Calving difficulty as related to body weights and measurements of cows and calves in a herd of Gascon breed

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ABSTRACT: This study was conducted to evaluate the body weights and measurements of 86 Gascon calves and their dams. The effects of the course of parturition, parity of the dams, sex of the calves, and live- or stillborn calves were analysed. Phenotypic correlations between different measurements and calf birth weight as well as the course of parturition were calculated. Internal pelvic measurements were significantly associated with the occurrence of assisted calvings and stillborn calves. Primiparous cows had a smaller pelvic area, lower live weight, and more frequent difficulty in calving compared to older cows. A higher incidence of difficult calvings was observed in bull-calves due to their higher (P < 0.001) birth weight. High and significant correlation coefficients were determined between the birth weight and body measurements of the calves as well as between the calf birth weight and the course of parturition (r = 0.34; P < 0.01). Negative correlations (r = –0.21 to –0.30) were calculated between the internal pelvic measurements of the cows and the course of parturition score. It was concluded that the internal pelvic measurements of the dam and the size and shape of the calf were the factors influencing the course of parturition in this study to the largest extent.

Keywords: beef cattle; course of parturition; pelvic measurements; calving difficulty

Economic losses associated with the mortality of calves during parturition and in the early *postpartum* period substantially affect the profitability of a beef herd. Difficult calvings are often accompanied by an increased proportion of stillborn calves, low viability and weight gain of the calves, and as a consequence, reduced income from the sales of weaned calves (Choroszy et al., 2002; Goonewardene et al., 2003). In addition, problems during calving may result in increased veterinary costs, more frequent death of dams, delayed onset of heat, longer calving intervals, lower milk yield, and reduced welfare of the cows (see the review by Meijering, 1984; Phocas and Laloë, 2003). The main factors associated with the course of parturition are breed, parity, body condition of the dam, gestation length, body weight and muscularity of the dam and sire, sex and body weight of the calf, the number of foetuses, and the season of parturition (Meijering, 1984; Štráfelda, 1990; Murray et al., 1999; Nogalski, 2003). As the major cause of dystocia, high birth weight and size of the calf in relation to the small pelvic area of the dam is reported (Naazie et al., 1989; Nugent et al., 1991; Basarab et al., 1993; Coopman et al., 2003).

The objective of the study was to determine the effect of the pelvic measurements of cows and the body weight and measurements of calves on the course of parturition and the proportion of liveborn calves in a Gascon herd.

MATERIAL AND METHODS

Data on 86 parturitions were collected over a period of 4 years (2003–2006) in a herd of purebred Gascon cows stabled at the experimental station

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of the Institute of Animal Science. Each year the calving season extended from January to March. The course of parturition was scored according to the methodology of the Czech Beef Breeders Association (ČSCHMS, 2007) using a 4-point scale: 1 – spontaneous calving (no assistance required); 2 – easy calving (assistance of 1–2 persons); 3 – difficult calving (assistance of 3 or more persons or a veterinarian); 4 – caesarean section. The calves were weighed within 24 h after calving, and 8 body measurements were taken within 48 h after calving (height at the sacrum, height at the withers, head circumference, chest girth, head width, width at the hips and thurls, and pelvic length). The dams were weighed 2 months prior to calving, and their external pelvic measurements (width at the hips, thurls and pins, pelvic length) and internal pelvic measurements (pelvic height and width; measured with a pelvimeter) were taken 2 to 5 months after parturition. The pelvic area was calculated as the product of the internal pelvic height and width (Gaines et al., 1993; Murray et al., 1999; Nogalski, 2003). In addition, the following ratios were calculated: (a) dam pelvic area to calf birth weight; (b) dam weight before calving to calf birth weight.

