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RESEARCH ARTICLE

Pelvic Parameters in Holstein-Friesian and Jersey Heifers in Relation to Their Calving

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ABSTRACT

The objective of the study was to compare calving ease, pelvic structure and pelvic angle in 74 Holstein-Friesian and 45 Jersey heifers. The frequency of difficult calving was 15.2% in Holstein-Friesians and only 2.2% in Jersey heifers. Compared with Jersey cows, Holstein-Friesians were characterized by a higher calf weight to cow weight ratio, and higher ratios of pelvic area to cow weight and pelvic area to calf weight. The results of the study show that higher frequency of difficult calving recorded in Holstein-Friesians, in comparison with Jersey heifers, could be a consequence of relatively high calf weight and less preferable pelvic structure. Large variation in the internal dimensions of the pelvis in HF heifers encouraged reducing the occurrence of dystocia through selection of the dimensions of the pelvis.

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INTRODUCTION

In order to reduce costs of milk and meat production, these days selection is aimed at combining functional and production traits and their balanced improvement (Mee *et al.,* 2011). An example of a functional trait is calving ease, which determines delivery of live, healthy offspring, and is a key element of successful herd reproduction. The growing interest in the course of parturition results from serious consequences of dystocia, including increased calf mortality, a higher rate of cow culling in the postnatal period, lower fertility indices, reduced milk production, and high costs of veterinary care services (Oliveira and Gheller, 2009).

Calving ease is significantly affected by birth weight and sex of the calf, body conformation of the cow and calf, body condition of the cow at calving, abnormalities in the hormone profile of the cow, and abnormal presentation of the calf at birth (Mee *et al.,* 2011). Calving ease may also be influenced by the level of development of reproductive organs, especially in heifers (Mee *et al.,* 2011). Close correlations between calving ease and pelvic measurements and shape were observed by Nogalski (2002). Their studies resulted in indirect improvement of calving ease in heifers and cows by selection based on rump width and angle.

Pelvimetry deals with measurement of the dimensions of the pelvic canal. Due to significant differences in the anatomy of the female pelvis, both inter-species and inter-breeds (Ramin *et al.,* 1995; Bennett *et al.,* 2008), this problem has not gained enough attention so far. Long and wide rumps, with large pelvic area, are conducive to calving ease (Oliveira and Gheller, 2009). Apart from pelvic measurements, course of parturition is also positively influenced by a sloping rump (Tyczka, 1998; Nogalski, 2002). However, a too sloping rump may be the reason for prolapse of the uterus and vaginal walls (Nogalski, 2002). It follows that a slightly inclined rump is most desirable.

The effect of breed on calving ease is widely differentiated, and varies from almost 0% of difficult calving in White Park and Longhorn cows to 80-90% in Belgian Blue-and-White cows (Bennett *et al.,* 2008). The results of studies on calving ease in Friesians show that the frequency of difficult calving may even reach 50% (Steinbock *et al.,* 2003). Compared with Holstein-Friesians (HF), Jersey cows are distinguished by very low frequency of difficult calving, which is a consequence of relatively low calf weight and desirable dimensions of pelvic bones (Bleul, 2011). Micke *et al.* (2010) suggested that pelvic area measurement at selection in heifers may be useful for identifying heifers at an increased risk of dystocia.

The aim of this study was to determine the share of dystocia and stillbirths among HF and Jersey heifers. An attempt was made in the study to explain, at least partly, the high frequency of difficult calving in Holstein-Friesian heifers, comparing their pelvic structure with the pelvic structure of Jersey heifers.

MATERIALS AND METHODS

The study was conducted at the Experimental Station of the University of Warmia and Mazury in Olsztyn, located in Bałdy, Poland. The experimental material comprised 119 pregnant heifers, including 74 Holstein-Friesian (HF) and 45 Jersey (J) ones. They were kept in a free-stall system, under identical conditions. About one to two weeks before expected calving the heifers were moved to a calving pen. The course of parturition was determined on the basis of direct observations concerning calving ease, calf condition after delivery and time of placenta expulsion. Twin pregnancies were disregarded since in their case high incidence of difficult labor and stillbirths is natural (Berry *et al.,* 2007).

The course of parturition was evaluated according to a four-grade scale:

1) No assistance,
2) Slight problem – needed assistance of one person,
3) Difficulty – needed assistance of several persons,
4) Extreme difficulty – needed assistance of a veterinary doctor.

Grades 1 and 2 were considered as easy calving, while grades 3 and 4 were considered as difficult calving. Perinatal mortality rate (PM) was estimated according to a two-grade scale:

1) Calf born alive, survived 24 hours after parturition,
2) Stillborn calf or died within 24 hours after parturition.

