The effect of season of birth on the morphometrics of newborn Belgian Blue calves

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Abstract
Breed type and environmental factors such as breeding season may have a significant impact on neonatal morphometrics. We followed a total of 236 elective cesarean sections in Belgian Blue (BB) cows, from which neonatal calves were morphometrically assessed (in cm) within the first 72 h of delivery using a strictly standardized protocol. The effect of the season of birth on each calf measurement was analyzed using mixed linear regression models, including the farm of origin as a random effect. Calves born in spring had a longer diagonal length (69.7 ± 1.24; \( P = 0.05 \)) than those born in autumn (66.9 ± 1.16). The tibial length of calves born in spring (35.8 ± 0.48) was longer (\( P < 0.02 \)) than of those born in autumn (33.1 ± 0.57) or summer (34.1 ± 0.49). Calves born in autumn have a shorter head diameter (12.9 ± 0.23; \( P < 0.02 \)) than those born in summer (12.6 ± 0.29) or winter (13.5 ± 0.22). For all other parameters, no differences were found (\( P > 0.08 \)). Based on the results of this study, it can be concluded that the birth season influences the morphometrics of neonatal BB calves, with a tendency for spring to be associated with the largest body size. The latter is important to avoid dystocia when BB cattle are crossed with other breeds.

Keywords Double-muscle cattle · Dystocia · Cesarean section · Calf size

Introduction
Dystocia is a well-known problem since it increases the incidence of neonatal calf death (Bleul 2011; Barrier et al. 2014) and hereby compromises the income of the farmer (Hohnholz et al. 2019). Multiple factors such as breed, genetic potential of bulls and dams, sex of the calf, the degree of inbreeding, or genetic disorders are all known to be associated with the weight and size of a newborn calf. However, environmental factors like the effect of the season of the year seem to be associated with neonatal calf morphometrics (Koçak et al. 2007). Belgian Blue (BB) cattle have double-muscled properties, resulting in an excellent carcass conformation but an increased risk of dystocia (Olivier and Cartwright 1968). Cases of severe dystocia requiring surgical intervention are usually those caused by a disproportion between the shoulders, hip or rump of the fetus, and the anterior pelvic canal or pelvic opening of the double-muscled dam (Ménissier and Foulley 1979).

We investigated the impact of calving seasons on body measurements of neonatal BB calves. We hypothesized that the season of birth impacts newborn BB calf sizes because of multiple prenatal factors, including the cow’s physiology to adapt to heat stress and the frequently observed seasonal changes in diet.

Materials and methods
Two hundred and thirty-six BB cows from 42 farms in Belgium delivered between October 2016 and June 2020 were enrolled. All calves were born by elective cesarean section (CS) in the Clinic of Reproduction and Obstetrics
at the Faculty of Veterinary Medicine of Ghent University (Belgium). From each CS, the following data were recorded: farm of origin, date of birth and parity of the dam, date of CS, calf gender, calf birth weight, height at the withers, width at the shoulder, pelvic height and width, radial and tibial length, metacarpal and metatarsal length, head diameter and circumference, heart girth, circumference at the claws, and diagonal length as described in detail by (Fig. 1) (Kamal et al. 2014).

**Fig. 1** Illustration of morphometric parameters on Belgian Blue calves: (a) width at the shoulder, (b) pelvic width, (c) height at the withers, (d) tibial length, (e) metatarsal length, (f) head circumference, (g) head diameter, (h) heart girth, (i) pelvic height, (j) circumference at the claws, (k) radial length, (l) metacarpal length, (m) diagonal length

**Fig. 2** Correlation plot showing the associations among Belgian Blue calf measurements involving a total of 236 elective cesarean sections. The color intensity is proportional to the strength of the (Pearson) correlation.
Statistical analyses were performed using RStudio version 4.0.4 (R Core Team, Vienna, Austria). The calf was considered as the unit of interest. Cows originated from 42 farms, but farms that provided ≤ 10 cows (n = 30) were classified in 1 farm category. The effect of season: spring (March 21–June 21), summer (June 22–September 23), fall (September 24–December 22), and winter (December 23–March 20), on each calf measurement was analyzed using mixed linear regression models, with the farm of origin as a random effect. Season of birth was forced into each model, and covariates (parity (primiparous or multiparous) and calf gender (male or female)) were offered into each model and retained when \( P < 0.05 \). Model residuals were assessed using a scatterplot of the studentized residuals for homoscedasticity, a linear predictor for linearity, and a Shapiro-Wilk test for normality. Differences between levels of explanatory variables (winter, spring, summer, and fall) were assessed with Tukey’s post hoc test. Results are expressed as least squares means and standard errors. A Pearson correlation plot was used to describe the coefficients of determination among each calf measurement, and a heat map was made to improve the visualization of the results.