The data were analysed using the GLM procedure of SAS (SAS, 2001). To evaluate the relationships between the body measurements of cows and the course of parturition, the following Equation 1 was used:

Equation 1:

$$y_{ijkl} = \mu + Y_i + P_j + A_k + e_{ijkl}$$

where:

μ = average value of dependent variable

Y_i = fixed effect of the year of calving (i = 1–4)

P_j = fixed effect of dam parity (j = 1–3)

A_k = alternative effect (k = 1–2)

e_{ijkl} = residual effect (random error)

To evaluate the relationships between body weight and measurements of calves and the course of parturition or the incidence of stillborn calves, the following Equation 2 was used:

Equation 2:

$$y_{ijkl} = \mu + Y_i + P_j + S_k + F_l + A_m + e_{ijklmn}$$

Table 1. The proportion of total variability explained by the used model

Dependent variable	R-Square	CV	Root MSE
Dam			
Live weight (kg)	0.4238	10.47	75.25
Pelvic height (cm)	0.3901	9.19	1.87
Pelvic width (cm)	0.2430	8.22	1.56
Pelvic area (cm^2)	0.3697	16.55	23.51
Width at hips (cm)	0.3576	5.48	3.04
Width at thurls (cm)	0.3680	3.72	1.93
Width at pins (cm)	0.2591	9.60	2.01
Pelvic length (cm)	0.2127	5.19	2.79
Calf			
Birth weight (kg)	0.4159	14.09	6.16
Height at withers (cm)	0.3077	5.06	3.81
Height at hips (cm)	0.4032	4.67	3.74
Width of head (cm)	0.3467	8.87	1.20
Circumference of head (cm)	0.4341	4.81	2.44
Width at hips (cm)	0.3317	8.44	1.43
Width at thurls (cm)	0.1780	8.22	1.68
Pelvic length (cm)	0.5630	6.02	1.39
Girth of chest (cm)	0.3176	5.88	4.57
Ratio			
Pelvic area of dam:birth weight of calf	0.2831	23.43	2.10
Weight of dam:birth weight of calf	0.4367	17.78	3.00

Table 2. Number of observations and course of parturition with regard to analysed effects

		Number of observations	Course of parturition	
		(n)	($\bar{x}$)	(s)
Live- or stillborn calves	liveborn calves	79	1.23	0.51
	stillborn calves	7	1.86	0.69
Parity	first parity	18	1.39	0.50
	second parity	17	1.12	0.33
	later parity	51	1.29	0.61
Sex of calves	male	48	1.38	0.64
	female	38	1.16	0.37
Total		86	1.28	0.55

where:

μ = average value of dependent variable

Y_i = fixed effect of the year of calving (i = 1–4)

P_j = fixed effect of dam parity (j = 1–3)

S_k = fixed effect of the sex of calves (k = 1–2)

F_l = fixed effect of the sire of calves (l = 1–7)

A_m = alternative effect (m = 1–2)

e_{ijklmn} = residual effect (random error)

In Equations 1 and 2, the following alternative effects were used:

Table 3. Body weights and measurements of dams and their calves with regard to the course of parturition

	Spontaneous calving (n = 66)		Calving with assistance (n = 20)		Significance
	LSM	± SEM	LSM	± SEM	P > F
Dam					
Parity	3.03	0.33	2.56	0.51	0.3564
Live weight (kg)	685.1	10.14	724.3	18.18	0.0504
Pelvic height (cm)	20.4	0.21	18.8	0.45	0.0021
Pelvic width (cm)	19.0	0.21	18.1	0.38	0.0270
Pelvic area (cm^2)	383.2	8.56	334.6	15.35	0.0046
Width at hips (cm)	54.6	0.41	53.5	0.73	0.1574
Width at thurls (cm)	51.5	0.26	51.3	0.47	0.7201
Width at pins (cm)	20.7	0.27	20.1	0.49	0.2434
Pelvic length (cm)	53.5	0.38	52.8	0.67	0.3333
Calf					
Birth weight (kg)	42.4	1.07	43.6	1.72	0.5059
Height at withers (cm)	75.1	0.65	74.5	1.05	0.5788
Height at hips (cm)	79.3	0.65	79.5	1.04	0.8628
Width of head (cm)	13.4	0.21	13.3	0.33	0.8040
Circumference of head (cm)	49.9	0.43	50.3	0.68	0.5421
Width at hips (cm)	16.7	0.25	17.5	0.40	0.0473
Width at thurls (cm)	20.2	0.30	20.8	0.47	0.1935
Pelvic length (cm)	22.7	0.24	23.4	0.39	0.0944
Girth of chest (cm)	76.8	0.80	74.7	1.28	0.0959
Ratio					
Pelvic area of dam:birth weight of calf	9.16	0.37	7.87	0.59	0.0326
Weight of dam:birth weight of calf	16.31	0.53	17.66	0.84	0.1128

