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EFFECT OF SELECTED FACTORS ON THE COURSE OF PARTURITION IN HOLSTEIN-FRIESIAN HEIFERS

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ABSTRACT

The paper presents the basic outside and inside pelvic diameters of 136 Holstein-Friesian cows, and the coefficients of phenotypic correlation between these measurements and the course of parturition.

The frequency of difficult labor was growing with an increase in the fetus weight. It was found that a large size of the pelvis and a steep (“roof-like”) position of the rump had a positive effect on the labor. A statistical correlation was observed between the course of parturition and the pelvis area (r = -0.37), including: height r = -0.41, width r = -0.22, as well as its position (-0.30). A more advanced age of heifers at the first calving had a favorable effect on the size of the pelvic canal and the course of parturition.

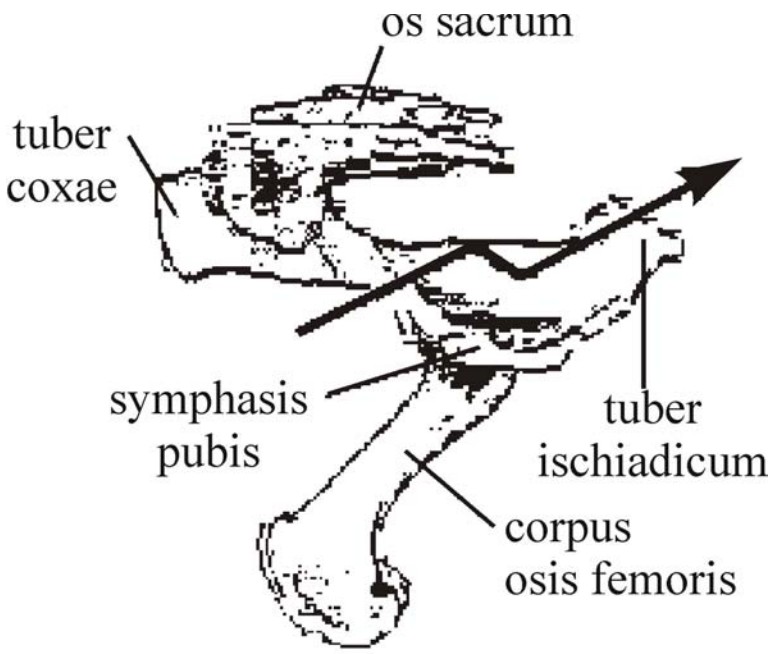
Key words: dairy cattle, course of parturition, pelvic diameters, Rica pelvimeter.

INTRODUCTION

The course of parturition depends first of all on the weight and sex of a calf, the degree of development of the genital tract, the physical condition and hormonal profile of a cow, and the fetus position [13, 15]. Difficult parturition, concerning mainly young heifers [19, 21], results in increased perinatal calf mortality and postnatal cow mortality, lower fertility and productivity of a herd, and higher veterinary costs [4, 7, 14].

The birth canal (uterus, uterine cervix, vagina, vestibule of the vagina and vulva), which can expand considerably, is limited by the pelvic girdle [1, 21]. The cow's pelvis is long, with visible fundus indentation. The pelvic axis is bent twice (Fig. 1). During bearing down, the fetus must go through rigid, almost inflexible narrowing. The most critical places are the pelvic inlet and outlet. The inlet, which has the form of an osseous, stretching–resistant ring, is characterized by transverse dimensions, whereas the outlet – by longitudinal dimensions.

Fig. 1. Route of foetus during parturition



It is not enough to know the body weight of a heifer to determine its reproduction maturity [2, 5, 12]. Apart from body weight, also its constitution is important, as it affects the performance of a heifer [11]. The optimum heifer size can be determined taking into consideration the pelvis inner area, which is easy to measure in live animals.

The studies conducted in Poland on the correlation between the course of parturition and body measurements in cows are few and concern Black-and-White cattle [3], Red-and-White cattle [21] and beef crossbreeds [16].

