The Influence of Feto-pelvic Disproportion on the Fertility of Milk cows

Marek Gehrke, Ph DVM[1,3]

Anna Markiewicz, DVM[2]

Dawid Marcinkowski, MA[3]

Amila Gębska, MA[3]

[1]Department of Cattle Breeding
Faculty of Animal Breeding and Biology
University of Technology and Life Sciences, 85-084 Bydgoszcz, Poland

[2]Department of Pathophysiology of Reproduction and Mammary Gland,
National Veterinary Research Institute, 85-090 Bydgoszcz, Poland

[3]Department of Veterinary Medicine,
University of Life Sciences, Wojska Polskiego 20, 60-625 Poznan, Poland
Corressponding author address:
Faculty of Animal Breeding and Biology
University of Technology and Life Sciences, Mazowiecka 28,
85-084 Bydgoszcz, Poland
Corresponding author e-mail address: mgehrke@utp.edu.pl

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ABSTRACT

The aim of the study was to evaluate the relation between the feto-pelvic proportion and fertility of milk cows, select proportions and critical values of disproportion that best predict cows with the risk of lower fertility as a result of difficult calving as well as to evaluate the fertility of cows selected on the basis of chosen criteria. The study was carried out on black-and-white and red-and-white Polish Holstein-Friesian cows in six farms diversified by the number of livestock (from 10 to 20 to over 180 cows) and milk yield (from 6563 – 9788 kg/305 days). In total 100, parturitions have been analysed (one in each cow) resulting in giving birth to one calf, without of complications related to foetus presentation, posture, and position or the need for caesarean section or fetotomy and retained placenta. The analysed parturitions were the result of artificial insemination pregnancies in 53 cases with semen from 33 domestic HF bulls and in 47 cases with semen from 26 foreign HF bulls. Using the critical values for feto-pelvic disproportion in relation to proportion between head and chest perimeter and pelvis length, shoulders width vs pelvis length or chest vs pelvis perimeter of the cow. A group of cows was selected, where more than every third cow had a delayed over 90 days the calving-conception period and more than every fourth became pregnant after at least three inseminations.

INTRODUCTION

An increase of the percentage of difficult calvings observed in the dairy cows breeding in the world partially is the result of introduction of Holstein-Friesian cattle genes.[1,8,11,16,19] In homogenous groups of cows depending on the age structure there are 2-7% of difficult calvings a year. The United States is an exception, where the percentage of cases is higher (heifers –

22.6%, cows – 9.6%).[6] The high percentage of difficult calvings in the USA results from the size of herds, insufficient selection for easy calving, as well as inadequacy of maintenance and organization of parturitions. Putting the easy calving feature on the selection index, despite its low heredity (0.02-0.09), may reduce the tendency to increase the number of difficult calvings. It has been found that in countries that use selection indices in relation to calving, the percentage of difficult parturitions is lower, despite the influence of breed, maintenance and environment.[8,22]

The ranking of direct causes of difficult calvings changes with the age of cows.[15] In heifers, the most important is feto-pelvic disproportion (FPD), whereas in multiparous cows, the most common are foetus presentation, posture, and position abnormalities. Other causes include uterine inertia, cervical and vaginal stenosis, as well as torsion of the gravid uterus. However, feto-pelvic disproportion is statistically the most important factor influencing parturition and as a consequence the loss of newborn calves or further cow fertility.[5,10,11,13,16]

In cows after difficult calving, the first heat and first insemination are delayed, the calving index decreases, the number of inseminations per pregnancy increases, and the intercalving period is longer.[3,8,14,20] Direct causes of lower fertility in cows include longer time of uterine involution, delay of first ovulation, and disturbance in progesterone secretion.[4,7] Cows with difficult parturition history also have problems with subsequent calvings. As a result, of numerous early or late consequences of difficult parturition, the cost of treatment increases, and their late diagnosis additionally worsens reproductive indices of the herd.[15] The herds where difficult parturitions occur more often focus the attention of breeders, veterinarians, and researchers, forcing them to evaluate the risk factors and take prophylactic measures.

