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Pelvic Dimensions in Phenotypically Double-muscled Belgian Blue cows

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Contents

Some anatomical characteristics of 507 Belgian Blue (BB) cattle, withers height (WH), heart girth (HG), the distance between the two *tubera coxae* (TcTc) and the distance between the two *tubera ischiadica* (TiTi), were compared with the internal pelvic measurements of width, height and area. Mean values were 58.9 ± 6.2 cm for TcTc, 14.6 ± 2.3 cm for TiTi, 15.2 ± 2.1 cm for pelvic width (PW), 18.8 ± 1.9 cm for pelvic height (PH) and 288.5 ± 60.9 cm^2 for pelvic area (PA). Cows that calved *per vaginam* had larger WH ($p < 0.05$), TcTc ($p < 0.05$) and TiTi ($p < 0.001$) and internal pelvic measurements [PH and PA ($p < 0.001$)] compared with those whose parturition was managed by caesarean section (CS): Correlations between internal pelvic measurements and TcTc were higher ($r = 0.58$–0.63) than TiTi ($r = 0.22$–0.28). Correlations between other external body measures such as HG and WH with the internal pelvic measurements were even higher for HG ($r = 0.69$–0.74) and for WH ($r = 0.67$–0.74). HG and WH, together with internal pelvic measures, may be added to estimated breeding values (EBV's) that should assist breeders in selecting cows that can calve *per vaginam*, thereby reducing the breed's dependence on elective CS for maintaining its unique characteristics.

Introduction

The Belgian Blue (BB) breed of cattle is characterized by a double-muscled (DM) phenotype typified by a deletion within the myostatin (*mh*) gene (Grobet et al. 1998; Lips et al. 2001): These cattle present with less bone and fat, more muscle and a higher muscle/bone ratio than other breeds of beef cattle (Shanin and Berg 1985). This breed has excellent meat quality and superior killing-out percentage, traits associated with the DM phenotype that have been developed using elective caesarean section (CS) for routine management of parturition (Vandeplassche 1974). Pleiotropic effects of the *mh*-gene have been associated with feto-maternal disproportion in this breed (Coopman et al. 2003), but Murray et al. (1999) found that the pelvic area of BB cows was 12% larger than estimated previously. However, Coopman et al. (2003) suggested that this gene effect was also associated with hypermuscularity and growth of the foetus.

Dystocia and ease of calving have been investigated in other beef and dairy breeds and are included in estimated breeding values (EBV's) for bulls of all breeds. The estimate of ease of calving is compiled from calving difficulty scores, birth weight (BW) and gestation length, the most significant being calving difficulty (Splan et al. 1988; Kriese et al. 1994; Meadows et al. 1994; McGuirk et al. 1998; Luo et al. 1999). In Belgium, parturition in the BB breed is managed routinely by CS and a calving difficulty score is almost impossible to obtain. Hence, other factors besides ease of calving should be included in an EBV for the BB bulls. To select for natural calving in this breed, the objective should be to reduce the degree of foetal muscular hypertrophy found on the shoulders and hindquarters and increase the pelvic area (PA) of the cow.

The Rice pelvimeter has been used to measure internal pelvic dimensions of several other breeds (Johnson et al. 1988), and Murray et al. (1999) used it to describe a sample of double-muscled Belgian Blue (DM-BB) cows in the United Kingdom. Cows that were given the opportunity to calve *per vaginam* had a significantly larger pelvic height (PH) and PA than those whose parturition was managed by CS, and significant correlations between internal and external pelvic measurements and age were described. When BB cows in nine herds in Flanders were compared to cows of a similar breed in the United Kingdom, there was no difference in internal pelvic sizes but cows bred in the United Kingdom, where calving *per vaginam* was more common, had significantly larger internal PA (Murray et al. 2002). Coopman et al. (2003) repeated a similar study but included body weight and withers height of the dam: Together with the distance between the two *tubera coxae* (TcTc), these external measurements were good estimators of internal pelvic size.

Selection towards an increase in PA is only feasible if there is a substantial variation for this trait within the DM-BB breed in combination with a moderate-to-high heritability for this trait. Heritability for pelvic size is moderate to high: In the Simmental (Benyshek and Little 1982) and other beef breeds (Morrison et al. 1986; Green et al. 1988), it is 0.43–0.59 for PH, 0.36–0.82 for PW and 0.53–0.68 for PA. In the Aberdeen Angus and Hereford breeds, Morrison et al. (1986) showed that an increase in PA can be achieved without causing significant increase in cow size. Even so, a small increase in body weight would not necessarily be unfavourable in the DM-BB breed as it will result in higher meat production per animal, and thus, better financial returns if conformation is retained.