Table 4. Body weights and measurements of dams and their calves with regard to live- or stillborn calves

	Liveborn calves (n = 79)		Stillborn calves (n = 7)		Significance
	LSM	± SEM	LSM	± SEM	$P > F$
Dam					
Parity	2.92	0.31	3.48	0.77	0.4473
Live weight (kg)	694.7	9.73	674.3	29.82	0.5051
Pelvic height (cm)	20.2	0.24	18.0	0.73	0.0050
Pelvic width (cm)	18.9	0.20	17.4	0.60	0.0144
Pelvic area (cm^2)	378.1	8.09	309.0	24.78	0.0078
Width at hips (cm)	54.6	0.37	50.9	1.12	0.0016
Width at thurls (cm)	51.51	0.24	50.52	0.74	0.1971
Width at pins (cm)	20.8	0.25	18.7	0.75	0.0105
Pelvic length (cm)	53.5	0.34	51.1	1.06	0.0296
Calf					
Birth weight(kg)	42.6	1.04	43.4	2.58	0.7550
Height at withers (cm)	75.0	0.63	73.1	1.58	0.2083
Height at hips (cm)	79.5	0.62	77.8	1.55	0.2820
Width of head (cm)	13.4	0.20	13.2	0.50	0.6737
Circumference of head (cm)	49.9	0.41	50.3	1.02	0.7475
Width at hips (cm)	16.9	0.25	16.6	0.61	0.6363
Width at thurls (cm)	20.3	0.29	20.2	0.71	0.8552
Pelvic length (cm)	22.8	0.24	22.9	0.59	0.9283
Girth of chest (cm)	76.8	0.72	70.6	1.80	0.0008
Ratio					
Pelvic area of dam:birth weight of calf	9.05	0.35	6.76	0.87	0.0085
Weight of dam:birth weight of calf	16.53	0.51	17.16	1.28	0.6117

(a) fixed effect of the course of parturition score;
(b) fixed effect of dams with live- or stillborn calves.

Due to the low frequency of parturitions scored 2 and 3 and no caesarean section performed, groups 2, 3, and 4 were combined into a single group. Therefore, the course of parturition score used for these calculations was finally either 1 (spontaneous calving) or 2 (calving with assistance).

Pearson's correlation coefficients were calculated using the CORR procedure. To account for differences in frequencies, the course of parturition class values were transformed to the standard normal distribution. Each dam parity × sex of calves frequency was transformed to a number from an underlying normal distribution that matches the frequency (NRS, 2007).

RESULTS AND DISCUSSION

The proportion of variability explained by the used model is given in Table 1. While the effect of year was not significant for any of the observed traits, the effect of sire (used in Equation 2) significantly affected the birth weight of calves and most of the body measurements. However, these effects were not the subject of our research, and therefore they were not further analysed in this paper. A total of 66 (76.7%) parturitions occurred spontaneously (score 1), 16 (18.6%) with the assistance of 1–2 persons (score 2), 4 (4.7%) parturitions were evaluated as difficult (score 3), while no caesarean section (score 4) was performed. Table 2 shows the number of observations and the average course of parturition score in each evaluated class. It is evident that a higher frequency of difficult

