Risk factors for stillbirth and dystocia in Japanese Black cattle

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Abstract

Stillbirth and dystocia are major factors that negatively affect productivity in beef industry since producers' revenue relies merely on calf production as opposed to dairy cattle. The objective was to determine the effect of season, parity, and gestation length on the incidence of stillbirth and dystocia in Japanese Black cattle. Calving records were obtained from 905 farms between April 2006 and March 2010 in Miyazaki Prefecture, Japan. During the investigation period, the average age and parity of 41,116 calvings in 15,378 animals were 4.87 ± 2.95 (mean ± SD), and the percentage of primiparous cows in of 41,116 calvings was 14.42%. The number of stillbirths was 1,013 and the stillbirth rate was 2.46 ± 15.50%. For primiparous cows, rates of stillbirth and dystocia were higher (P <0.05) compared with those of multiparous cows. Stillbirth rates were higher in cows ≥301 days of pregnancy and those ≤280 days of pregnancy than any other groups between 281 and 300 days of pregnancy (P <0.05). The stillbirth rate in winter (December to February) was 3.18 ± 17.54%, which was higher (P <0.05) than calvings that occurred in spring (March to May), summer (June to August) and autumn (September to November). Similarly, the dystocia rates in winter and spring were higher (P <0.05) compared with those that occurred in the other seasons (P <0.05). Low temperatures in winter, first calving, premature birth and excessive fetal weight

are risk factors for stillbirth and dystocia in Japanese Black cattle.

Keywords: Cattle; Dystocia; Risk factors; Season; Stillbirth

Introduction

Stillbirth and dystocia are major factors that negatively affect productivity in the beef industry. Stillbirth and dystocia are costly to producers due to calf losses and decreased subsequent reproductive performance, and its impact on the producers' revenue is much greater than that on dairy industry. The conception rate was lower, and the number of services per conception was higher in cows afflicted with dystocia compared with normal calving cows in beef cattle (83.7 vs. 89.8% and 1.70 vs. 1.66, respectively; Laster *et al*., 1973). In recent years, stillbirth in cattle has been increasing in countries around the world such as Iran (Atashi, 2011), Denmark (Hansen, 2004) and the United States (Meyer *et al*., 2001). Ogata *et al*. (1995) reported that the stillbirth rate of Japanese Black cattle was 2.4% through 1987 to 1993. Likewise, dystocia rates in Holstein-Friesian cattle have been reported to be high in Ireland (6.8%, Mee *et al*., 2011), Canada (6.9%, Sewalem *et al*., 2008) and the United States (13.7%, Gevrekci *et al*., 2011). Dams that have experienced dystocia reportedly had poor subsequent reproductive performance. The conception rate was lower, and the number of services per conception was higher in cows afflicted with dystocia compared with normal calving cows in Holstein-Friesians (60.5 vs. 73.0% and 3.4 vs. 2.7, respectively; Gaafar *et al*., 2011). When the mean air temperature increased up to -0.6 from -6.7°C, the average birth weight of newborn calves decreased to 32.7 kg from 37.3 kg and the rate of dystocia also decreased to 35 % from 58% in beef cattle (Colburn *et al*., 1997). In a 6-year study, calves born during the coldest winter (-5°C) were 5 kg heavier than those born during the warmest winter (0.5°C), and the dystocia rate in the coldest winter was 29 percentage points higher than that in the warmest winter in beef cattle (Deutscher *et al*., 1999). The beef calves born from 2-year-old cows suffered more from dystocia and had a lower neonatal survival rate due to a severe cold climate than calves born from older cows (Azzam *et al*., 1993).

Japanese Black is the main breed of beef cattle in Japan. Because of the quite intensive house system adapted, where the animals were housed throughout their life and fed with high-quality hay (rice, Italian and oat straw) and concentrate, rearing Japanese Black cattle requires high production costs, and the price of a Japanese Black calf is about four times higher than that of a Holstein-Friesian calf in Japan. Therefore, the economic loss incurred by stillbirth in Japanese Black cattle has a devastating impact on beef producers. Ogata *et al*.