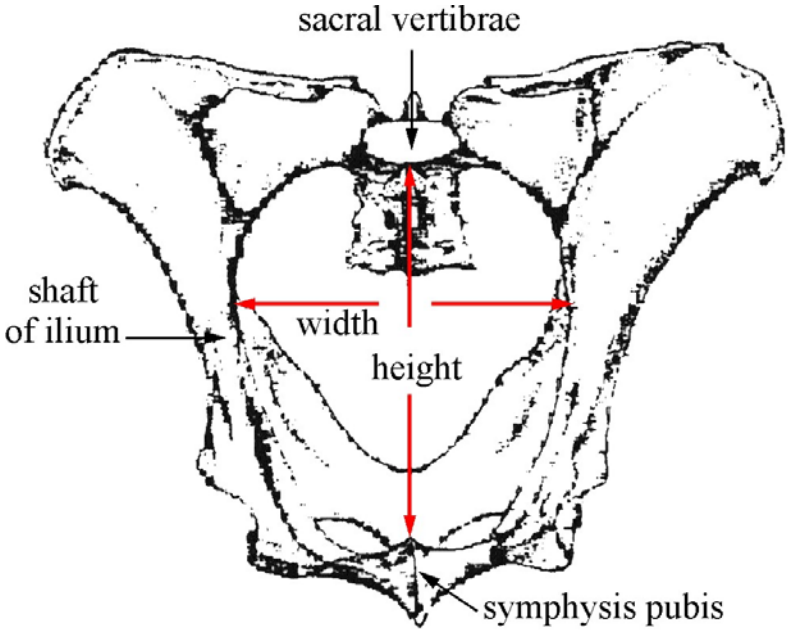
The aim of the present research was to determine the effect of selected factors on the course of parturition in Holstein-Friesian heifers, paying special attention to the development of the pelvic skeleton.

MATERIALS AND METHODS

136 heifers with at least 75% genes of the Holstein-Friesian breed constituted the experimental material. They were kept in a loose barn in north–eastern Poland. Parturition took place in separate, long stalls, where heifers were tied ca. two weeks before the expected date of calving. Newborn calves were weighed. The course of parturition was evaluated according to the scale: 1 – normal, no assistance required; 2 – assistance of 1 person; 3 – difficult, assistance of several persons; 4 – very difficult, assistance of a veterinary doctor; 5 – cesarean section. Due to a low number of cases, groups 4 and 5 were treated as one. The health state (vitality) of newborn calves was evaluated according to the scale: 1 – normal, healthy; 2 – feeble; 3 – stillborn or dead within 24 hours after delivery. The time of placenta expulsion was classified as follows: 1 – placenta expelled spontaneously within 12 hours after delivery; 2 – placenta expelled spontaneously within 24 hours after delivery; 3 – detachment of the placenta. In order to determine the effect of age at calving on the traits examined, the heifers

were divided into three age groups: 1 – up to 27 months, 2 – 27-30 months, 3 – above 30 months. As regards the birth weight of calves, three classes were distinguished: 1 – up to 38 kg, 2 – 38-43 kg, 3 – above 43 kg. Taking into account the month in which heifers were born, the following division was made: 1 – autumn–winter season (from October to January), 2 – winter-spring season (from February to May), 3 – summer season (from June to September). The heifers were measured between the 2nd and 3rd week after parturition (after edema regression). The following measurements were taken: height at and width of hips, pins, thurls; length of the pelvis, chest girth, fore cannon circumference and – with the Rica pelvimeter – inner height and width of the pelvis (Fig. 2). The pelvis inner area is the product of the pelvis height and width [17]. The pelvis position was determined as the difference in the height at hips, pins and thurls.

Fig. 2. Inside dimension of pelvic



The numerical data obtained were subjected to an analysis of variance, using the following linear model:

$$Y_{ijklm} = \mu + A_i + B_j + C_k + e_{ijklm}$$

where:

Y_{ijklm} – value of the measurements taken
μ – mean for population
A_i – effect of i–course of parturition
B_j – effect of j–birth season
C_k – effect of k–age at calving
e_{ijklm} – random error.

The significance of differences between the mean values was estimated using the Duncan test. The coefficients of correlation between the course of parturition and body measurements of cows were also calculated.

RESULTS

Traits characterizing parturition in 136 heifers were analyzed (Tables 1, 2, 3). Spontaneous labor or labor requiring the assistance of one person was noted in 54% of cases. 39 deliveries required the assistance of two or three persons, whereas 24 were complicated, and the help of a veterinary doctor was indispensable. The season when heifers were born had no significant influence on the course of parturition (Table 1). An increase in the fetus weight was accompanied by delivery complications. The number of difficult deliveries was lower in older heifers, irrespective of the fetus sex.

Table 1. Classification of the course of parturition by the birth season, heifers' age at first calving, birth weight and sex of calves

Factor	Grade	Sex of calves						Total		
		bulls			heifers					
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD
Birth season	1	37	2.44	1.13	35	2.38	1.03	72	2.42	1.07
	2	11	2.53	1.36	11	2.21	1.13	22	2.36	1.25
	3	26	2.37	1.02	16	2.28	0.77	42	2.33	0.69
Age at first calving	1	18	2.51	1.11	22	2.39	1.00	40	2.44	1.05
	2	42	2.44	1.13	30	2.31	1.07	72	2.38	1.08
	3	14	2.31	1.10	10	2.20	1.03	24	2.26	1.10
Birth weight of calves	1	14	1.21^{AB}	0.72	33	2.03	1.01	47	1.80^{AB}	0.99
	2	31	2.58^{A}	1.06	18	2.61	0.78	49	2.63^{A}	0.97
	3	29	2.86^{B}	1.00	11	2.72	1.10	40	2.80^{B}	1.01
Total average		74	2.43	1.12	62	2.32	1.03	136	2.39	1.07

^{aA} – Means with the same subscripts differ significantly: small letters – p ≤ 0.05; capital letters ps ≤ 0.01.