Table 5. Body weight and measurements of dams with regard to parity

	First parity (n = 18)		Second parity (n = 17)		Later parity (n = 51)		Significance
	LSM	± SEM	LSM	± SEM	LSM	± SEM	$P > F$
Dam							
Live weight (kg)	635.7^A	18.38	706.3^B	20.58	772.1^C	11.52	<0.0001
Pelvic height (cm)	19.1^A	0.45	19.3	0.51	20.4^B	0.29	0.0170
Pelvic width (cm)	18.1^A	0.38	18.3	0.48	19.2^B	0.23	0.0153
Pelvic area (cm^2)	340.7^A	15.52	346.2	17.37	389.8^B	9.72	0.0064
Width at hips (cm)	52.6^A	0.74	52.7^A	0.83	56.8^B	0.47	0.0001
Width at thurls (cm)	50.4^A	0.47	51.0^A	0.52	52.8^B	0.30	0.0001
Width at pins (cm)	19.64^A	0.49	20.3	0.55	21.3^B	0.31	0.0075
Pelvic length (cm)	52.7	0.68	52.4	0.76	54.3	0.43	0.0275
Calf							
Birth weight of calves (kg)	42.60	1.66	43.20	1.98	43.10	1.22	0.9614
Pelvic area of dam:birth weight of calf	8.25	0.57	8.17	0.68	9.12	0.42	0.1927
Weight of dam:birth weight of calf	15.35^A	0.82	16.97	0.97	18.63^B	0.60	0.0012

values with different superscripts (^{A,B}) differ significantly ($P < 0.05$)

calvings was observed in cows delivering stillborn calves compared to those delivering liveborn ones, in first-calvers compared to older cows, and when a male calf was born.

The body weight and measurements of cows and calves grouped according to the course of parturition score are given in Table 3. Cows delivering spontaneously had larger measurements of internal pelvic height ($P < 0.01$), and a similar tendency was observed in internal pelvic width ($P < 0.05$). As a result, the calculated pelvic area was significantly greater (12.7%; $P < 0.01$) in cows with spontaneous calving than in cows calving with assistance. Similar differences in the pelvic area in relation to the calving difficulty score were determined in 2-years-old beef heifers (Naazie et al., 1989). Murray et al. (1999) reported a 12 to 13% larger pelvic area in Belgian Blue cows calving unassisted compared to

Table 6. Body weights and measurements of calves with regard to sex

	Male (n = 48)		Female (n = 38)		Significance
	LSM	± SEM	LSM	± SEM	$P > F$
Birth weight (kg)	45.3	1.39	40.7	1.36	0.0029
Height at withers (cm)	75.9	0.85	73.6	0.83	0.0153
Height at hips (cm)	81.0	0.84	77.8	0.83	0.0009
Width of head (cm)	13.7	0.27	13.1	0.27	0.0506
Circumference of head (cm)	51.6	0.55	48.6	0.54	0.0001
Width at hips (cm)	17.3	0.32	17.0	0.32	0.3516
Width at thurls (cm)	20.6	0.38	20.4	0.37	0.6352
Pelvic length (cm)	23.7	0.31	22.4	0.31	0.0005
Girth of chest (cm)	77.0	1.03	74.6	1.01	0.0354
Pelvic area of dam:birth weight of calf	8.01	0.48	9.02	0.47	0.0552
Weight of dam:birth weight of calf	15.80	0.68	18.16	0.67	0.0022

those delivering with assistance or by caesarean section. In our study, the external pelvic measurements were also slightly greater in cows calving without assistance, but no significance was noted.

The birth weight of spontaneously delivered calves was 1.2 kg (2.8%) lower but with no significance observed. However, a significant increase in calf birth weight associated with more complicated parturitions was reported in Holsteins (Nogalski, 2003), Angus heifers (Tozer et al., 2002) and Belgian Blue cows (Fiems et al., 2001). In agreement with the findings of Gaines et al. (1993), a significant difference ($P < 0.05$) between both groups analysed was found in the ratio of the pelvic area of the dam to the birth weight of the calf, suggesting that this ratio is strongly related to calving difficulty.