(1999) reported that the cases of stillbirth without a specific cause were characterized by a shorter gestation period and a lower than normal birth weight than normal calving. So far, however, the incidence rates, risk factors and causes of stillbirth and dystocia in Japanese Black cattle have not been fully understood.

Our objective, therefore, was to clarify the risk factors for the incidence of stillbirth and dystocia in Japanese Black cattle by retrospectively analyzing reliable calving records.

Materials and methods

Study area

Data of all of the farms (n = 905), located in suburban area of Miyazaki City, including the surrounding towns, i.e. Kunitomi town and Aya town, in Japan, were used. Data on daily minimum and maximum temperatures in Miyazaki City were collected from the Japan Meteorological Agency (http://www.jma.go.jp/jma/menu/report.html). The temperature measurement point was located at 131° 24’ E longitude and 31° 56’ N latitude at an altitude of 9 m. All of the 905 farms surveyed were located within a 20 km radius from the temperature measurement point. The average altitude of the farms was 46.9 ± 50.6 m (mean ± SD).

The average annual temperature of the city was 17.8 °C, the average lowest temperature was 13.7°C, the average highest temperature was 22.4°C. The average temperature in spring (March to May) was 15.9°C that in summer (June to August), autumn (September to November) and winter (December to February) were 25.9°C, 19.4°C and 8.5°C, respectively. The average lowest temperatures in spring, summer, autumn and winter were 11.3°C, 22.8°C , 16.0°C and 4.5°C, respectively. The average highest temperatures in spring, summer, autumn and winter were 20.7°C, 29.8°C, 24.5°C and 14.4°C, respectively.

Animals

We investigated a total of 41,116 calvings, that took place between April 2006 and March 2010, in 15,378 animals. The average number of female adult cattle per farm was 17.96 ± 29.05 animals ranging from 1 to 454. All the animals were housed all day long throughout the year in uninsulated barns. The barns were ‘open cubicle housings’ without wall, and therefore, there was no difference in air temperature between inside and outside of the barns. Rice, Italian or oat straw were fed individually to cows twice daily. All of the animals were bred by artificial insemination.

Data collection

All of the dams had a 10-digit unique identification number (dam number) that is managed by National Livestock Breeding Center (Shin-Shirakawa, Fukushima, Japan) and Miyazaki Prefecture Livestock Association (Miyazaki, Japan). The following data were obtained from an existing database managed by the Miyazaki Prefecture Livestock Association; dam number, birth date of dam, date of AI and calving, parity, gestation length, stillbirth, dystocia and causes of dystocia.

Definitions

Stillbirth was defined as a dead fetus found during parturition that occurred more than 240 days after AI at which the born calf could survive after birth, following the definition of stillbirth in Japanese Black cattle by elsewhere (Ogata *et al*., 1995). Stillbirth rate was calculated as the number of stillbirth records divided by the number of all calving records. Dystocia was defined as calving that required veterinary assistance. Veterinarians were called whenever calving assistance was needed. Calving assistance was carried out by a veterinarian or by a veterinarian and farmer(s). A total of 30 veterinarians were involved in calving assistance and all of them used a medical recording system of the same format according to the same criteria for diagnosis. Dystocia rate was calculated as the number of dystocia records divided by the number of all calving records. Causes of dystocia were recorded according to the standard veterinary criteria, and were classified into either maternal factors including weak labor pains and narrow birth canal, or fetal factors including excessive birth weight, abnormal position and/or posture, twins and congenital anomalies. Excessive birth weight was defined as that fetus weight was greater than 29 kg in female and 30 kg in male calves, respectively (Ogata *et al*., 1999; Ibi *et al*., 2008). Caesarean section was carried out if vaginal delivery was not possible after attempt of manual correction of abnormal position and/or abnormal posture. Congenital anomalies were defined as structural defects.