Placenta expulsion was classified as follows:

1) Expelled within 12 hours after parturition,
2) Expelled within 24 hours after parturition,
3) Retained placenta

In the first week postpartum, the cows were weighed and their condition was evaluated according to a five-grade scale (1-5). Between the 2nd and 3rd week postpartum (after regression of perinatal edema), inner pelvic sizes were estimated rectally with the Rice pelvimeter, i.e. the height of the pelvic canal, which was the vertical measurement between the pubic symphysis on the floor of the pelvis and the sacral vertebrae, and the width of the pelvic canal, which was the horizontal measurement between the interior surfaces of the left and right ileal shafts. Estimated pelvic inner area was the product of the height and width of the pelvic canal. Pelvic angle was determined as the difference in height at hips and pins, and the difference in height at the hip bone and the greater trochanter (Fig. 1). Rump angle was determined as the slope of the rump (RS) from hip to pin, taking into account pelvic length (Fig. 1).

The following measurements were also performed:

(i) width at hips-the horizontal measurement between extreme edges of hip bones,

(ii) width at pins-the horizontal measurement between pin bones,

(iii) width at trochanters-the horizontal measurement between the greater trochanters,

(iv) pelvic length-the oblique diameter between the hip bone and the pin bone,

(v) $\propto$ - rump slope,

$$\sin\alpha(RS) = \frac{TcH - TiH}{TcTi}$$

The above measurements provided the basis for calculating the following indices:

- ratio of calf weight to cow weight (%),
- ratio of pelvic area to calf weight,
- ratio of pelvic area to cow weight.

The data were processed statistically using Statistica 9.0 software. The effects of genotype on reproductive traits and indicators of body composition were estimated by one-way ANOVA.

RESULTS

Difficult calving, which required assistance of several persons, and extremely difficult calving, which required assistance of a veterinary doctor, accounted for 16.2% in Holstein-Friesians, and only 2.2% in Jersey heifers (Table 1). Stillbirths and calf deaths within the first 24 hours following calving, referred to as the so called perinatal death loss, constituted 6.7% in HF (4.84% in the group of easy calving and 16.67% in the group of difficult calving). In the group of 45 Jersey heifers, only two cases of stillbirth were noted (4.4 %). In HF 8.4% (6.40% in the group of easy calving and 16.67% in the group of difficult calving) cases of retained placenta were recorded, while in Jersey there were only 4.4%. Birth weight of Jersey calves was, on average 15.4 kg lower than birth weight of Holstein-Friesian calves. As expected, the pelvises of HF primiparous were wider and longer when measured externally than when measured internally (Table 2). This concerned especially rump width measured at pins, where the average difference between HF and Jersey was 27.08%. The inner pelvic size showed wide variation. The average difference in the inner pelvic height and inner pelvic width between Jersey cows and HF cows was 7.02 and 13.53% respectively (The differences with HF easy calving were lower). The pelvic canal in Jersey cows was oval and laterally flattened. The pelvic canal in Holstein-Friesians was more oval, with mean inner height and mean inner width of 17.1 and 17.0 cm, respectively. The difference in height at the hip bone and the greater trochanter, reflecting the size of the pelvic inlet, was by 1.2 cm higher in difficult calving Holstein-Friesians than in easy calving Holstein-Friesians and Jersey. The difference in height at the hip bone and the pin bone, reflecting the size of the pelvic outlet, was higher in Jersey heifers. Rump angle, determined as the slope of the rump (RS) from hip to pin, taking into account pelvic length, was smaller in HF cows.

Table 1: Traits determining quality of calving (Means ± SD)

Traits	Holstein-Friesian		Jersey
	Easy calving	Difficult calving	
Number	62	12	45
Frequency of difficult calving (%)	0.0	100	2.20
Frequency of PM (%)	4.84	16.67	4.40
Retained placenta (%)	6.40	16.67	4.40
Mean age at calving (months)	26.7±1.7^{A}	26.3±1.6^{A}	24.4±1.1^{B}
Cow weight after calving (kg)	516.1±35.3^{A}	506.8±32.1^{A}	345.0±18.7^{A}
Body condition score (points)	2.9±0.43	2.8±0.38	2.8±0.40
Calf weight after delivery (kg)	39.6±4.23^{A}	42.9±3.41^{A}	24.8±2.69^{B}

Means followed by different letters differ significantly P≤0.01.