However, an objective assessment of parturition is difficult because of a subjective character of phenotypic criteria of classifying calvings into ”easy” or “difficult.” It has been suggested that although the real percentage of difficult parturitions is lower, as much as 50% of calvings are human-assisted.[11,12]

The improvement of fertility indices in herds of cows can be obtained by early selection of females at risk of complicated uterine involution (endometritis), detailed diagnostic examination, and early treatment. Due to subjective character of phenotypic evaluation of parturition, the aim of the study was to compare proportions between morphometric and pelvimetric parameters of new-born calves of randomly selected group of cows with their subsequent fertility as well as to evaluate the selecting criteria of females at risk of lower fertility as a result of feto-pelvic disproportion.

MATERIALS AND METHODS

The study was carried out on black-and-white and red-and-white Polish Holstein-Friesian cows in six farms. The number of cows and their average milk yield in standard lactation (305 days) during the observation period were respectively:

- herd A – 32 cows/9,248 kg
- herd B – 14 cows/6,563 kg
- herd C – 27 cows/7,534 kg
- herd D - 184 cows/7,400 kg
- herd E - 100 cows/9,008 kg
- herd F – 100 cows/9788 kg.

In four farms, the animals were kept in tie-up barns, and in two farms, in free stall barns. Calvings took place in separate rooms, where cows were moved 2 weeks before the planned date of parturition. In total, 100 parturitions have been analysed (one in each cow) resulting in giving birth to one calf, without complications related to foetus presentation, posture, and position or the need for caesarean section or fetotomy and retained placenta. Additional criterion for selection of cows for analysis was another pregnancy after insemination at the end of the postparturient period. Among the analysed calvings 16 took place in spring, 22 in summer, 49 in autumn, and 13 in winter.

Forty five heifer calves and 55 young bulls were born as a result of pregnancies of the average length 278±7.4 days. All pregnancies were the result of artificial insemination -- in 53 cases with semen from 33 domestic HF bulls, and in 47 cases, with semen from 26 foreign HF bulls from USA (9), Canada (5), France (4), Holland (3), Denmark (3), and Switzerland (2).

Pelvimetric examination was performed 14 days before parturition by measuring the outer distance between the sciatic and coxal tubers on the same side (pelvis length) and on the opposite sides (pelvis diagonal), and between two sciatic tubers and coxal tubers (pelvis width). The age of heifers (22 cows), primiparas (17 cows), and multiparas (61 cows) on the day of parturition was on average 26.9±3.4, 37.6±7.3, and 78.4±27.6 months, and the HF gene share 91.0±9.0%, 92.1±6.7%, and 85.1±16.6%. In the analysed population of cows, 20 were not registered in the breed registry for dairy cattle. These were 4 heifers, 1 primipara, and 15 multiparas with the average HF gene share 62.9±12.5%. Forty one cows were in the initial breed registry (average HF gene share -– 89.7±2.8%)and 39 were in the main breed registry (average HF gene share – 98.1±2.1%). Among the studied animals registered in the breed registry were 18 heifers, 16 primiparas, and 46 multiparas.

Morphometric examinations of newborn calves were performed on the day of parturition. The measurements included body weight and the head width at temporal bone, trunk width at shoulders and hips, head circumference from the bottom of the mandible to the occipital bone as well as chest circumference just behind the scapular bones. Among the studied calves in most cases one (36 cases) or two (16 cases) offspring of one bull were examined. In two cases, morphometric examinations were performed in three and four offspring. There were also cases where five, six, and seven offspring of one bull were examined.

In all farms, the cows were under supervision of a local veterinarian. Cows showed post-parturient metritis, clinical metritis, or endometritis were treated with antibiotics systemically and/or locally (recognition based on general signs, characteristics of the discharge obtained during examination per vaginam, and rectal palpation of uterus -- definition suggested by Sheldon et al.[18]

The fertility of cows after calving was assessed on the basis of analysis of the date of first and subsequent inseminations, their efficiency, total number of inseminations until pregnancy was determined per rectum over 42 days after insemination, the percentage of, ”repeating” cows, and cows culled due to infertility as well as the length of calving-conception period.

The comparisons of mean values of pelvimetric measurements of cows, morphometric examinations of calves, coefficients of proportion changeability between them, as well as selected indices of fertility, were performed using one-way analysis of variance and division into homogenous groups was done using Student-Newman-Keuls test. The correlation between the measurable fertility indices (the length of calving-conception period and number of inseminations per pregnancy/without reinsemination) and the indices of proportions of the size of the new-born calf to the size of mother’s pelvis was assessed using Pearson’s correlation coefficient.