Greater than parity 10 were combined into parity 10. Calving month was divided into four groups according to seasons; winter, spring, summer and autumn. Winter was defined as the months from December to February, spring as March to May, summer as June to August, and autumn as September to November. Gestation length was divided into five groups; ≤270 days, 271–280 days, 281–290 days, 291–300 days, and ≥301 days.

Statistical analysis

All statistical analyses were conducted with SAS software (SAS Institute Inc., Cary, NC, USA). A mixed-effects logistic regression model using GLIMMIX procedure with contrasts was applied to investigate the association of season, parity and gestation length with stillbirth and dystocia rate. Model was:

$Logit\ (p_{ijklmn}) = \alpha + PY_i + SSN_j + GL_k + F_l + Y_m + F_l \times Y_m,$

where p_{ijklmn} was probability of a stillbirth occurrence (stillbirth rate) or probability of a dystocia occurrence (dystocia rate); α was the intercept; PY_i was the fixed effect of the *i*th parity groups (i=1 to 10); SSN_j was the fixed effect of *j*th season groups (j=1 to 4); GL_k was the fixed effect of *k*th gestation length groups (k=1 to 5); F_l was the random effect of *l*th farm (l=1 to 905); Y_m was the random effect of *m*th calving year (m=1 to 5); $F_l \times Y_m$ was the random interaction effect between the *l*th farm and the *m*th year. The two-way random interaction was used to account for a part of the correlations of the data within a cattle in the model.

Results

During the investigation period, the average age, parity and gestation length of the 41,116 calvings were 2283.37 ± 1206.05 (mean ± SD), 4.87 ± 2.95 and 289.73 ± 5.92 days, respectively (Table 1). Number of stillbirths was 1,013 and the rate of stillbirth was 2.46 ±

15.50%. Herd average of stillbirth rate on 905 farms was 2.44 ± 5.29% (mean ± SD). The rates of stillbirth were lower in summer but higher in winter, changing cyclically throughout the 4 years (Figure 1). In this survey, winter 2007 was the warmest, when the stillbirth rate was the lowest (2.41 ± 0.56%).

Stillbirth rate was associated with season, parity, and gestation length. Stillbirth rate in winter was 3.18 ± 17.54%, which was higher compared with those in spring, summer and autumn. Odds ratios (ORs) were 1.008 and 1.004 for stillbirth rate in winter vs. summer and spring vs. summer, respectively ($P < 0.05$; Table 3). Stillbirth rate at first calving was higher than those at second to sixth, eighth and over the 10th calving. OR was 1.010 for first calving vs. fifths calving ($P < 0.05$; Table 2). Stillbirth rate in the dams calved at less than 270 days of pregnancy was the highest among the gestation length groups ($P < 0.05$). Stillbirth rates were higher in cows at ≥ 301 days of pregnancy and those at ≤ 280 days of pregnancy than any other groups between 281 and 300 days of pregnancy. ORs were 2.072, 1.084 and 1.049 for ≤ 270 days vs. 281–290 days, 271–280 days vs. 281–290 days, and ≥ 301 days vs. 281–290 days, respectively ($P < 0.05$; Table 4).

Out of the 41,116 calvings, 3,514 were dystocia (8.55 ± 27.96 %). Herd average of dystocia rate on 905 farms was 12.43 ± 15.12 %. Dystocia rate was associated with season, parity and gestation length. Dystocia rate in winter and spring was higher compared with those in summer and autumn. ORs were 1.011 and 1.020 for dystocia of winter vs. summer and spring vs. summer, respectively ($P < 0.05$; Table 3). Dystocia rate in primiparous cows was higher than that in multiparous cows. OR was 1.053 for first calving vs. fifths ($P < 0.05$; Table 2). Dams calved at 291 to 300 days had the lowest dystocia rate of all the gestation length groups. ORs were 1.124, 1.076, 0.981 and 1.033 for ≤ 270 days vs. 281–290 days, 271–280 days vs. 281–290 days, 291–300 days vs. 281–290 days and ≥ 301 days vs. 281–290 days, respectively ($P < 0.05$; Table 4).