### Table 1. Summary of mixed linear regression models for the effect of season on Belgian Blue calf measurements involving a total of 236 elective cesarean sections. The season was forced into each model and dam parity and calf gender were offered as covariates to all models

| Outcome                      | n   | Least square means ± standard error |               |       | Note |
|------------------------------|-----|------------------------------------|---------------|-------|------|
|                              |     | Winter                | Spring        | Summer| Fall |
| Weight (kg)                  | 211 | 54.8 ± 1.71\(^a\)     | 58.1 ± 1.94\(^a\) | 56.3 ± 2.09\(^b\) | 54.2 ± 1.82\(^a\) | 0.13 | 1   |
| Height at the withers (cm)   | 236 | 71.1 ± 0.70\(^a\)     | 71.1 ± 0.82\(^a\) | 71.7 ± 0.90\(^a\) | 70.7 ± 0.76\(^a\) | 0.35 | 2   |
| Width at the shoulder (cm)   | 236 | 25.5 ± 0.44\(^a\)     | 25.4 ± 0.51\(^a\) | 24.9 ± 0.56\(^a\) | 24.8 ± 0.48\(^a\) | 0.35 | 3   |
| Diagonal length (cm)         | 236 | 67.3 ± 1.08\(^ab\)    | 69.7 ± 1.24\(^a\) | 68.6 ± 1.34\(^ab\) | 66.9 ± 1.16\(^b\) | 0.05 | 4   |
| Pelvic height (cm)           | 107 | 75.1 ± 0.68\(^a\)     | 77.1 ± 0.72\(^a\) | 75.8 ± 0.73\(^a\) | 74.4 ± 0.91\(^a\) | 0.06 | 5   |
| Pelvic width (cm)            | 236 | 27.0 ± 0.43\(^a\)     | 27.3 ± 0.50\(^a\) | 26.6 ± 0.55\(^a\) | 26.5 ± 0.46\(^a\) | 0.43 | 6   |
| Radial length (cm)           | 236 | 27.2 ± 0.53\(^a\)     | 28.0 ± 0.60\(^a\) | 27.8 ± 0.65\(^a\) | 27.3 ± 0.57\(^a\) | 0.33 | 7   |
| Metacarpal length (cm)       | 107 | 23.9 ± 0.26\(^a\)     | 23.9 ± 0.28\(^a\) | 24.2 ± 0.28\(^a\) | 24.5 ± 0.36\(^a\) | 0.37 | 8   |
| Tibial length (cm)           | 107 | 35.4 ± 0.47\(^ab\)    | 35.8 ± 0.48\(^a\) | 34.1 ± 0.49\(^bc\) | 33.1 ± 0.57\(^c\) | 0.0001 | 9   |
| Metatarsal length (cm)       | 236 | 31.6 ± 0.56\(^a\)     | 32.4 ± 0.62\(^a\) | 31.1 ± 0.65\(^a\) | 31.4 ± 0.59\(^a\) | 0.11 | 10  |
| Head diameter (cm)           | 236 | 13.5 ± 0.22\(^a\)     | 13.4 ± 0.28\(^a\) | 12.6 ± 0.29\(^a\) | 12.9 ± 0.23\(^a\) | 0.002 | 11  |
| Head circumference (cm)      | 236 | 51.0 ± 0.45\(^a\)     | 51.1 ± 0.65\(^a\) | 50.4 ± 0.68\(^a\) | 49.8 ± 0.49\(^a\) | 0.16 | 12  |
| Heart girth (cm)             | 236 | 80.2 ± 0.97\(^a\)     | 82.1 ± 1.16\(^a\) | 79.6 ± 1.27\(^a\) | 81.0 ± 1.06\(^a\) | 0.21 | 13  |
| Circumference at the claws (cm) | 169 | 17.7 ± 0.16\(^a\) | 17.5 ± 0.18\(^a\) | 17.4 ± 0.22\(^a\) | 17.9 ± 0.26\(^a\) | 0.36 | 14  |