In order to determine the critical values of feto-pelvic disproportions, proportion ranges were set using categorization method based on integers. Critical values for each range were tested with respect to efficiency of division of the studied cows into statistically maximally diversified by the incidence of cows with prolonged calving conception period (CCP>90days) and non-pregnant cows after two inseminations (repeating’ cows). The deciding criterion of the efficiency of division were the results of logistic regression performed for each proportion separately as well as for interaction between them. The P values (statistical significance) within the range of 0.10-0.05 were used as tendency markers, whereas values <0.05

Table 1. *Results of pelvis measurements of heifers, primiparas and multiparas in the last month of pregnancy (mean ± standard deviation)*

[1]Measurement (in cm):	Group of cows:		
	heifers (n=22)	primiparas (n=17)	multiparas (n=61)
[1] distance between sciatic tubers	26.3±1.0	26.1±1.0	26.5±1.5
[2] distance between coxal tubers	51.8±3.4	49.9±3.7	51.1±4.5
[2][3] distance between coxal and sciatic tubers on the opposite side - diagonal	63.3±3.5	61.5±3.1	62.2±3.9
[3][4] distance between coxal and sciatic tubers on the same side	51.8±3.2	50.7±4.0	50.8±4.2
[4][5] pelvis circumference	204.8±9.7	199.0±8.5	202.1±12.1

[1] [...] symbol of measurement; [2] diagonal mean; [3] mean of measurements on the right and left side; [4] sum of distances between coxal and sciatic tubers and distance between sciatic and coxal tubers on the opposite side - diagonals; abc p<0.05.

Table 2*. Results of morphometric measurements of new-born calves with respect to sex (mean ± standard deviation)*

[1]Measurement (in cm):	New-born calf sex:	
	heifers (n=45)	bulls (n=55)
[A] body weigth (kg)	36.7±4.9a	39.5±4.6b
[B] head width (cm)	14.9±1.4	15.2±1.7
[C] shoulders width (cm)	19.6±1.3	20.0±1.4
[D] hips width (cm)	20.4±2.2	20.5±1.8
[E] head circumference (cm)	51.9±1.7a	53.3±3.1b
[F] chest circumference (cm)	80.2±6.0	80.7±4.8

[1][...] symbol of measurement; ab p<0.05.

Table 3. *Sex of new-born calves and selected fertility indices of cows after calving.*

Index:	Group of mother		
	after first calving (n=22)	after second calving (n=17)	after third and more calvings (n=61)
number of new-born heifers	13	10	32
number of newborn bulls	9	7	29
date of 1st insemination (days after calving)	85.8±14.0	81.4±11.0	81.9±9.6
pregnancy index after 1st insemination (%)	81.8^{b}	70.6^{ab}	50.9^{a}
insemination index	1.41 ± 0.91^{ab}	1.29 ± 0.47^{a}	1.84 ± 1.03^{b}
calving-conception period (days)	94.1 ± 22.1^{ab}	84.2 ± 13.8^{a}	98.6 ± 25.6^{b}

^{abc} p<0.05.

confirmed higher percentage of cows with lower fertility after calvings with feto-pelvic disproportion. The data were analysed using the STATISTICA StatSoft®-PL software.

RESULTS

The results of external pelvis measurements in heifers, primiparas, and multiparas presented in Table 1 did not differ statistically. Morphometric examinations of new-born calves (Table 2) confirmed a common opinion concerning a bigger size of young bulls in comparison with heifer calves verified statistically with respect to body weight and head circumference of new-born calves. Differences in proportions of newborns' sexes were not statistically confirmed in diversified by numbers of deliveries groups of females despite a bit bigger number of delivered calves (Table 3).

Higher index of calving after first insemination and lower insemination index were observed at younger cows whatsoever, with the consequence of differences in the length of calving-conception period. The greatest variability concerned proportions between head width and head circumference, as well as new-born calves chest circumference and mothers' pelvis size (P<0.05 – data not in Tables). The range of alternations regarding examined proportions was observed not significant comparing the mass of new-borns' bodies, the width of shoulders' and hips with/to measurements of the mothers' pelvis.