Out of 3,514 dystocia cases, 254 (7.2%) were stillbirth. Among the different causes of dystocia, excessive fetal birth weight was the most frequently encountered finding (39.7%). However, the major reasons for fetal death due to dystocia were congenital anomalies, twins, and abnormal position and/or posture (Table 5).

Dystocia rate due to excessive birth weight was associated with season, parity and gestation length ($P < 0.05$; Table 2, 3, 4). The dystocia due to excessive birth weight rate in spring was the highest among the four seasons (3.99 ± 19.57%) compared with those in summer and autumn. OR was 1.005 for dystocia due to excessive birth weight rate of spring vs. summer ($P < 0.05$; Table 3). Dams calved at 301 days or longer of pregnancy had higher dystocia rate due to excessive birth weight than the dams calved at 300 days or shorter of pregnancy. OR was 1.031 for dystocia rate by excessive birth weight at ≥ 301 days vs. 281–290 days ($P < 0.05$; Table 4).

Dystocia rate due to abnormal position and/or posture was associated with season and gestation length. ORs were 1.007 and 1.006 for winter vs. summer and spring vs. summer, respectively, ($P < 0.05$; Table 3, 4), but not with parity. Dams calved at gestation length of 291 to 300 days had the lowest rate of dystocia due to abnormal position and/or posture. ORs were 1.050, 1.030, 0.996 and 1.019 for ≤ 270 days vs. 281–290 days, 271–280 days vs. 281–290 days, 291–300 days vs. 281–290 days and ≥ 301 days vs. 281–290 days, respectively ($P < 0.05$; Table4). In addition, dates of dystocia due to abnormal position and/or posture in winter and spring were higher than those in summer and autumn. ($P < 0.05$; Table 3).

Discussion

The incidence was lower compared with those of previous studies. Berglund *et al.* (2003) reported that during the past 20 years an increase from 6.0 to 10.3% occurred in the incidence of stillbirth in first calving Swedish Holstein cows in Sweden. Meyer *et al.* (2001)

reported that from 1985 to 1996 the incidence of stillbirth increased from 9.5 to 13.2% in primiparous and 5.0 to 6.6% in multiparous cows. Here, the stillbirth rate of Japanese Black cattle was 2.46% and this figure was consistent with that shown by a previous report (Ogata *et al*., 1995). Relatively low figures in the stillbirth rate in Japanese Black cattle may result from the intensive calving management of the housed beef cattle.

We showed that the stillbirth rate in winter was higher compared with those in summer and autumn. In this survey, winter 2007 had the highest temperature and lowest stillbirth rate (2.41 ± 0.56%) of the 4 years of the investigation period. Deutscher *et al*. (1999) reported that as average winter temperatures decreased, subsequent calf birth weights increased and calving difficulty increased, and that as temperature decreased, dystocia rate increased. Colburn *et al*. (1997) suggested that severely cold winter in Nebraska can increase calf birth weights and can cause calving difficulty. Increased blood flow to the uterus at low temperatures is thought to be the primary factor that increases fetal growth (Ferrell, 1991). The climate in Miyazaki was warmer than that in Nebraska. Further studies will be required to determine whether low temperatures in winter in the area we studied may affect (increase) blood flow to the uterus in Japanese Black cattle. Mee *et al*. (2008) reported that the principal types of dystocia differ between primiparous and multiparous cows, with feto-pelvic disproportion predominating in the former and fetal malposition in the latter. In order of importance, the two major determinants of feto-pelvic disproportion are calf birth weight and maternal pelvic size. It is, therefore, suggested that an increase in fetal weight is one of the factors that increases the rates of dystocia and stillbirth in winter.