Table 2. Classification of the placenta delivery by the course of parturition, birth season, heifers' age at calving, birth weight and sex of calves

Factor	Grade	Sex of calves						Total		
		bulls			heifers					
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD
Course of parturition	1	20	1.05^{ab}	0.22	23	1.15	0.50	43	1.07	0.27
	2	18	1.38	0.60	12	1.10	0.28	30	1.23^{AB}	0.50
	3	20	1.55^{a}	0.82	19	1.31	0.63	39	1.45^{A}	0.76
	4	16	1.50^{b}	0.63	8	1.50	0.53	24	1.50^{B}	0.58
Birth season	1	37	1.40	0.64	35	1.20	0.53	72	1.30	0.59
	2	11	1.36	0.67	11	1.36	0.50	22	1.36	0.58
	3	26	1.31	0.61	16	1.25	0.57	42	1.28	0.59
Age at first calving	1	18	1.33	0.68	22	1.27	0.63	40	1.30	0.64
	2	42	1.33	0.61	30	1.23	0.50	72	1.29	0.56
	3	14	1.50	0.65	10	1.20	0.42	24	1.37	0.57
Birth weight of calves	1	14	1.21	0.57	33	1.21	0.48	47	1.21	0.51
	2	31	1.42	0.67	18	1.39	0.69	49	1.41	0.67
	3	29	1.38	0.62	11	1.09	0.30	40	1.30	0.56
Total average		74	1.36	0.63	62	1.24	0.53	136	1.31	0.59

^{aA} – Means with the same subscripts differ significantly: small letters – p ≤ 0.05; capital letters p ≤ 0.01.

Table 3. Classification of the vitality of calves by the course of parturition, birth season, heifers' age at calving, birth weight and sex of calves

Factor	Grade	Sex of calves						Total		
		bulls			heifers					
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD
Course of parturition	1	20	1.05^{A}	0.22	23	1.10	0.45	43	1.07^{A}	0.35
	2	18	1.16^{B}	0.38	12	1.09	0.28	30	1.10^{B}	0.30
	3	20	1.10^{C}	0.31	19	1.47	0.79	39	1.29^{C}	0.63
	4	16	2.12^{ABC}	0.80	8	1.62	0.74	24	1.95^{ABC}	0.80
Birth season	1	37	1.32	0.66	35	1.23	0.59	72	1.28	0.63
	2	11	1.45	0.82	11	1.45	0.82	22	1.45	0.80
	3	26	1.23	0.43	16	1.37	0.62	42	1.28	0.51
Age at first calving	1	18	1.16	0.51	22	1.36	0.78	40	1.27	0.67
	2	42	1.33	0.61	30	1.33	0.60	72	1.33	0.60
	3	14	1.43	0.75	10	1.10	0.31	24	1.29	0.62
Birth weight of calves	1	14	1.07	0.26	33	1.33	0.64	47	1.25	0.56
	2	31	1.38	0.61	18	1.27	0.66	49	1.35	0.63
	3	29	1.36	0.72	11	1.27	0.65	40	1.32	0.69
Total average		74	1.31	0.67	62	1.31	0.61	136	1.31	0.62

^{aA} – Means with the same subscripts differ significantly: capital letters – p≤ 0.01.

Placenta expulsion depended on the course of parturition. The process was longer in the case of assisted deliveries (often requiring also the intervention of a veterinary doctor), regardless of the fetus sex. The vitality of newborn calves was also connected first of all with the course of parturition. Difficult and very difficult labor resulted in a significant decrease in their vitality. The other factors had no influence on the vitality of calves.

Heifers which required assistance during calving were characterized by shorter and narrower pelvises – measurements taken at hips and pins (Table 4). As regards the birth season, heifers born in summer had wider and longer pelvises. The differences were confirmed statistically for the width of thurls and pelvis length ($p \leq 0.01$). A more advanced age at the first calving resulted in a significant increase in the outer pelvic diameters.