In the studied population of cows, the length of calving conception period and the number of inseminations per pregnancy only in some cases was correlated with the feto-pelvic proportion determined at calving (Table 4). The highest values of correlation coefficients refer to proportions from comparison of head width and circumference, shoulders width and chest circumference of new-born calves with mother's pelvis length (notation [3]), its diagonal (notation [4]), and circumference (notation [5]). The lack of significant relationship (P<0.05) or "correlation" tendency (0.05≤P<0.10) between fertility indices and other proportions were the reason to exclude them from further analysis. The results presented in Tables 5 and 6 estimate the accuracy of critical values selection for different feto-pelvic proportions, thanks to which there is a possibility to select from the whole population the cows in which the significant disproportion could be the cause of lower fertility. As a criterion of correctness of choosing critical value for a given proportion was the comparison of percentage of cows with calving-conception period >90 days with the cases where more than two insemination were necessary to get the cow pregnant.

In five cases (B:3/B:4/B:5/E:3/F:3), the found critical values of feto-pelvic proportions significantly differentiate (P<0.05) the population with regard to the percentage of females with CCP>90 days. Three cases (C:3/C:5/F:4) demonstrated a tendency (0.05≤P<0.10), and in four (C:4/E:4/E:5/F:5), such tendency was not found (P>0.10). Also, in the case of five feto-pelvic proportions (C:3/E:3/E:4/F:3/F:4), the chosen critical values allowed for selecting a group of cows with an increased percentage of, "repeating" cases (P<0.05), four (B:3/B:4/E:5/F:5) demonstrated a tendency (0.05≤P<0.10), and in case of three proportions (B:5/C:4/C:5), critical values were not found (P>0.10). The assumption was correct (P<0.05) with regard to the two fertility indices in cows for two proportions (E:3 and F:3), whereas in four (B:3/B:4/C:3/F:4), one comparison demonstrated a tendency. Among these proportions that exceeded values of E:3>1.00 and F:3>1.60 as well as C:3>0.40 or F:4>1.30 very accurately (P<0.015) marked out the cows at risk of prolonged calving-conception period (52.2% vs. 25.0%) and lack of pregnancy after two inseminations (35.2% vs. 11.1%) (Table 7).

The comparison of values of fertility indices significantly differentiates the group of cows selected on the basis feto-pelvic disproportions from the controls, which were assumed to be the cows whose critical values were not exceeded (Table 8). In the group of cows selected on the basis of E:3 and F:3 quotient with disproportion with

***Table 4**. Correlation coefficient between fertility indices and proportion of size of new-born calf and mother's pelvis (r – correlation coefficient. p – statistical significance)*

[1]Analyzed proportion:	[2]Fertility index	
	calving-conception period	number of inseminations per pregnancy
A:1	r =-0.017 p = 0.872	r = 0.032 p = 0.760
A:2	r = 0.093 p = 0.371	r = 0.063 p = 0.547
A:3	r = 0.117 p = 0.262	r = 0.109 p = 0.295
A:4	r = 0.135 p = 0.195	r = 0.123 p = 0.237
A:5	r = 0.095 p = 0.360	r = 0.089 p = 0.393
B:1	r = 0.067 p = 0.521	r = 0.197 p = 0.057
B:2	r = 0.157 p = 0.131	r = 0.182 p = 0.079
B:3	r = 0.195 p = 0.059	r = 0.252 ***p* = 0.014**
B:4	r = 0.204 ***p* = 0.049**	r = 0.251 ***p* = 0.015**
B:5	r = 0.175 p = 0.092	r = 0.234 ***p* = 0.023**
C:1	r = 0.014 p = 0.889	r = 0.144 p = 0.165
C:2	r = 0.152 p = 0.144	r = 0.146 p = 0.159
C:3	r = 0.209 p = 0.043	r = 0.245 ***p* = 0.017**
C:4	r = 0.221 ***p* = 0.032**	r = 0.247 ***p* = 0.016**
C:5	r = 0.183 p = 0.078	r = 0.222 ***p* = 0.031**
D:1	r =-0.014 p = 0.892	r = 0.045 p = 0.667
D:2	r = 0.089 p = 0.391	r = 0.061 p = 0.562
D:3	r = 0.131 p = 0.207	r = 0.128 p = 0.219
D:4	r = 0.152 p = 0.144	r = 0.143 p = 0.169
D:5	r = 0.104 p = 0.320	r = 0.101 p = 0.330
E:1	r =-0.049 p = 0.640	r = 0.140 p = 0.178
E:2	r = 0.106 p = 0.310	r = 0.138 p = 0.184
E:3	r = 0.156 p = 0.134	r = 0.236 ***p* = 0.022**
E:4	r = 0.166 p = 0.109	r = 0.228 ***p* = 0.027**
E:5	r = 0.128 p = 0.220	r = 0.217 ***p* = 0.036**
F:1	r = 0.033 p = 0.755	r = 0.146 p = 0.160
F:2	r = 0.145 p = 0.164	r = 0.135 p = 0.196
F:3	r = 0.204 ***p* = 0.049**	r = 0.228 ***p* = 0.027**
F:4	r = 0.209 ***p* = 0.043**	r = 0.227 ***p* = *0.028***
F:5	r = 0.176 p = 0.089	r = 0.202 ***p* = 0.050**