Table 4 shows body weights and measurements of dams and calves with regard to the delivery of liveborn or stillborn calves. The dams of stillborn calves had lower measurements of internal pelvic height ($P < 0.01$), width ($P < 0.05$), pelvic area ($P < 0.01$), width at the hips ($P < 0.01$), and width at the pins ($P < 0.05$). The pelvic area of the dams that gave birth to live calves was 18.3% greater than in the dams with stillborn calves. Accordingly, a 9.5% larger pelvic area was observed in Belgian Blue cows with liveborn calves compared to those with stillborn calves (Murray et al., 2002).

The effect of parity on the characteristics analysed is given in Table 5. The parity of the dam significantly affected the live weight of the cows before calving, with the heaviest being at third or higher parity ($P < 0.001$). The oldest cows also had a 12.6% larger pelvic area ($P < 0.05$) and larger external pelvic measurements ($P < 0.05$) compared to primiparous cows. Similarly, Coopman et al. (2003) reported that both external and internal pelvic measurements were positively correlated with age. In our study, the differences between primi- and multiparous cows in the birth weight of calves were small and insignificant. Similar results were reported for the Holstein breed (Nogalski, 2003) but, on the contrary, significantly different birth weights of Charolais and Hereford calves from first-calvers and higher parity cows were observed by Eriksson et al. (2004). The results of Naazie et al. (1989) show that the relationship between the birth weight of the calf and the weight of the dam is more important for predicting calving difficulty than the calf birth weight itself. Indeed, a broader ratio of dam weight to calf birth weight for primiparous compared to third parity and older cows ($P < 0.01$) was obtained in our study. As the birth weight was not affected by parity, this ratio may provide a plausible explanation of the higher occurrence of difficult calvings in primiparous cows in our experiment. Our findings are also in agreement with the conclusion drawn from the review by Meijering (1984) that the ratio between calf size and effective pelvic dimensions is more critical in primiparous than in older cows. In addition, the difference between primiparous and older cows in the incidence of difficult calving may also be associated with the fact that the cows with the difficult first calving are often removed from the herd (Štráfelda, 1990).

Birth weights and measurements of calves as affected by sex are presented in Table 6. Bull-calves were 10.2% heavier at birth than heifers ($P < 0.01$). Higher birth weights of bulls compared to heifers were also reported in other cattle breeds, e.g. in Slovak Fleckvieh by 8.6% (Strapák et al., 2000) and in Belgian Blue by 8.4% (Coopman et al., 2004). In a study analysing growth traits in beef breeds raised in Slovakia (Krupa et al., 2005), both males-singles and males-twins had higher birth weights than females-singles and females-twins by 9.8 and 7.9%, respectively. The differences in birth weights between beef breeds in north-western Poland (Red Angus, Salers, Hereford, Limousin, and Simmental) ranged from 2.3 to 7.4%. (Pilarczyk and Wójcik, 2007). In our study, the higher birth weight of bulls resulted in their significantly larger body measurements compared to heifers, except for the width of head, width at hips, and width at thurls. Accordingly, Holstein bull-calves had higher measurements of chest girth and, in addition, fore cannon circumference (Nogalski, 2003). Similarly, higher withers height, hearth girth, and shoulder width of newborn Belgian Blue bulls compared to heifers were also reported (Coopman et al., 2004).

As published in a review by Holland and Odde (1992), the birth weight of a calf ranges from 5 to 10% of the weight of its dam. This proportion reported by Nogalski (2003) for Holstein calves is 7.34%, while in our study it was 6.09%.

The results of the correlation analysis are given in Table 7. While no significant correlations were determined between the pelvic measurements of the dams and the birth weight of the calves, moderate to high correlation coefficients ranging from $r = 0.60$ to $r = 0.76$ ($P < 0.001$) were calculated between the birth weight and body measurements of the calves.