The objective of this study was to explore the variation among the different internal and external pelvic measurements in DM-BB cows, irrespective of how their parturition was managed. Models were created to explore the relationships between external conformational characteristics and internal pelvic measures, the correlations including age and type of calving. The different descriptors of pelvic conformation were used to predict the likelihood of calving being managed *per vaginam*, defined as calving without help or with slight traction.

Materials and Methods

During housing periods of the years 2005–2007, internal and external pelvic measurements and other conformational characteristics (see Table 1) were obtained in DM-BB herds located in Flanders. Farms were selected where all cows exhibited extreme muscularity, classified as 'S' according to the SEUROP carcass classification system of the European Community [2003-10-03/37]. In most herds, parturition was managed routinely by CS, but occasionally cows calved *per vaginam*, mostly by accident.

For those herds calving February–May, calves were removed directly after birth and the cows managed subsequently at pasture during the summer. During the winter period, pregnant cows were housed variably in tie-stalls or in straw yards. For the remaining herds, late pregnant cows were mainly housed inside until they had calved. When inside, cows were fed grass and maize silage to appetite. Some herds fed 2 kg of concentrates to heifers during the last 2 months of pregnancy.

For measuring, cows were restrained either in a tie-stall or by halter, standing on a flat concreted surface. External measurements were obtained from the standing animal. Prior to using the Rice pelvimeter (Lane Manufacturing, 2075 So; Balentia St., Unit C, Denver, CO, USA), epidural anaesthesia was administered to all cows using 2 ml of 4% procaine hydrochloride [Procaine Hcl 4%, VMD, Belgium]; thus, during the procedure, cows stood normally during rectal manipulation. The method has been previously described by Kolkman et al. (2009). Late pregnant cattle were not examined as the presence of the foetus within the pelvic entrance made accurate measurements almost impossible.

Data collection and statistical methods

Data were placed on a separate data capture sheet for each cow: The identity of each cow was taken from its ear tag. These data were transferred to an Excel spread sheet (Microsoft Office Excel, 2007), cleaned and checked by SPSS 16.0 for Windows (SPSS Inc. 233 S. Wacker Drive, Chicago).

The independent variables were examined for normality using the Kolmogorov–Smirnov test and Q–Q plots. Cows 8–12 years old were considered together (referred to as the 8+ group) because the group was rather small in number.

Correlations between the different external and internal measurements were investigated using the Pearson correlation coefficient; also, their relationship with the management of parturition was investigated. Partial correlations were corrected for age and management of calving.

Single associations between each independent cow variable and management of calving were investigated using a multivariate mixed ANOVA with herd as a random factor (SAS 9_2).

The relationship between external measurements and age with internal pelvic measurement was investigated using a mixed multivariable general linear regression model, with herd as random factor: Only single factors with $p < 0.20$ were incorporated into the model. Whenever a high correlation between two factors existed ($r > 0.60$), the most relevant factor biologically was investigated further. The significance level for the analyses was set at $p < 0.05$.

Finally, generalized estimating equation methods were used to estimate the likelihood of cows calving naturally based on their internal pelvic dimensions.

Results

During the 3 years, 27 herds provided 507 cows for study. Of these, only 56 (10%) had calved at least once *per vaginam*. The age of the animals was 2–12 years with a mean of 5. The external and internal measurements of these cows, related to their age and type of calving, are summarized in Table 2. The variation in PA within each age category is shown in Fig. 1. Cows that gave birth *per vaginam* generally had larger WH ($p < 0.05$), TcTc ($p < 0.05$), TiTi ($p < 0.001$), and PH and PA ($p < 0.001$) compared to those that were delivered following CS. There is a significant difference between almost all measurements of immature animals compared to mature cows 4 years of age and older ($p < 0.05$ for heart girth (HG) and TiTi; $p < 0.001$ for WH, PW, PH and PA). Therefore, from now on, only 405 mature cows are considered.