[1] notation according to tables 1 and 2.

regard to one out of two proportions, the pregnancy index after 1st insemination and the calving conception period differed statistically from the control group.

DISCUSSION

The lack of differences between mean values of external pelvis measurements in pregnant heifers in relation to older cows (primiparas and multiparas) signifies a similar level of somatic size of young cows. It is worth emphasizing that the first calving in heifers took place between 23 and 36 month of life (on average 26.9±3.4), which agrees with the breeding recommendations concerning optimal time of breeding maturity, first insemination/covering, and date of first calving. It has been calculated that the level of, infusion" of HF genes in

Table 5. *Critical values of analysed feto-pelvic proportions and statistics with respect to percentage of cows with calving-conception period (CCP) over 90 days.*

[1]Analyzed proportion:	Critical value of proportion:	[2]Cows with CCP >90 days (% vs. %)	Wald Chi^2 statistic	[3]AOR	P
B:3	0.30	53.8 vs. 20.0	13.7049	5.8235	0.00036
B:4	0.24	55.0 vs. 20.4	12.6484	5.7778	0.00060
B:5	0.80	60.0 vs. 24.6	9.4841	4.5882	0.00273
C:3	0.40	45.9 vs. 26.3	3.7725	2.3800	0.05516
C:4	-	-	no critical value found (p>0.1000)		
C:5	0.95	40.0 vs. 18.2	3.2099	2.5555	0.07648
E:3	1.00	45.3 vs. 19.5	6.5133	3.4138	0.01235
E:4	-	-	no critical value found (p>0.1000)		
E:5	-	-	no critical value found (p>0.1000)		
F:3	1.60	51.4 vs. 23.7	7.2106	3.4034	0.00860
F:4	1.30	46.3 vs. 26.0	3.0280	2.1631	0.08518
F:5	-	-	no critical value found (p>0.1000)		

[1] notation according to tables 1 and 2; [2] percentage of cows with CCP over 90 days in group with exceeded critical value of proportion vs. other cows; [3] adjusted odds ratio (AOR).

Table 6. *Critical values of feto-pelvic proportions and statistics with respect to percentage of „repeating" cows.*

[1]Analyzed proportion:	Critical value of proportion:	[2] „Repeating" cows (% vs.%)	Wald Chi^2 statistic	[3]AOR	P
B:3	0.30	28.2 vs. 12.7	3.3827	2.694	0.0691
B:4	0.24	37.5 vs. 13.0	3.0185	2.547	0.0857
B:5	-	-	no critical value found (p>0.1000)	4.5882	0.00273
C:3	0.40	29.7 vs. 12.3	4.1853	3.022	0.0436
C:4	-	-	no critical value found (p>0.1000)		
C:5	-	-	no critical value found (p>0.1000)	2.5555	0.07648
E:3	1.00	30.2 vs. 4.9	7.3893	8.432	0.0078
E:4	0.85	23.3 vs. 11.5	4.1162	3.067	0.0454
E:5	2.60	26.5 vs. 11.1	3.4135	2.889	0.0679
F:3	1.60	34.3 vs. 10.2	7.4744	4.609	0.0075
F:4	1.30	29.5 vs. 10.0	5.3230	3.774	0.0233
F:5	4.00	27.5 vs. 13.0	3.0185	2.547	0.0857

[1] notation according to tables 1 and 2; [2] percentage of „repeating" cows in the group with exceeded critical value of proportion vs. other cows; [3] adjusted odds ratio (AOR).