Table 2: Pelvic measurements and rump slope (Mean±SD)

Traits	Holstein-Friesian (Calving)		Jersey
	Easy	Difficult	
Width at hips (cm)	52.9±1.95[A]	52.7±2.18[A]	44.5±2.14[B]
Width at trochanters (cm)	49.0±1.40[A]	48.1±2.80[A]	39.8±1.27[B]
Width at pins (cm)	19.3±1.16[A]	19.0±1.05[A]	14.0±0.96[B]
Pelvic length (cm)	52.5±1.43[A]	51.9±1.13[A]	47.4±1.71[B]
Height of the pelvic canal (cm)	17.2±1.15	16.8±1.11	15.9±0.83
Width of the pelvic canal (cm)	17.0±0.71[a]	16.9±0.82	14.7±0.86[b]
Pelvic area (cm^2)	292.7±23.9[A]	283.9±28.1[A]	233.7±15.8[B]
Difference in height at the hip bone and the greater trochanter (cm)	17.3±2.39[a]	16.1±2.08	16.1±1.54[b]
Difference in height at hips and pins (cm)	7.3±2.14	5.9±2.23	7.4±2.29
Rump slope (°)	8.1±3.94	6.6±2.72	9.1±2.95

Means followed by different letters differ significantly: capital letters at P≤0.01; small letters at P≤0.05.

Table 3: Indices determined on the basis of body measurements (Mean±SD)

Traits	Holstein-Friesian		Jersey
	Easy calving	Difficult calving	
Ratio of calf weight to cow weight (%)	7.70±0.92	8.50±0.96	7.20±0.81
Ratio of pelvic area to cow weight (cm^2/kg)	0.57±0.06	0.56±0.04	0.68±0.05
Ratio of pelvic area to calf weight (cm^2/kg)	7.49±1.08[A]	6.65±1.23[A]	9.60±1.58[B]
Ratio of pelvic area to height at withers (cm^2/cm)	2.14±0.16	2.11±0.19	1.92±0.16

Means followed by different letters differ significantly: capital letters at P≤0.01.

From the perspective of calving ease, the value of the calf weight to cow weight ratio was more desirable in Jersey heifers (Table 3). The ratio of pelvic area to cow weight indicates that in Jersey cows the pelvic bones were disproportionately large, compared with other body measurements. In Holstein-Friesians pelvic area was by 0.11 cm^2 per kg of body weight smaller than in Jersey heifers. The ratio of pelvic area to calf weight was significantly higher in Jersey cows.

DISCUSSION

Heifers examined in the present study were at the age considered optimum for calving in the Holstein-Friesian and Jersey breeds (Bluel, 2011). Yildiz *et al.* (2011) obtained greater calf perinatal mortality among HF heifers than in our study: 12.72%, but in normal parturition – 10% and in difficult calving – 14.28%. Bluel (2011) recorded 2.9% perinatal mortality in Jersey cattle. However, with regard to all breeds of cattle, an overall increase in perinatal mortality from 1.8% in 2005 to 2.8% in 2007 was noted (Bluel, 2011). In Germany, Gundelach *et al.* (2009) recorded 9.7% PM in dairy herds, including 18.9% among heifers. In the USA the proportion of stillbirths in Holstein-Friesians increased from 9.5% in 1985 to 13.2% in 1996 (Johanson and Berger 2003), and it still shows a rising tendency (Olson *et al.,* 2009). It is difficult to ascertain univocally whether intrauterine fetal death leads to dystocia or dystocia increases the chance of stillbirths (Bicalho *et al.,* 2007).

The course of labor is also affected by ease of the expulsion of the fetal membranes after parturition. The placenta is normally expelled within the first five to six hours after birth. However, sometimes it fails to separate from the uterus. Placenta retention occurs more frequently in cows having higher potential for calving difficulty. In the present study, placenta retention rates were by 12.27% higher in Holstein-Friesians (with difficult calving) than in Jersey heifers. High birth weight of Holstein-Friesian calves could be one of the reasons for high frequency of difficult calving in this group, which is consistent with the findings of other authors (Johanson and Berger, 2003; Micke *et al.,* 2010). Investigating dystocia in Jersey and Holstein–Friesian breeds, Berry *et al.* (2007) estimated the probability of dystocia occurring at third calving of a male calf weighing 20, 30, 40 and 50 kg as 1.0, 2.0, 5.0 and 15.0%, respectively.

In our study the pelvic canal in Holstein-Friesians was more oval than in Jersey. A similar correlation between inner pelvic height and width was reported by Ramin *et al.* (1995) and Oliveira and Gheller (2009). The studies conducted by Weiher *et al.* (1992) on German Black-and-White primiparous heifers revealed that their pelvic lumen was more flattened laterally, and the inner height and width of the pelvic canal were 18.7 and 17.5 cm, respectively. They also discovered that the inner shape of the pelvis in beef cattle resembled a flattened oval, whereas in dairy cattle it was rounded, which positively affected calving ease. High variation of inner pelvic sizes obtained in this study, and high heritability of these traits (Olson *et al.,* 2009), suggest that they can be improved through selection.