Simple and partial correlations and simple class correlations between all external parameters and internal pelvic measurements are shown in Tables 3 and 4,

Table 1. Measurements variables, their definitions and methods of measurements

Variable	Abbreviation	Definition	Method of measurement
External			
Withers height	WH	Vertical height of withers from concrete floor	Measuring stick
Heart girth	HG	Circumference of chest immediately behind the elbows	Tape measure
Distance *tuber coxae*	TcTc	Distance between dorso-lateral extremities of both *tuber coxae*	Callipers
Distance *tuber ischiadici*	TiTi	Distance between caudo-medial aspects of end *tuber ischiadici*	Graduated tape
Internal			
Pelvic width	PW	Distance between the shafts of the *ilium* at the widest points	Rice pelvimeter
Pelvic height	PH	Distance between the pubic *symphysis* and the sacral vertebrae	Rice pelvimeter
Pelvic area	PA	Calculated by multiplying PH and PW	

Table 2. Means and standard deviation of WH (withers height), HG (heart girth), TcTc (distance between the *tubera coxae*), TiTi (the distance between the *tubera ischiadica*), PW (pelvic width), PH (pelvic height) and PA (pelvic area) for 507 double-muscled Belgian Blue cows and heifers related to management of parturition (CS; caesarean section: *PV*; *per vaginam*) and their age

			External measurements						Internal measurements	
	Age	Parturition	N	WH (cm)	HG (cm)	TcTc (cm)	TiTi (cm)	PW (cm)	PH (cm)	PA (cm^2)
Immature	2	CS	12	118.7 ± 5	194.3 ± 17	50.0 ± 4	14.7 ± 2	12.3 ± 2	15.0 ± 2	188.6 ± 58
		PV								
	3	CS	90	119.7 ± 5	193.3 ± 12	53.5 ± 5	13.7 ± 2	13.0 ± 2	17.0 ± 2	222.0 ± 43
		PV								
	Total	CS	102	119.6 ± 4	193.6 ± 12	53.1 ± 5	13.8 ± 2	12.9 ± 2	16.7 ± 2	218.1 ± 46
		PV								
Mature	4	CS	88	125.6 ± 5*	205.8 ± 11	58.4 ± 5	14.7 ± 2	14.7 ± 2*	18.6 ± 1	273.5 ± 42*
		PV	7	130.2 ± 5	207.7 ± 14	59.5 ± 6	16.2 ± 4	15.9 ± 1	19.6 ± 1	311.8 ± 18
	5	CS	90	127.5 ± 4**	212.5 ± 14	59.9 ± 5	14.9 ± 2	15.6 ± 1	19.2 ± 1*	300.0 ± 40*
		PV	5	132.9 ± 3	222.0 ± 9	57.2 ± 9	15.3 ± 2	16.7 ± 1	20.3 ± 1	339.6 ± 31
	6	CS	69	139.5 ± 4**	216.6 ± 11	61.9 ± 4	14.6 ± 2	16.2 ± 1*	19.3 ± 1**	314.1 ± 33**
		PV	10	133.6 ± 3	220.3 ± 8	62.7 ± 2	15.4 ± 3	17.0 ± 1	20.5 ± 1	348.9 ± 31
	7	CS	53	132.0 ± 5	222.7 ± 12	63.3 ± 5	15.3 ± 2	16.6 ± 2	19.9 ± 1*	329.8 ± 40
		PV	14	130.1 ± 6	219.0 ± 9	61.9 ± 3	15.5 ± 2	16.8 ± 2	20.6 ± 1	345.6 ± 41
	8+	CS	49	131.9 ± 6	222.0 ± 10	63.0 ± 4	15.3 ± 2	17.0 ± 1	20.0 ± 1**	342.5 ± 39
		PV	20	133.6 ± 7	217.6 ± 15	63.4 ± 5	15.4 ± 4	16.6 ± 2	21.0 ± 1	347.5 ± 50
	Total	CS	349	128.5 ± 5***	213.8 ± 13*	60.7 ± 5	14.9 ± 2*	15.8 ± 2***	19.2 ± 1***	304.2 ± 46***
		PV	56	132.3 ± 6	217.8 ± 12	61.5 ± 5	15.5 ± 3	16.6 ± 2	20.5 ± 1	342.1 ± 41
Total		CS	451	126.6 ± 6***	208.4 ± 16***	59.0 ± 6**	14.6 ± 2**	15.1 ± 2***	18.6 ± 2***	248.8 ± 57***
		PV	56	132.1 ± 6	217.3 ± 12	61.1 ± 5	15.6 ± 3	16.6 ± 2	20.6 ± 1	342.7 ± 40

*p < 0.05, **p < 0.01, ***p < 0.001.