Table 7. *Efficiency of selection of cows with longer calving-conception period (CCP) and „repeating" cows in groups diversified by feto-pelvic disproportion criteria.*

[1]Criteria of disproportion evaluation:	Cows with CCP >90 days				[2] „Repeating" cows			
	[2]Proportion (% vs. %)	Wald Chi[2] statistic	[3]AOR	P	[2]Proportion (% vs. %)	Wald Chi[2] statistic	AOR	P
E:3. F:3	51.4 vs. 23.7	7.2106	3.403	0.0086	34.3 vs. 10.2	7.4744	4.609	0.0075
E:3. F:3. B:3	53.8 vs. 26.5	6.0025	3.241	0.0162	26.9 vs. 16.2	-	-	>0.05
E:3. F:3. B:4	53.8 vs. 26.5	6.0025	3.241	0.0162	26.9 vs. 16.2	-	-	>0.05
E:3. F:3. C:3	53.6 vs. 25.8	6.4809	3.326	0.0126	35.7 vs. 12.1	6.5180	4.028	0.0123
E:3. F:3. F:4	51.6 vs. 25.4	6.1254	3.133	0.0152	35.5 vs. 11.1	7.2777	4.400	0.0083

[1] notation according to tables 1 and 2; [2] percentage cows with CCP over 90 days or „repeating" cows in the group with exceeded value of E:3>1.00 and F:3>1.60 vs. others, E:3>1.00. F:3>1.60 and B:3> 0.30 vs. others, E:3>1.00. F:3>1.60 and B:4>0.24 vs. others, E:3>1.00. F:3>1.60 and C:3> 0.40 vs. others, E:3>1.00. F:3>1.60 and F:4>1.30 vs. others; 3 adjusted odds ratio (AOR).

Table 8. *Selected fertility indices of cows after calving in groups with feto-pelvic disproportion and control.*

Index:	[1]Criteria of disproportion evaluation:	[2]Group		
		with disproportion in all criteria	with disproportion not in all criteria	control
date of 1st insemination (days after calving)	E:3. F:3	83.4±17.4	82.9±2.6	82.1±4.7
	E:3. F:3. C:3	83.3±17.5	84.4±11.6	81.8±4.2
	E:3. F:3. F:4	83.3±18.5	82.1±5.2	82.6±5.2
pregnancy index after 1st insemination (%)	E:3. F:3	48.6[a]	50.0[a]	78.0b
	E:3. F:3. C:3	42.9[a]	64.7[ab]	71.4b
	E:3. F:3. F:4	48.4[a]	58.8[ab]	71.7b
insemination index	E:3. F:3	1.97±1.12[b]	1.83±1.04[ab]	1.27±0.55[a]
	E:3. F:3. C:3	2.07±1.15[b]	1.71±1.10[ab]	1.37±0.63[a]
	E:3. F:3. F:4	2.00±1.15[b]	1.65±0.93[ab]	1.39±0.71[a]
calving-conception period (days)	E:3. F:3	103.7±29.5[b]	97.3±24.8[b]	86.5±11.7[a]
	E:3. F:3. C:3	106.1±29.6[b]	96.9±28.8[ab]	87.9±13.1[a]
	E:3. F:3. F:4	104.5±31.1[b]	93.3±21.6[ab]	89.1±15.1[a]

[1] notations according to tables 1 and 2; 2 with disproportion: E:3>1.00 and F:3>1.60 (n=35); E:3>1.00. F:3>1.60 and C:3> 0.40 (n=28) or E:3>1.00. F:3>1.60 and F:4>1.30 (n=31); controls: E:3≤1.00 and F:3≤1.60 (n=41). E:3≤1.00. F:3≤1.60 and C:3≤0.40 (n=49) or E:3≤1.00. F:3≤1.60 and F:4≤1.30 (n=46); with disproportion not in all criteria: n=18, n=17 and n=17 respectively; abc p<0.05.

the studied population was the lowest in the group of cows calving at least for the third time (85.1±16.6%). It is known that the size of HF female cows is bigger than analogous in native breeds of dairy cattle. This allows to assume that lower share of genes of this breed in older cows was the cause of higher percentage of feto-pelvic disproportion in this group. Assuming the index of selection of cows at risk of difficult calving the feto-pelvic disproportion of E:3.F:3 and C:3 or E:3. F:3 and F:4 more than 2/3 of cows (25/36 - 69.4% or 20/30 - 66.7% respectively) were cows calvings at least for the third time.

