Fig. 1), whereas PBA in crossbred gilts only increased from 10.7 to 11.1 pigs over the same age range ($P<0.05$).

Berkshire females tended to have a lower survival probability ($P=0.05$). At 60 weeks from first-mating, the survival probabilities for Berkshire and crossbred females were 68.9 and 74.8 %, respectively (Fig. 2).

Discussion

The increased age of Berkshire gilts at first-mating (approximately 6 weeks older) compared with crossbred gilts indicates that Berkshire gilts grow more slowly and have later puberty than crossbred gilts, when reared in the subtropical climate zone. Also, the greater increase in PBA in Berkshire gilts than crossbred gilts (1.1 vs. 0.4 pigs) achieved by delaying first-mating for 90 days, implies that age at first-mating is more important for PBA in Berkshire gilts than in crossbred gilts. Therefore, this indicates that in order to improve PBA at parity 1, producers should not mate Berkshire gilts until they have matured (e.g., 280 days or later) and developed sufficient

Table 1 Comparisons between Berkshire and crossbred female pigs for reproductive and lifetime performance

Measurements	Berkshire females		Crossbred females	
	N	Mean±SE	*N*	Mean±SE
Gilts				
Age at first-mating of gilts, days	11,608	280.5±10.5^{x}	8809	240.7±12.3^{y}
Farrowing rate at first-service, %	11,608	86.3±3.85	8809	87.4±4.26
Re-service rate at first-service, %	11,608	13.7±3.87	8809	12.5±4.25
Farrowing rate at second-service, %	1735	59.8±2.78^{y}	1078	77.4±3.24^{x}
Removed females				
Parity at removal	10,967	3.5±0.45^{y}	8040	6.2±0.55^{x}
Reproductive herd-life day, days	10,967	634.3±8.38^{y}	8040	858.7±11.1^{x}
Culling risk for reproductive failure				
At parity 0, %	10,967	7.5±1.60^{x}	8040	3.8±0.44^{y}
At parity 1, %	9562	7.8±2.86	7636	4.2±0.77
At parity 2 to 5, %	7867	19.3±3.85	6873	14.8±1.48
Culling risk for locomotor problems				
At parity 0, %	10,967	0.01±0.06	8040	0.2±0.07
At parity 1, %	9562	0.2±0.14^{y}	7636	0.9±0.23^{x}
At parity 2 to 5, %	7867	0.9±0.50	6873	2.8±0.69
Average lifetime pigs born alive, pigs	9562	6.9±0.16^{y}	7636	11.1±0.19^{x}
Average lifetime pigs weaned, pigs	9562	6.7±0.26^{y}	7636	9.8±0.30^{x}
Sows				
Lactation length, days	43,828	26.3±1.33	41,696	22.6±1.39
Farrowing rate at first-service, %	43,828	73.3±5.33^{y}	41,696	92.5±1.97^{x}
Farrowing rate at second-service, %	4457	72.7±1.90	2998	76.8±2.37

Mean and SE were estimated by mixed-effects multivariable models

Means within a row with different letters differ ($P \leq 0.05$)

body reserves. Also, crossbred gilts have been selected for early puberty in order to decrease age at first-farrowing and increase lifetime reproduction (Tummaruk et al. 2009), whereas Berkshire pigs have been selected for meat quality (Thomsen et al. 2004; Tomiyama et al. 2009) but not for early puberty.

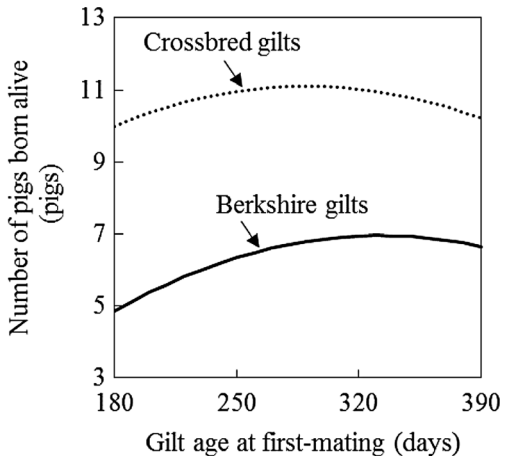

Fig. 1 Effect of gilt age at first-mating on estimated number of pigs born alive in two breed groups

In our study, the higher culling risk for reproductive failure at low parity, lower reproductive herd-life days, and lower survival probability in Berkshire females imply that Berkshire females in subtropical climate zones are likely to be culled earlier than crossbred females due to reproductive failure. Furthermore, in addition to the genetic effect, the lower

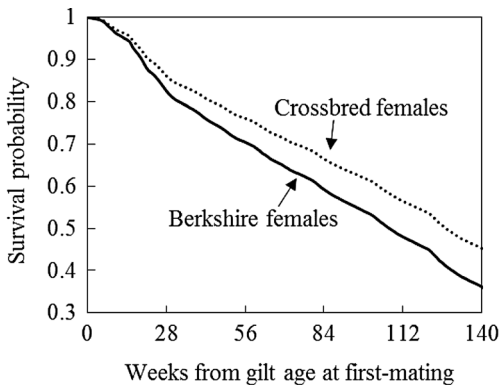

Fig. 2 Survival probability curves of female pigs in two breed groups. Survival probability curves were estimated by using the proportional hazards model

farrowing rate in Berkshire females than in crossbred females suggests that estrus detection and timing of mating are more difficult in Berkshire females. In summary, Berkshire females in the subtropical commercial herds had later puberty, were more sensitive to age at first-mating for PBA, and had lower fertility and a lower survival probability than crossbred females.

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Conflict of interest The authors declare that they have no conflict of interest.

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