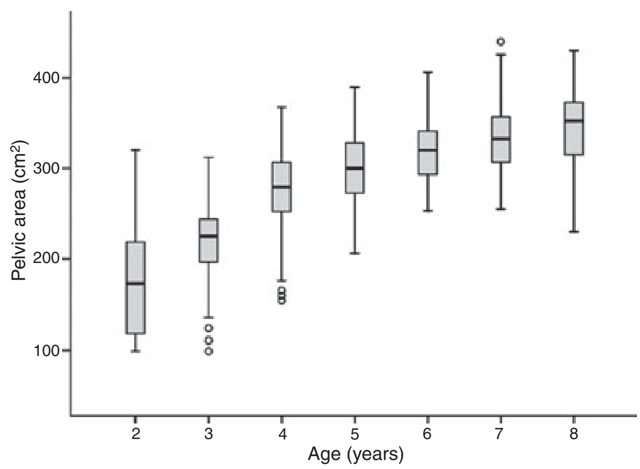

Fig. 1. Median pelvic area for the 507 double-muscled Belgian Blue cows and heifers associated with age

Table 3. Simple and partial correlations for 405 double-muscled Belgian Blue cows adjusted for age, related to WH (withers height), HG (heart girth), TcTc (distance between the *tubera coxae*), TiTi (distance between the *tubera ischiadica*), PW (pelvic width), PH (pelvic height) and PA (pelvic area)

	External measurements				Internal measurements		
	WH	HG	TcTc	TiTi	PW	PH	PA
External measurements							
WH		0.781**	0.682**	0.338**	0.715**	0.672**	0.740**
HG	0.623**		0.804**	0.453**	0.711**	0.689**	0.741**
TcTc	0.484**	0.687**		0.373**	0.614**	0.581**	0.627**
TiTi	0.237**	0.393**	0.287**		0.281**	0.217**	0.263**
Internal measurements							
PW	0.495**	0.496**	0.366**	0.158**		0.747**	0.954**
PH	0.434**	0.471**	0.326**	0.074**	0.557**		0.903**
PA	0.518**	0.530**	0.368**	0.124**	0.916**	0.828**	

**Correlations significant at the 0.01 level.

taking into account age and management of calving. Whilst the correlations between internal pelvic measurements and TcTc were reasonable, there were even higher with regard to with HG and WH. Partial correlations within the dataset corrected for age (Table 3) and management of parturition (Table 4) were lower compared to the simple correlations. Also, the overall simple class correlations found in animals calving *per vaginam* were also lower compared to those in cows that calved following CS. It was envisaged that these two different correlations could be used to produce a more robust model that described internal with external measurements but the partial and class correlations, being lower than the simple, suggested that there was no advantage in using either one or the other for estimating internal pelvic measurements.

Models for PW, PH and PA, describing their relationships with external measurements of mature cows, are described by the equations in Table 5: Only HG and WH were significant in all three models at the 5% level. Correlation coefficients r^2 of the models were 65% for both PW and PH and 72% for PA.

The most robust model was given by the equations below for a 4-year-old cow: for example,

1 $PW = -2.72 - 0.84\ \text{Age} + 0.10\ \text{WH} + 0.03\ \text{HG}$
2 $PH = 3.03 - 0.08\ \text{Age} + 0.09\ \text{WH} + 0.02\ \text{HG}$
3 $PA = -244.23 - 32.71\ \text{Age} + 3.02\ \text{WH} + 0.87\ \text{HG}$

The probability of mature cows calving *per vaginam* is shown in Fig. 2 that uses the variable PH and Fig. 3 that uses PA. For PH, the maximum height of 23 cm gave a probability of almost 80% that a cow

Table 4. Simple, partial and simple class correlations for 405 double-muscled Belgian Blue cows adjusted for management of parturition (CS; caesarean section: PV; delivery *per vaginam*), related to WH (withers height), HG (heart girth), TcTc (distance between the *tubera coxae*), TiTi (distance between the *tubera ischiadica*), PW (pelvic width), PH (pelvic height) and PA (pelvic area)