Comparison studies confirm positive correlation between internal and external pelvimetric measurements irrespective of the method of measurement (bow compass, Rice pelvimeter, computer tomography).[15,21] However, there is some variability that differ particular external and internal measurements, and which are not the result of differences of the precision of measurements. The variability differences can also be observed comparing the results of different morphometric measurements in calves.[2] This shows that the use of feto-pelvic proportion as an objective criterion to evaluate the difficulty at calving requires standardization.

According to affected examinations, the disproportion is not reflected at the same level as all proportions between measurements at calves and pelvic measurements of their mothers. Assuming a priori the relationship, emphasized in literature, between the course of calving and further fertility of the cow, we selected proportions and critical values of disproportions that best select cows with prolonged calving-conception period and calving difficulties. New-born calves measurements (head, pectoral girdle, chest) chosen on the basis of mathematical analysis reflect the moments during parturition when the trunk of the foetus traveling through the birth canal makes it difficult or slows down the moment of pushing out the foetus.

Similarly, a simple external measurement of the length of pelvis diagonal and circumference turns out to precisely enough (keeping the measurement repeatability) characterize the size of the birth canal. Morphometric measurements of new-borns together with external pelvimetric measurements of mothers might be faulty. To minimise the number of faults considering improper typing of cows after deliveries with feto-pelvic disproportion, one should confirm its presence taking under consideration more parameters to compare. "Disproportion" according only to one measurement at the mother and the new-born might be doubtful. Fertility of cows in groups "control" (all proportions considered under limiting values), with "disproportion" (all proportions considered over limiting values) and in cows with the disproportion only according to some parameters of the mother and the new-born calf, was presented in Table 8 to emphasise aforementioned facts. As it is observed in the comparison the index of conception after first insemination, insemination index together with calving conception period in the group with in disproportion to that of partially considered parameters of the mother and the calf to have average values.

They don't differ significantly from corresponding ones in cows with "disproportion" and "control." Moreover, it confirms the group of cows with doubtful diagnosis contain cows after deliveries either with actual "disproportion" or faulty one. The comparison of calving efficiency after first insemination and the length of calving-conception period suggest higher accuracy of cow's selection on the basis of three and not two proportions (Table 8). This is confirmed by the lack of statistically better values of these indices in cows with a single disproportion when the evaluation criterion is the ratio of head and chest circumference to the pelvis length.

It is disputable that there is no connection between the proportion of new-born calves weight and the mother's pelvis and the feto-pelvic disproportion assessed on the basis of fertility indices. The weight of a calf is very often used as a criterion in determining the reasons of difficult calving due to easy measurement.[13] However, the correlation between weight and other morphometric measurements is poor.[9] The lack of statistically confirmed difference between body weight of new-born calves diversified by sex suggests small morphometric differences between offspring. This emphasizes the importance of proportions demonstrated in our own study as sensitive parameters of evaluation of feto-pelvic disproportion. Using the critical values for feto-pelvic disproportion with regard to proportion of head and chest circumference to pelvis length, as well as shoulder width vs pelvis length or chest circumference vs pelvis circumference, we can select a group of cows in which more than every third cow will have over 90 days calving conception period and more than every fourth becomes pregnant after at least three inseminations.

Monitoring the cases of feto-pelvic disproportion seems to be justified because of at least two reasons. Firstly, it shows that the process of, Holsteinization" of domestic headage of cattle requires the selection of bull's semen not only for heifers but also older cows. Secondly, due to subjective criteria of phenotypic assessment of the course of calving, the estimation of feto-pelvic disproportion is a simple, objective and quite efficient method of selecting cows at risk of lower fertility. The selection of such cows may be of special importance in herds where there is a lack of permanent and systematic gynaecological supervision and a significant percentage of cows with fertility disturbances.