Table 7. Phenotypic correlations between birth weight of calves, course of parturition and body measurements and weights of dams and calves

	Birth weight of calves (kg)		Course of parturition (points)	
	r	significance	*r*	significance
Dam				
Live weight (kg)	0.09	0.4220	0.20	0.0600
Pelvic height (cm)	0.01	0.9146	–0.30	0.0050
Pelvic width (cm)	–0.08	0.4739	–0.21	0.0538
Pelvic area (cm^2)	–0.03	0.7870	–0,26	0.0155
Width at hips (cm)	0.12	0.2602	–0.06	0.5768
Width at thurls (cm)	0.02	0.8605	–0.03	0.7583
Width at pins (cm)	0.19	0.0802	–0.15	0.1714
Pelvic length (cm)	0.01	0.9304	0.03	0.7960
Calf				
Birth weight (kg)			0.34	0.0016
Height at withers (cm)	0.64	<0.0001	0.14	0.1974
Height at hips (cm)	0.72	<0.0001	0.26	0.0161
Width of head (cm)	0.60	<0.0001	0.27	0.0109
Circumference of head (cm)	0.76	<0.0001	0.20	0.0627
Width at hips (cm)	0.65	<0.0001	0.32	0.0025
Width at thurls (cm)	0.67	<0.0001	0.28	0.0083
Pelvic length (cm)	0.60	<0.0001	0.19	0.0880
Girth of chest (cm)	0.63	<0.0001	0.04	0.6947

The correlation coefficient for the relationship between the course of parturition and the birth weight of the calves was $r = 0.34$ ($P < 0.01$). Similar phenotypic correlations were also determined by Hradecká (2002) in Charolais ($r = 0.44$), Blonde d'Aquitaine ($r = 0.42$), Limousin ($r = 0.28$), and by Nogalski (2003) in Holstein cattle ($r = 0.27$). Negative correlations were observed between the course of parturition score and the internal pelvic measurements of the dams, indicating that a smaller pelvic size was associated with an increased risk of calving difficulty. The relationship between the pelvic area and the course of parturition ($r = –0.26$) was, however, not as close as that reported by Nogalski (2003) in Holsteins ($r = –0.51$). Except for chest girth, height at withers, pelvic length ($P = 0.0880$) and circumference of head ($P = 0.0627$), body measurements of the calves were positively and significantly correlated with the course of parturition score. The highest correlation coefficient ($r = 0.32$) was found for the width at hips ($P < 0.01$). It is therefore suggested that the size and shape of calves are also related to the frequency of complicated calvings.

CONCLUSIONS

The results of this study indicated that the internal pelvic measurements of the dam and the size and shape of the calf were the factors influencing the calving difficulty in Gascon cattle to the largest extent. Pelvic area measurements and calf birth weight have the potential to be used as a selection tool to reduce the risk of difficult calvings in a beef herd.

REFERENCES

Basarab J.A., Rutter L.M., Day P.A. (1993): The efficacy of predicting dystocia in yearling beef heifers: I. Using ratios of pelvic area to birth weight or pelvic area to heifer weight. J. Anim. Sci., 71, 1359–1371.

Coopman F., de Smet S., Gengler N., Haegeman A., Jacobs K., van Poucke M., Laevens H., van Zeveren A., Groen A.F. (2003): Estimating internal pelvic sizes using external body measurements in the double-muscled Belgian Blue breed. Anim. Sci., 76, 229–235.

Coopman F., Gengler N., Groen A.F., de Smet S., van Zeveren A. (2004): Comparison of external morphological traits of newborns to inner morphological traits of the dam in the double muscled Belgian Blue breed. J. Anim. Breed. Genet., 121, 128–134.

Choroszy Z., Choroszy B., Trela B. (2002): Effect of calving season on calving ease of crossbred beef cows and vitality and growth rate of their calves. Anim. Sci. Pap. Rep., 20, 117–123.