Primiparous cows had higher rates of both dystocia and stillbirth than multiparous cows. These results suggest that feto-pelvic disproportion is also a major reason for dystocia and stillbirth in Japanese Black primiparous cows. It was reported that female Japanese Black cattle become fully developed in body size at 36 months (Wada *et al*., 1987). In this survey, average age of the first calving cows was 713 days. At the first calving, the body size does not mature yet. Heifers with an immature pelvis that are pregnant with a large fetus are at the greatest risk of dystocia.

Azzam *et al*. (1993) reported that calves born to 2-year-old cows were more susceptible to severe weather conditions than calves born to older cows, and that the negative effect on survival increased with decreasing temperature. Similarly, our study showing stillbirth rate was the highest in the Japanese Black primiparous cows in winter indicate that winter, when the temperature was the lowest, had the greatest impact on stillbirth rate compared with other seasons.

The average gestation length of Japanese Black cattle in the present study, 289 days, is similar to another study reporting 287 days (Uchida *et al*., 2002). Here, rates of stillbirth and dystocia were higher in cows ≥ 301 days and ≤ 280 days of gestation period. In particular, high rates of stillbirth and dystocia in cows ≤ 270 days of gestation period (74.5 ± 2.1% and 20.5 ± 2.0%, respectively) were consistent with the figures reported in Holstein cows (Olson *et al*., 2009).

When no delivery takes place by the expected date of birth in human, stillbirth rate will be high because of decreased placental function, reduced amniotic fluid, turbid amniotic fluid by meconium and damage due to excessively large fetus at delivery (Robert, 2007). It seems to be logical to infer that rates of stillbirth and dystocia could be affected by the gestational age of the cow as it is in humans. As to whether pathology for stillbirth and dystocia in the cow is similar to humans, there is a need for further research in this area.

The incidence of dystocia in our study was 8.55%, which agrees with reports from around the world such as Ireland (6.8%, Mee *et al*., 2011), Canada (6.9%, Sewalem *et al*., 2008) and the United States (13.7%, Gevrekci *et al*., 2011). The dystocia definition of these previous studies were considerable calving difficulty and veterinary assistance (Mee et al., 2011), hard pull and surgery (Sewalem et al., 2008) and needed assistance, considerable force and extreme difficulty (Gevrekci et al., 2011), and therefore, our definition of dystocia was about the same as those by above mentioned previous studies. In addition, our finding that the rate of dystocia was associated with temperature is supported by other reports (Azzam *et al*., 1993; Zaborski *et al*., 2009).

When classified on the basis of causes of dystocia, cows with abnormal position and/or posture, twins and congenital anomalies were more likely to have a stillbirth. Our results in Japanese Black cattle were consistent with other reports in Holstein cattle (Correa *et al*., 1993; Emanuelson *et al*., 2004), and in Swedish Red White cattle (Maizon *et al*., 2004). Rates of dystocia caused by abnormal position and/or posture were higher in winter and spring than those in summer and autumn. Stillbirth caused by dystocia due to fetal abnormal position and/or posture is probably one of the factors that increases stillbirth rate in winter since it not only has high incidence but it also occurs in a greater number of animals. Because fetal abnormal position and/or posture may also be caused by fetal death in utero before the onset of parturition, a greater number of fetuses may have died in winter before calving. Possibility of the fetal death in utero at the end of pregnancy are in need of further research.

Rate of dystocia caused by excessive birth weight was higher in spring than the other three seasons. Dams spend late pregnancy in winter, calve in spring. When dams are at the end of the gestation period in winter, the fetuses need to get through days of rapid growth in winter, and this may be more likely to result in dystocia caused by excessive birth weight compared with other seasons. Approximately 90% of fetal weight is increased in the last 40% of the total gestation period (Ferrell *et al*., 1976). Although other factors such as management and nutrition (feeding) need to be investigated as possible factors that may influence on the incidence of excessive birth weight, we conjecture that parturition in cows exposed to a cold environment during the last part of pregnancy may be more prone to have stillbirth and dystocia compared to the other seasons. Effective measures in calving management must be taken to reduce stillbirth and dystocia rates in winter.