	External measurements				Internal measurements		
	WH	HG	TcTc	TiTi	PW	PH	PA
External measurements							
WH		0.781**	0.682**	0.338**	0.715**	0.672**	0.740**
CS							
PV							
HG	**0.754****		0.804**	0.453**	0.711**	0.689**	0.741**
CS	0.746**						
PV	0.698**						
TcTc	**0.654****	**0.788****		0.373**	0.614**	0.581**	0.627**
CS	0.637**	0.782**					
PV	0.561*	0.568**					
TiTi	**0.275****	**0.406****	**0.329****		0.281**	0.217**	0.263**
CS	0.260**	0.378**	0.291**				
PV	0.207	0.335**	0.284*				
Internal measurements							
PW	**0.678****	**0.677****	**0.579****	**0.217****		0.747**	0.954**
CS	0.701**	0.698*	0.585**	0.183**			
PV	0.274*	0.245	0.238	0.222			
PH	**0.616****	**0.645****	**0.539****	**0.123****	**0.709****		0.903**
CS	0.634**	0.657**	0.533**	0.125**	0.734**		
PV	0.121	0.161	0.133	−0.192	0.217		
PA	**0.698****	**0.706****	**0.592****	**0.182****	**0.950****	**0.883****	
CS	0.723**	0.728**	0.599**	0.165**	0.953**	0.897**	
PV	0.265*	0.263*	0.239	0.239	0.910**	0.601**	

Partial correlations in **bold**; *Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level.

Table 5. Predictive equations for PW (pelvic width), PH (pelvic height) and PA (pelvic area) using WH (withers height), HG (heart girth) and age of 405 double-muscled Belgian Blue cows using a mixed multivariable general linear regression model

	Parameter	Estimate	SE	p
PW	Intercept Age (years)	−2.72	1.64	NS
	4	−0.84	0.24	0.001
	5	−0.38	0.26	NS
	6	−0.04	0.24	NS
	7	−0.10	0.24	NS
	WH (cm)	0.10	0.16	< 0.001
	HG (cm)	0.03	0.01	< 0.001
PH	Intercept Age (years)	3.03	1.53	< 0.05
	4	−0.08	0.22	< 0.001
	5	−0.56	0.22	< 0.05
	6	−0.72	0.22	< 0.01
	7	−0.44	0.22	< 0.05
	WH (cm)	0.09	0.01	< 0.001
	HG (cm)	0.02	0.01	< 0.001
PA	Intercept Age (years)	−244.23	43.26	< 0.001
	4	−32.71	6.36	< 0.001
	5	−18.76	6.13	< 0.01
	6	−13.74	6.30	< 0.05
	7	−9.59	6.31	NS
	WH (cm)	3.02	0.41	< 0.001
	HG (cm)	0.87	0.18	< 0.001

could calve naturally. With the mean PH of 19.4 cm for all mature cows, the chance similar cows calving naturally would be just below 10%. For PA, cows with a maximum value of 444.0 cm^2 have a 70% probability of calving *per vaginam*; if the mean value for cows investigated was 309.5 cm^2, then the probability of them calving naturally would be only 11%.

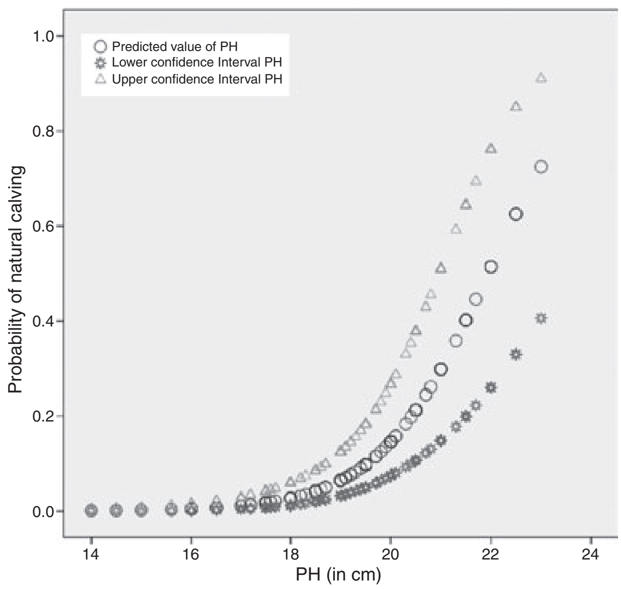

Fig. 2. Probability of 405 mature BB cows calving *per vaginam* related to PH (pelvic height)