ČSCHMS (2007): Performance recording in beef cattle. Available at: http://www.cschms.cz/DOC_LEGISLATIVA_svaz/117_Metodika_KUMP.pdf. 11.7.2007 (in Czech)

Eriksson S., Näsholm A., Johanson K., Philipsson J. (2004): Genetic parameters for calving difficulty, stillbirth, and birth weight for Hereford and Charolais at first and later parities. J. Anim. Sci., 82, 375–383.

Fiems L.O., de Campeneere S., van Caelenbergh W., Boucqué Ch.V. (2001): Relationship between dam and calf characteristics with regard to dystocia in Belgian Blue double-muscled cows. Anim. Sci., 72, 389–394.

Gaines J.D., Peschel D., Kauffman R.G., Schaefer D.M., Badtram G., Kumi-Diaka J., Clayton M.K., Milliken G. (1993): Pelvic growth, calf birth weight and dystocia in Holstein × Hereford heifers. Theriogenology, 40, 33–41.

Goonewardene L.A., Wang Z., Price M.A., Yang R.C., Berg R.T., Makarechian M. (2003): Effect of udder type and calving assistance on weaning traits of beef and dairy × beef calves. J. Anim. Sci., 81, 47–56.

Holland M.D., Odde K.G. (1992): Factors affecting calf birth weight: a review. Theriogenology, 39, 769–798.

Hradecká E. (2002): Estimation of breeding values for calving difficulty. [Doctoral Thesis.] University of South Bohemia, České Budějovice, CR, 134 pp. (in Czech)

Krupa E., Oravcová M., Polák P., Huba J., Krupová Z. (2005): Factors affecting growth traits of beef cattle breeds raised in Slovakia. Czech J. Anim. Sci., 50, 14–21.

Meijering A. (1984): Dystocia and stillbirth in cattle – a review of causes, relations and implications. Livest. Prod. Sci., 11, 143–177.

Murray R.D., Cartwright T.A., Downham D.Y., Murray M.A. (1999): Some maternal factors associated with dystocia in Belgian Blue cattle. Anim. Sci., 69, 105–113.

Murray R.D., Cartwright T.A., Downham D.Y., Murray M.A., de Kruif A. (2002): Comparison of external and internal pelvic measurements of Belgian Blue Cattle from sample herds in Belgium and the United Kingdom. Reprod. Domest. Anim., 37, 1–7.

Naazie A., Makarechian M.M., Berg R.T. (1989): Factors influencing calving difficulty in beef heifers. J. Anim. Sci., 67, 3243–3249.

Nogalski Z. (2003): Relations between the course of parturition, body weights and measurements of Holstein-Friesian calves. Czech J. Anim. Sci., 48, 51–59.

NRS (2007): Management Guides, E 14. Calving ease index. Available at: http://www.nrs.nl

Nugent R.A., Notter D.R., Beal W.E. (1991): Body measurements of newborn calves and relationship of calf shape to sire breeding values for birth weight and calving ease. J. Anim. Sci., 69, 2413–2421.

Pilarczyk R., Wójcik J. (2007): Comparison of calf rearing results and nursing cow performance in various beef breeds managed under the same conditions in northwestern Poland. Czech J. Anim. Sci., 52; 325–333.

Phocas F., Laloë D. (2003): Evaluation models and genetic parameters for calving difficulty in beef cattle. J. Anim. Sci., 81, 933–938.

SAS (2001): Release 8.2 (TS2MO) of the SAS® System for Microsoft® Windows®. SAS Institute Inc., Cary, NC, USA.

Strapák P., Vavrišínová K., Candrák J., Bulla J. (2000): Calving ease and birth weight of calves of Slovak Simmental cows. Czech J. Anim. Sci., 45, 293–299.

Štráfelda, J. (1990): Evaluation of the course of parturitions in cows kept in the Czech-Socialist-Republic. Czech J. Anim. Sci., 35; 97–103. (in Czech)

Tozer P.R., Scollard D.L., Marsh T.L., Marsh T.J. (2002): Recursive systems model of fetal birth weight and calving difficulty in beef heifers. Canadian J. Anim. Sci., 82, 19–27.

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