Conclusions

Rates of stillbirth and dystocia were significantly higher in primiparous cows compared with multiparous cows. Rates of stillbirth and dystocia were high in cows ≤ 280 days and ≥ 301 days of gestation. Stillbirth rate in winter was significantly higher compared with in spring, summer and autumn. Dystocia rates in winter and spring were significantly higher compared with those in summer and autumn. Low temperatures in winter, first calving, premature birth and excessive fetal weight are risk factors for stillbirth and dystocia in

Japanese Black cattle.

Conflict of interest statement

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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Table 1. Descriptive statistics

	Number of animals	Mean ± SD
Stillbirth rate	41,116	2.46 ± 15.50
Dystocia rate	41,116	8.55 ± 27.96
Dystocia by excessive birth weight	41,116	3.40 ± 18.11
Dystocia by abnormal position and/or posture	41,116	2.13 ± 14.43
Parity	41,116	4.87 ± 2.95
Age at calving	41,116	2283.37 ± 1206.05
Age of first conception in heifers	5,855	425.41 ± 63.95
Age of first calving in heifers	5,855	713.00 ± 64.13
Gestation period	41,116	289.73 ± 5.92

Table 2. Stillbirth and dystocia rate by parity

Parity	Number of animals	Stillbirth rate, %		Dystocia rate, %		Dystocia rate by excessive birth weight, %		Dystocia rate by abnormal position and/or posture, %	
		Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]
1	5,855	3.71 ± 18.89[a]	1.010* (1.004-1.015)	13.00 ± 33.63[a]	1.053* (1.042-1.064)	5.84 ± 23.45[a]	1.033* (1.026-1.041)	2.82 ± 16.55	NS
2	5,235	2.22 ± 14.72[b]	NS	7.66 ± 26.60[b]	NS	3.13 ± 17.42[b]	NS	2.08 ± 14.28	NS
3	4,785	2.26 ± 14.85[b]	NS	8.13 ± 27.33[b]	NS	3.45 ± 18.25[b]	NS	1.59 ± 12.50	NS
4	4,514	2.41 ± 15.35[b]	NS	7.35 ± 26.11[b]	NS	3.04 ± 17.16[b]	NS	2.06 ± 14.21	NS
5	4,239	2.22 ± 14.73[b]	Reference	7.93 ± 27.02[b]	Reference	2.95 ± 16.92[b]	Reference	1.98 ± 13.94	Reference
6	4,096	1.51 ± 12.21[b]	NS	7.93 ± 27.03[b]	NS	2.76 ± 16.38[b]	NS	2.25 ± 14.82	NS
7	3,752	2.48 ± 15.55[ab]	NS	8.02 ± 27.17[b]	NS	2.96 ± 16.95[b]	NS	2.29 ± 14.97	NS
8	3,207	2.09 ± 14.30[b]	NS	7.33 ± 26.06[b]	NS	3.06 ± 17.21[b]	NS	1.75 ± 13.10	NS
9	2,379	2.82 ± 16.55[ab]	NS	7.23 ± 25.90[b]	NS	2.48 ± 15.55[b]	NS	2.02 ± 14.06	NS
≥10	3,054	2.62 ± 15.97[b]	NS	8.58 ± 28.01[b]	NS	2.69 ± 16.17[b]	NS	2.16 ± 14.54	NS

Values within a column without a common superscript (a-b) were different ($P < 0.05$).
[1]The values in the parentheses were 95% confidence intervals. *$P < 0.05$
NS = Not significant