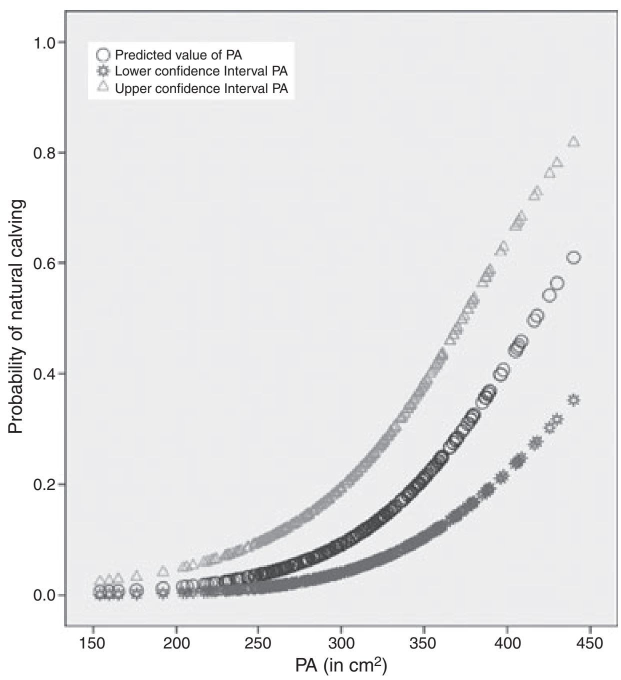

Fig. 3. Probability of mature BB cows calving *per vaginam* related to PA (pelvic area)

Discussion

This present study is the first to demonstrate that only relatively small increases in pelvic height and area are necessary to increase the probability of natural calving in DM-BB cows. An increase of only 2 cm in pelvic height and 50 cm^2 in area will almost double the probability of mature cows calving *per vaginam*, because the differences in pelvic dimensions between cows calving *per vaginam* and those delivered by caesarean section (CS) are relatively small; for example, they are only 1.5 and 2.0 cm for width and height, respectively. The DM-BB sample that was studied here presented a large variation in internal pelvic measurements, for example 16–21.5 cm in pelvic height in a 5-year-old cow. As there is high heritability for this trait in other breeds (Benyshek and Little 1982; Morrison et al. 1986; Green et al. 1988), selection towards larger pelvic area in DM-BB cows may be a realistic goal. The practical implication of this in the purebred DM-BB breed is the following: selection for this trait should be without loss of conformational characteristics or losing carcass quality. This study suggests that there is a substantial margin in pelvic area of animals within the S-carcass classification to increase pelvic area without losing traditional breed conformation: Selection is possible using multiple trait sires to minimize the degree of calving difficulty whilst still maintaining this breed's unique characteristics.

Currently, there is no defined selection or mating strategy for ease of calving in the DM-BB breed, because the estimates of those genetic parameters associated with maternal trait of calving ability, spread throughout different parities in DM cattle, are not available. Explicit for the BB breed maternal factors that can influence calving ability are body size, more specific the conformational characteristics and the pelvic slope, and differences in calving ability, such as preparation for calving, the relaxation of soft tissues and the determination and muscular power to strain during parturition. In other breeds, dairy as well as beef, EBV's for calving ease have been used widely as selection criteria in attempts to reduce feto-maternal disproportion (Freer 2008). In such a selection programme, the selection of these maternal traits is complex because they are influenced by the sire effect, through the size and conformation of the foetus (direct parameters), as well as dam effects related mostly to the pelvic dimensions (maternal parameters; Pausch et al. 2011). In Norwegian Red cattle, calving difficulty has been considered a part of the total merit index used for sire selection, with the weight placed on this trait depending on its frequency within the population (Heringstad et al. 2007). As both direct and maternal parameters influence the anatomical and physiological components that compromise calving ability (Philipsson 1976), these parameters have been used in other models for genetic evaluation of ease of calving in other breeds; good correlations have been found within direct and maternal effects (Gevrekçi et al. 2006). Most studies show no genetic correlation between direct and maternal effects (Gevrekçi et al. 2006; Heringstad et al. 2007), implying that bulls should be evaluated as sire of the foetus and sire of the cow (Heringstad et al. 2007). Quantitative trait loci (QTL) have been described that influence calving ease in German Fleckvieh. To use QLT mapping in selection for calving ease in a cattle population of moderate size such as the BB (around 550 000 cows in Belgium), progeny testing is essential to provide reliable EBV's and high heritability for ease of calving traits (Pausch et al. 2011).