1. Model covariates are parity and calf gender \((P = 0.001)\) and \( P < 0.0001 \), respectively
2. Model covariates are parity and calf gender \((P = 0.009)\) and \( P = 0.001 \), respectively
3. Model covariates are parity and calf gender \((P = 0.009)\) and \( P < 0.0001 \), respectively
4. Model covariates are parity and calf gender \((P = 0.002)\) and \( P = 0.007 \), respectively
5. Model covariate is calf gender \((P = 0.03)\)
6. Model covariates are parity and calf gender \((P = 0.02)\) and \( P = 0.03 \), respectively
7. Model covariates are parity and calf gender \((P = 0.007)\) and \( P = 0.009 \), respectively
8. Model includes season only
9. Model includes season only
10. Model covariates are parity and calf gender \((P = 0.004)\) and \( P = 0.02 \), respectively
11. Model covariate is calf gender \((P = 0.01)\)
12. Model covariate is calf gender \((P = 0.001)\)
13. Model covariates are parity and calf gender \((P = 0.0006)\) and \( P = 0.0008 \), respectively
14. Model covariates are parity and calf gender \((P = 0.0001)\) and \( P = 0.03 \), respectively

Means with different letter within factor are statistically different

Results and discussion

The Pearson correlation coefficients among each calf measurement are shown in Fig. 2. All variables were positively correlated among each other and the variables with the greatest \((P < 0.05)\) correlation values were height at the
withers and pelvic height \( (r = 0.75) \), pelvic height and tibial length \( (r = 0.72) \), tibial and metatarsal lengths \( (r = 0.69) \), withers height and weight \( (r = 0.67) \), radial and metacarpal lengths \( (r = 0.65) \), weight and shoulder width \( (r = 0.64) \), and weight and pelvic height \( (r = 0.62) \). Table 1 shows the morphometric outcome (and co-variables) at each season for each model. Supplementary Table 1 illustrates the number of animals included per season, calf sex, and parity of the dam. Calves that were born in spring had a longer \( (P = 0.05) \) diagonal length \((69.7 \pm 1.24 \text{ cm})\) than those delivered in fall \((66.9 \pm 1.16 \text{ cm})\). The tibial length of calves delivered in spring \((35.8 \pm 0.48 \text{ cm})\) was longer \((P < 0.02)\) in comparison to those born in fall \((33.1 \pm 0.57 \text{ cm})\) or summer \((34.1 \pm 0.49 \text{ cm})\). Calves that were born in winter had a longer \((P < 0.02)\) head diameter \((13.5 \pm 0.22 \text{ cm})\) than those born in summer \((12.6 \pm 0.29 \text{ cm})\) or fall \((12.9 \pm 0.23 \text{ cm})\). No differences were found for all the other parameters \((P > 0.05)\).

In general, results of the present study show that calves born in spring have larger body sizes in comparison to calves born in other seasons. This is in line with some previous studies that revealed that Holstein-Friesian calves born in spring have higher weight than those born in other seasons (Aksakal and Bayram 2009). This may be related to differences in ambient temperature and feed composition in the last trimester of pregnancy. During this time, placental blood flow increases, resulting in around 30% of the nutrient supply of the cow redirected to support fetal growth. Thus, comfort ambient temperature at the last trimester of gestation will result in optimal intra-uterine development due to sufficient provision of nutrients for the fetus. In contrast, the pregnant dam will direct a greater portion of the blood flow to peripheral tissues for cooling at the end of spring and summer, and beginning of fall (these animals will calve at the end of summer and fall, and beginning of winter, respectively). Therefore, blood flow to the core of the cow will be lower, resulting in a decrease in the amount of nutrients being transferred to the fetus (Koçak et al. 2007). Another reason might be variations in the diet of the pregnant cows in different seasons (Fiems and De Brabander 2009). In Belgium, spring calving cows are stabled in the last trimester of pregnancy and offered a high-quality feed (including mineral supplementation) compared to pregnant cows in the pasture in summer, fall, or winter. Variation in supply and composition of the ration has been shown to significantly affect the growth and weight of livestock at different life stages, including bone development and organ differentiation of the newborn calf (Sundaram et al. 2012). A limitation of the study is that cows originated from multiple farms, which may have introduced some bias. Moreover, we do not have access to the exact feed composition in most farms (cows came to the clinic only for the CS). Although the genetic diversity among the BB breed is relatively low, typical individual herd management factors may have affected our results.

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**Availability of data and material** Not applicable.

**Code availability** Not applicable.

**Author contribution** HSAT, GR, and B: writing; MVE, KV, and MM: study design; OBP and AVS: co-supervision; GO: supervision.

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**Declarations**

**Ethics approval** No ethical approval was obtained because this study did not involve a prospective evaluation and only involved non-invasive procedures.

**Consent to participate** Not applicable

**Consent for publication** Not applicable

**Competing interests** The authors declare no competing interests.

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