Table 3. Stillbirth and dystocia rate by season

Season	Number of animals	Stillbirth rate, %		Dystocia rate, %		Dystocia rate by excessive birth weight, %		Dystocia rate by abnormal position and/or posture, %	
		Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]
Winter	9,659	3.18 ± 17.54^{a}	1.008* (1.004-1.012)	9.01 ± 28.63^{a}	1.011* (1.004-1.019)	3.43 ± 18.19^{ab}	NS	2.42 ± 15.38^{a}	1.007* (1.003-1.011)
Spring	11,131	2.62 ± 15.98^{b}	1.004* (1.001-1.008)	9.98 ± 29.98^{a}	1.020* (1.013-1.027)	3.99 ± 19.57^{a}	1.005* (1.001-1.010)	2.43 ± 15.41^{ab}	1.006* (1.002-1.01)
Summer	11,361	2.01 ± 14.02^{c}	Reference	7.84 ± 26.89^{b}	Reference	3.24 ± 17.70^{b}	Reference	1.80 ± 13.31^{c}	Reference
Autumn	8,965	2.07 ± 14.25^{c}	NS	7.16 ± 25.79^{b}	NS	2.82 ± 16.56^{b}	NS	1.84 ± 13.44^{bc}	NS

Values within a column without a common superscript (a-c) were different ($P < 0.05$).
[1]The values in the parentheses were 95% confidence intervals. *$P < 0.05$
NS = Not significant

Table 4. Stillbirth and dystocia rate by gestation length

Gestation length	Number of animals	Stillbirth rate, %		Dystocia rate, %		Dystocia rate by excessive birth weight, %		Dystocia rate by abnormal position and/or posture, %	
		Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]	Mean ± SD	Odds ratio[1]
≤270	396	74.49 ± 43.64^{a}	2.072* (2.044-2.101)	20.45 ± 40.39^{a}	1.124* (1.095-1.154)	1.52 ± 12.23^{b}	NS	7.07 ± 25.67^{a}	1.050* (1.035-1.065)
271 to 280	1,472	9.65 ± 29.53^{b}	1.084* (1.076-1.092)	15.56 ± 36.26^{b}	1.076* (1.061-1.092)	2.99 ± 17.03^{b}	NS	4.82 ± 21.43^{ab}	1.030* (1.022-1.038)
281 to 290	19,833	1.51 ± 12.21^{d}	Reference	8.69 ± 28.17^{d}	Reference	3.39 ± 18.09^{b}	Reference	2.05 ± 14.18^{c}	Reference
291 to 300	18,965	1.31 ± 11.36^{d}	NS	7.54 ± 26.4^{e}	0.981* (0.976-0.987)	3.42 ± 18.18^{b}	NS	1.85 ± 13.48^{d}	0.996* (0.993-0.999)
≥301	450	6.22 ± 24.18^{c}	1.049* (1.035-1.062)	11.11 ± 31.46^{c}	1.033* (1.008-1.059)	5.56 ± 22.93^{a}	1.031* (1.014-1.048)	4.00 ± 19.62^{b}	1.019* (1.005-1.032)

Values within a column without a common superscript (a-e) were different ($P < 0.05$).

[1]The values in the parentheses were 95% confidence intervals. *$P < 0.05$

NS = Not significant

Table 5. The number (%) of stillbirth per dystocia in Japanese Black cattle by different causes

Cause	Number of dystocia	Relative frequency of cause, %	Death number of fetus (%)	
Excessive birth weight	1,396	39.7	52	(3.7)
Abnormal position and/or posture	875	24.9	114	(13.0)
Weak labor pains	633	18.0	15	(2.4)
Narrow birth canal	359	10.2	30	(8.4)
Twins	34	1.0	5	(14.7)
Congenital anomaly	9	0.3	5	(55.6)
Others	208	5.9	33	(15.9)
Total	3,514	100.0	254	

Figure legend

Figure 1. Changes in environmental temperature at Miyazaki City. Y axis indicates average daily temperature per month with error bars of standard deviation per month.