The best indirect predictors of internal pelvic sizes in mature cows were not external pelvic measures, but withers height and heart girth, confirming the observations of Coopman et al. (2003). Almost 10 years earlier, Murray et al. (2002) used external pelvic measurements to predict internal pelvic sizes, but the dataset in this present study indicated that the relationship between external and internal pelvic measurements was too low. Using withers height and heart girth in the models described in Table 5, a farmer can estimate the internal pelvic dimensions with a reliability of 65% for pelvic width and height and 72% for area. Thus, there remains about 30% of variation in internal pelvic measurements that cannot be accounted for. Direct internal pelvic measurements are the most reliable variables for including in EBV's to reduce dystocia. Pelvimetry is a simple reliable method for breeders to use who wish to select cows suitable for calving naturally. To determine the variation in pelvic size of cows in his herd, the breeder/farmer can ask a veterinary surgeon to obtain the data using the technique. Using pelvimetry within the broader context of a veterinary herd health programme merely adds to the costs. The authors believe that pelvimetry, whilst being invasive, has no adverse effect on cattle welfare: The procedure can be compared with pregnancy diagnosis or artificial insemination that both necessitate manipulation per rectum. The use of pelvic measurements to predict dystocia on an individual cow basis is limited because several other factors contribute to ease of calving, but it may be used to predict herd problems (Larson et al. 2004).

To increase the number of cows that can give birth *per vaginam* and improve the perception of the DM-BB breed more widely in Europe, there must be cooperation between farmers/breeders and the BB herd book. Estimated breeding values (EBVs) for pelvic measurements are essential, and to increase the reliability of these values within the population of BB in Belgium, the number of records available must be increased and the quality of data improved (Degano and Vicario 2007). Gathering the data to determine these EBVs can be performed with minimal effort as cows are registered already within the herd book, and pelvimetry data can be added relatively easily. To select heifers and bulls with good EBVs for increased pelvic size must be beneficial for the breed (Freking 2000) and its reputation abroad. PH in yearling bulls has a correlation of 0.6 with the PH, PW and PA in his offspring (Deutscher 1991; Torell et al. 1995; Brinks 2005), and thus, positive selection for this trait in young bulls should increase the pelvic area of heifers bred to them (Andersen et al. 1993; Brinks 2005). Kriese et al. (1994) also demonstrated that bulls with an increased pelvic area would be expected to increase their daughters' average area by 1.30 cm^2, thus improving calving ease by 0.03 compared to daughters sired by the average breed bull. Simultaneously, any selection for lowering the dystocia rate should focus also on lower birth weights and less extreme muscling of the DM-BB foetus.

To begin selection of ease of calving and natural birth in a particular herd, a breeder should identify 10–20% of his cows with PH >20 cm: These cows could be sired with a DM-BB bull that produces calves with a relatively low birth weight and/or smaller shoulder, and hip width. Sire selection should not be too intense, as the viability of the neonate diminishes with an excessive reduction in its potential birth weight: These calves must have the genetic potential to grow into large cows typical for this breed that are able to calve naturally. This small selection of cows should be given the opportunity to prepare for parturition and go into the second stage of labour with the objective of delivering the foetus *per vaginam*. If feto-maternal disproportion shows, parturition can always be managed through caesarean section as before.

Conclusion

Considering the existing variation in the DM-BB pelvic dimension and the high heritability estimates of pelvic conformation in other breeds (Benyshek and Little 1982; Morrison et al. 1986; Green et al. 1988), selection towards larger pelvic sizes in this breed is possible. Estimated breeding values (EBV's) for pelvic measurements should be determined. Gathering the information to determine these EBV's is possible as pedigree cattle are registered already: Pelvimetry data can be added. This should be started as soon as possible, because the pelvic area in BB cattle has decreased by 37 cm^2 during the last 6 years, through selection in Belgium for better muscled cattle. Simultaneously, the focus for selecting lower dystocia rates should be directed towards foetuses with a lower birth weight and decreased muscular conformation at birth in the DM-BB calf. Taking the bulls' EBVs for these traits into account at the same time will help in decreasing the number of CSs in the DM-BB population.

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Conflict of interest

None of the authors have any conflict of interest to declare.

Author contributions

I Kolkman did the measurements, the statistics and wrote the maniscript. S Aerts, G Hoflack, G Opsomer and D Lips helped with reviewing my article. H Laevens helped with the statistics.

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