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Reproductive performance of Japanese Black cattle: Association with herd size, season, and parity in commercial cow-calf operations

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ABSTRACT

The Japanese Black is the most common breed of beef cattle in Japan. However, only limited data are available on the associations of season, parity, and herd size with reproductive performance in Japanese Black cattle. Therefore, the objective of the present study was to determine the associations of these factors with reproductive performance parameters, such as the calving to first service interval (CFSI) and first service conception rate in Japanese Black cattle. Data were collected from 34,763 calvings in 13,186 animals from 826 commercial cow-calf operations in the Miyazaki prefecture, which is located on the south eastern coast of Kyushu, Japan. This region has a temperate climate with warm humid summers and cold winters. All cattle were reared intensively, and the animals were housed in free stalls throughout their lives. The mean number of cows per farm was 18 (range, 1–454). All animals were bred by artificial insemination. Herds were classified into three groups based on size: small ($\leq$10 cows), intermediate (11–50 cows), and large ($\geq$51 cows). The mean ($\pm$SD) parity, CFSI, and the first service conception rate were 4.9 $\pm$ 2.9, 80.0 $\pm$ 46.2 days, and 53.5 $\pm$ 49.9%, respectively. Cows that calved in the spring (March to May) and winter (December to February) had the longest CFSI ($P < 0.05$). The CFSI in first-parity cows was shorter than in cows at parity 7 or higher ($P < 0.05$). Cows in large herds had an approximately 10 days shorter mean CFSI than those in small herds ($P < 0.05$). Cows inseminated in the winter or spring had an approximately 5% points lesser first-service conception rate (FSCR) than those inseminated during the summer (June to August) or autumn (September to November; $P < 0.05$). As parity increased from 1 to 9, FSCR decreased from 60.0% to 43.1% ($P < 0.05$). Cows in small herds had a lesser FSCR than those in intermediate and large herds ($P < 0.05$). In summary, decreased reproductive performance in intensively reared Japanese Black cattle was associated with calving and artificial insemination during the winter and spring, greater parity, and small herd size.

1. Introduction

The Japanese Black, also known as the Wagyu, is the most common beef cattle breed in Japan. Known for its superior ability to produce marbled beef, the Japanese Black is a very pure breed; no foreign genes have been introduced into Japanese Black breeding stock in Japan for over a century [1]. Production of this breed is expensive, and the value of a Japanese Black calf is about four times that of a Holstein-Friesian calf [2]. Recently, the price of Japanese Black calves has gradually increased because of a decline in the number of cow-calf operations.

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Reproduction is one of the most economically important traits in beef production [3]. To improve productivity and reproductive efficiency, production standards and targets must be established to allow diagnosis of suboptimal reproductive rates. However, such standards and targets have not been well defined in Japanese Black cow-calf operations. Reproductive efficiency can be measured as the calving interval, which is strongly associated with the calving to first service interval (CFSI), first-service conception rate (FSCR), calving to conception interval (CCI), and the number of artificial inseminations (AI) per conception. In beef cattle, these performance parameters are reportedly associated with parity [4], season [5], and the number of days between calving and insemination [6]. In particular, heat stress decreases cow fertility in dairy cattle [7], but the relationship between heat stress and productivity in beef cows varies; in *Bos taurus* beef cows, there is no association between heat stress and pregnancy rates [8], whereas heat stress during early pregnancy reportedly increases embryonic mortality [9]. In addition, herd size influences standard operating procedures and can be associated with reproductive performance. Therefore, the objective of this study was to quantify the reproductive performance of Japanese Black cattle and to determine the associations of season, parity, and herd size with reproductive performance.

2. Materials and methods

2.1. Data collection

Data used in this study were collected from farms in suburban areas of the city of Miyazaki in Miyazaki prefecture, Japan. Miyazaki prefecture is located on the southeastern coast of Kyushu, Japan; it is a major cow-calf producing region and has the second largest cattle population in the country [10]. Miyazaki city is located at 131 ° 24′ E longitude and 31 ° 56′ N latitude and has a temperate climate with warm humid summers and cold winters. Of the 1101 farms in the area that raised Japanese Black cattle, calving data were available from 826. Data were collected from 34,763 calvings in 13,186 animals on these 826 farms between April 2006 and March 2010. All dams had a 10-digit unique identification number (National Livestock Breeding Center). Dam number, birth date of dam, date of AI and calving, and parity were obtained from the database managed by the Miyazaki Prefecture Livestock Association. The mean number of cows per farm was 18 (range, 1–454). All animals were reared in an intensive system in which animals were housed in uninsulated free stalls with cubicle beds throughout their lives. Cattle grazing was not performed in this region. Cows were fed rice, Italian, or oat straw twice daily. Artificial insemination was used exclusively on all operations, and there was no limited breeding season. Estrus detection was performed from approximately 40 days after calving. Pregnancy status was checked using an ultrasound scanner from approximately 30 days after AI. The calves were weaned at approximately 100 days of age, and cows and calves were separately reared after weaning.

Because these data were obtained from a regional database and no experiments were performed on live animals, Animal Care and Use Committee approval was not sought.

2.2. Definition and category

In this study, the reproductive performance of Japanese Black cattle was assessed based on four parameters: CFSI, CCI, FSCR, and number of AI per conception. Calving period and AI were categorized according to season: winter (December to February; n = 7589), spring (March to May; n = 8071), summer (June to August; n = 9601), and autumn (September to November; n = 9502). The average daily temperature was 8.6 °C in winter, 16.0 °C in spring, 25.9 °C in summer, and 19.4 °C in autumn (Japan Meteorological Agency). Herds were classified into three groups based on size: small (≤10 cows; n = 7335), intermediate (11–50 cows; n = 18,700), and large herds (≥51 cows; n = 8728). Parity was classified as 1 (n = 4721), 2 (n = 4485), 3 (n = 4175), 4 (n = 3937), 5 (n = 3687), 6 (n = 3543), 7 (n = 3173), 8 (n = 2705), 9 (n = 1972), and 10 or more (n = 2365). Values of CFSI were stratified into three groups on the basis of the upper and lower 25th percentiles: 0 to 50 days (n = 8922), 51 to 94 days (n = 17,338), and 95 days or more (n = 8503).

2.3. Statistical analysis

All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). A mixed-effects model was used to account for the clustering of parity records within individual cows and of cows within individual farms. A multilevel linear mixed-effects model using the MIXED procedure with Tukey–Kramer multiple comparisons and a multilevel mixed-effects logistic regression model using the GLIMMIX procedure with contrasts were used to compare the four measures of reproductive performance.

Statistical models were constructed to determine the associations of season, parity, and herd size with reproductive performance. The four reproductive performance parameters (CFSI, CCI, FSCR, and number of AI per conception) were separately used as the dependent variables. For the analysis of CFSI and CCI, the independent variables were herd size, season at calving, and parity. For the analysis of FSCR and number of AI per conception, the independent variables were herd size, season at service, parity, and CFSI group. All possible two-way interactions between the independent variables were included in all models, but insignificant interactions were removed from the final models ($P \geq 0.05$). Farm, calving year, and the interaction between farm and year were included as random intercepts in all models. Mean and SD were used to present data as descriptive statistics, and mean and SEM were used to show the results on the comparisons of productivity by each factor.

3. Results

Descriptive statistics for production performance parameters are presented in Table 1. The average cow age at calving (±SD) was 2274.4 ± 1172.7 days.

The CFSI was associated with herd size, season at calving, and parity ($P < 0.05$). Cows that calved in the spring (mean ± SEM: 82.5 ± 0.49 days) and winter