A significant effect of pelvic area on calving ease was observed by Micke *et al.* (2010) and Gundelach *et al.* (2009). A downward slope of the pelvis, a longer pelvis and a greater inner pelvis width were also linked to a lower (P<0.05) PM (Gundelach *et al.,* 2009). Gundelach *et al.* (2009) reported low PM frequency in cows whose pelvic area before calving was at least 320 cm^2. Johanson and Berger (2003) demonstrated that an increase in pelvic area (measured externally) by 1 dm^2 allowed to reduce the frequency of difficult calving by 11%. The high correlation between pelvic size and calving ease in Holstein-Friesians may be explained by the results obtained by Ramin *et al.* (1995), who discovered that Friesian cattle, in comparison with other breeds, have the smallest pelvic area at first calving.

In our study, rump angle was smaller in HF cows. This may be a consequence of selection for highly, widely and tightly attached, back and front, globular-shaped udder, extended forward and well backward. Such selection has been carried out for decades within the Holstein-Friesian breed. The sites of the attachment of the elastic suspensory ligament supporting the udder are the pelvic symphysis and ischiadic bones. A long and level rump is conducive to udder extension and its high vulvar-abdominal attachment. This kind of selection resulted in other traits changing for the worse, including natural calving ease, common in wild animals, which developed during thousands of years of evolution. According to Nogalski (2002), a sloping rump is positively correlated with calving ease. Tyczka *et al.* (1998) observed a strong influence of pelvic angle on the course of parturition. In their opinion a raised rump is a result of elongation and curving upward of the ischaidic bones, and leads to pelvic outlet narrowing, thus increasing the incidence of dystocia. The positive correlation between rump angle and calving ease is related to increased pelvic area resulting from increased vertical measurement of the pelvis (PelH in Fig. 1) in cows with sloping rumps.

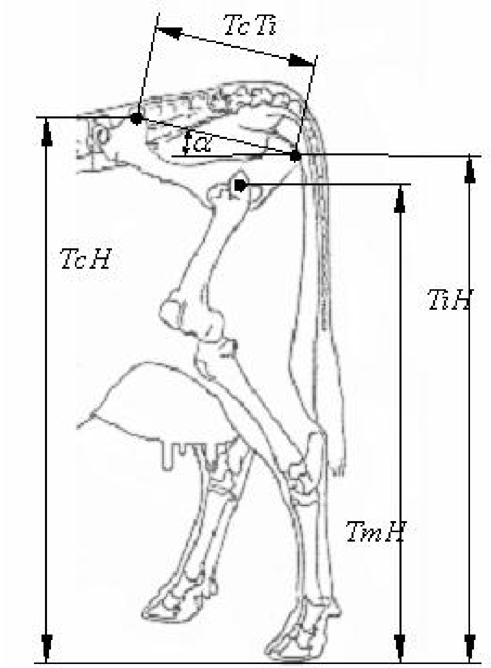

Fig. 1: The measurements of the pelvis:
TcH=height at hip (*tuber coxarum*), TiH= height at pin (*tuber ischium*), TmH=height at the greater trochanter (*trochanter major*), TcTi=pelvic length, ∝=rump slope.

The value of the calf weight to cow weight ratio in the HF group of easy calving was close to the optimum level determined for this breed by Johanson and Berger (2003). Johanson and Berger (2003) also demonstrated that the percentage of PM was negatively affected by both high and low values of the calf weight to cow weight ratio. The ratio of pelvic area to cow weight indicates that in Jersey cows the pelvic bones were disproportionately large, compared with other body measurements. In Holstein-Friesians pelvic area was by 0.11 cm^2 per kg of body weight smaller than in Jersey heifers. High frequency of difficult calving recorded in HF heifers could be caused by a disproportion between calf size and pelvic area (fetopelvic complex). In Jersey heifers, each kilogram of calf has had a 9.60 cm^2 birth canal. In contrast HF group of difficult calving has had only 6.65 cm^2. This was confirmed by the results of previous studies, where a high correlation (r = -0.46) was found between calving ease and the pelvic area to calf weight ratio (Nogalski, 2003). The disadvantage of the pelvic area to calf weight ratio as a predictor of calving ease is that calf weight is difficult to estimate before parturition. Therefore, it is better to use the ratio of pelvic area to height at withers, which is also highly correlated with calving ease (r=-0.37) (Nogalski, 2003). In the present study the value of pelvic area to height at withers ratio was more desirable in Jersey heifers.

Conclusion: Higher frequency of difficult calving recorded in Holstein-Friesians, in comparison with Jersey heifers, could be a consequence of relatively high calf weight and less preferable pelvic structure. Large variation in the internal dimensions of the pelvis in HF heifers encouraged reducing the occurrence of dystocia through selection of the dimensions of the pelvis.

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