REFERENCES

1. Adamec V, Cassell BG, Smith EP, Pearson RE. Effects of inbreeding in the dam on dystocia and stillbirths in US Holsteins. *J Dairy Sci* 2006; 89:307-314.
2. Becker M, Heun C, Tsousis G, Bollwein H. Application of computed tomography for the evaluation of obstetrically relevant measurements in German Holstein-Friesian calves. *Theriogenology* 2011; 75:1052-1056.
3. Buckley F, O´Sullivan K, Mee JF, Evans RD, Dillon P. Relationship among milk yield, body condition, cow weight and reproduction in spring-calved Holstein-Frisians. *J Dairy Sci* 2003; 86:2308-2319.
4. Dobson H, Tebble JE, Smith RF, Ward WR. Is stress really all that important? *Theriogenology* 2001; 55:65-73.
5. Donovan GA, Bennett FL, Springer FS. Factors associated with first service conception in artificially inseminated nulliparous Holstein heifers. *Theriogenology* 2003; 60:67-75.
6. Ettema JF, Santos JEP. Impact of age at calving on lactation, reproduction, health and income in first-parityHolsteins on commercial farms. *J Dairy Sci* 2004; 87:2730-2742.
7. Fourichon C, Seegers H, Malher X. Effect of disease on reproduction in the dairy cow: a meta-analysis. *Theriogenology* 2000; 53(9):1729-1759.
8. Gaafar HMA, Shamiah ShM, Abu El-Hamd MA, Shitta AA, Tag El-Din MA. Dystocia in Friesian cows and its effects on postpartum reproductive performance and milk production. *Trop Anim Health Prod* 2011; 43:229-234.
9. Grunert E, Steiner JF. Untersuchungen über den Wert von Beckenmassen zur Vorausbestimmung des Geburtsferlaufes beim Rind. Dtsch Tierarztl Wochenschr 1980; 87:120-124.
10. Gundelach Y, Essmeyer K, Teltscher MK, Hoedemaker M. Risk factors for perinatal mortality in dairy cattle: Cow and foetal factors calving process. *Theriogenology* 2009; 71:901-909.
11. Hansen M, Misztal I, Lund MS, Pedersen J, Christensen LG. Undesired phenotipic and genetic trend for stillbirth in Danish Holsteins. *J Dairy Sci* 2004; 87:1477-1486.
12. Heringstad B, Chang YM, Svendson M, Gianola D. Genetic analysis of calving difficulty and stillbirth in Norwegian Red cows. *J Dairy Sci* 2007; 90:3500-3507.
13. Johanson JM, Berger PJ. Birth weight as a predictor of calving case and perinatal mortality in Holstein cattle. *J Dairy Sci* 2003; 86:3745-3755.
14. Lopez de Maturana E, Legarra A, Varona L, Ugarte E. Analysis of fertility and dystocia in Holsteins using recursive models to handle censored and categorical data. *J Dairy Sci* 2007; 90:2012-2024.
15. Mee JF. Prevalence and risk factors for dystocia in dairy cattle: A review. *Vet J* 2008; 176:93-101.
16. Meyer CL, Berger PJ, Koehler KJ, Thompson JR, Sattler CG. Phenotypic trends in incidence of stillbirth for Holsteins in the United States. *J Dairy Sci* 2001; 84:515-523.
17. Murray RD, Cartwright TA, Downham DY, Murray MA, de Kruif A. Comparison of external and internal pelvic measurements in Belgian Blue cattle from sample herds in Belgium and the United Kingdom. *Reprod Domest Anim* 2002; 37:1-7.
18. Sheldon IM, Lewis GS, LeBlanc S, Gilbert RO. Defining postpartum uterine disease in cattle. *Theriogenology* 2006; 65:1516-1530.
19. Steinbock L, Nasholm A, Berglund B, Johannson K, Philipsson J. Genetics effects of stillbirth and calving difficulty in Swedish Holsteins at first and second calving. *J Dairy Sci* 2003; 86:2228-2235.

20. Tenhagen BA, Helmbold A, Henwieser W. Effect of various degrees of dystocia in dairy cattle on calf viability. milk production. fertility and culling. *J Vet Med* 2007; Series A 54(2):98-102.
21. Tsousis G, Heun C, Becker M, Bollwein H. Application of computed tomography for the evaluation of obstetrically relevant pelvic parameters in German Holstein-Frisian cows. *Theriogenology* 2010; 73:309-315.
22. Zaborski D, Grzesiak W, Szatkowska I, Dybus A, Muszyńska M, Jędrzejczak M. Factors affecting dystocia in cattle. *Reprod Domest Anim* 2009; 44: 540-551.