Table 4. Outside pelvic diameters [cm]

Factor	Grade	Width of hips		Width of buttock		Width of trochanter	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Course of parturition	1	52.5	1.69	19.9	1.14	47.4	1.68
	2	52.1	1.65	19.2	1.36	47.4	2.71
	3	51.8	2.48	18.9	1.39	47.5	2.29
	4	51.4	1.57	19.1	1.10	47.0	1.73
Birth season	1	51.9	1.99	19.1	1.09	47.1^{A}	2.13
	2	51.9	2.18	19.2	0.66	46.9^{B}	2.35
	3	52.6	2.39	19.6	1.46	48.1^{AB}	1.83
Age at first calving	1	51.9^{a}	1.75	19.1	1.27	47.0^{a}	2.26
	2	52.0^{b}	2.03	19.3	1.29	47.2^{b}	1.91
	3	53.0^{ab}	2.93	19.4	0.88	48.3^{ab}	2.31
Total average		52.1	2.16	19.3	1.27	47.4	2.12

Table 4 cont.

Factor	Grade	Lenght of pelvic		Height difference			
				hook bone – pin bone		hook bone – head of femur	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Course of parturition	1	52.5	1.87	10.1	3.08	18.6	4.22
	2	52.6	2.23	10.6^{ab}	2.51	19.3^{ab}	3.88
	3	51.7	2.08	8.7a	4.07	17.5^{a}	4.08
	4	52.0	2.09	8.3^{b}	3.57	17.3^{b}	2.46
Birth season	1	52.3A	2.04	9.6	3.86	18.2	3.90
	2	51.1^{AB}	1.94	8.8	2.68	17.5	2.06
	3	53.0^{B}	1.81	10.2	3.49	18.4	4.34
Age at first calving	1	51.3^{Aa}	1.63	9.1	3.36	17.2^{A}	3.08
	2	52.5^{a}	2.04	9.2	4.68	18.1^{a}	5.34
	3	52.7^{A}	2.42	10.3	4.26	20.0^{Aa}	3.45
Total average		52.3	2.04	9.5	3.24	18.3	3.81

^{aA} – Means with the same subscripts differ significantly: small letters – $p \leq 0.05$; capital letters $p \leq 0.01$.

As concerns the size of the pelvic inlet, the difference between the height at hips and thurls diminished significantly with increasing labor complications. A similar correlation was observed for the difference between the height at hips and pins. Heifers' age at calving was also correlated with the pelvis position. The biggest differences concerning the height at hips, and thurls, and at hips and pins were noted in the oldest heifers.

Both the inner and outer pelvic diameters affected the course of parturition (Table 5). Easier labor was observed in heifers characterized by higher values of the inner height, width and area of the pelvis. The differences were confirmed statistically for the height and area of the pelvis. The season in which heifers were born had no effect on the inner pelvic diameters. A more advanced age at calving was connected with a significant increase in the inner pelvis area, resulting from a significant increase in its transverse diameter.

Figure 3 and Table 5 present the correlation between the pelvis area in mothers and the fetus weight. A higher quotient of the pelvis area and fetus weight is accompanied by higher probability of spontaneous labor in heifers.

Fig. 3. Pelvic area of mothers and body weight of calves in relation to course of parturition

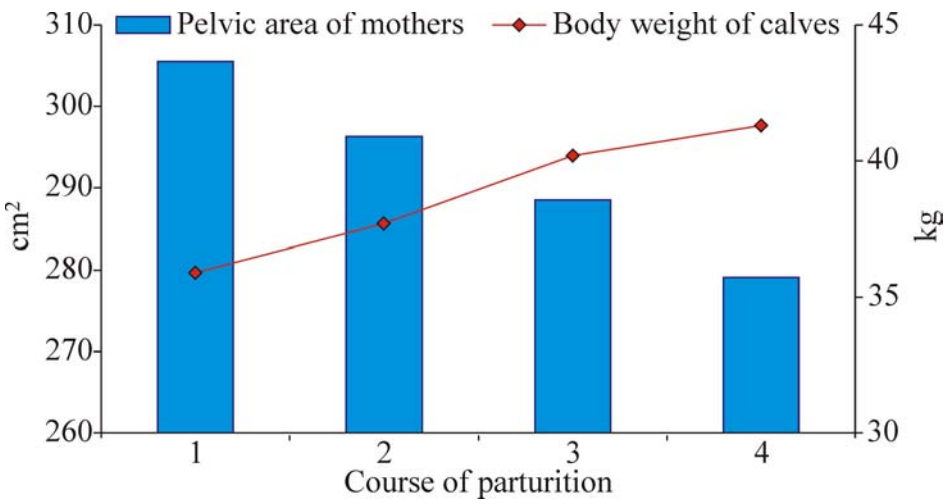


Table 5. Inside pelvic diameters, chest girth, cannon circumference, body weight of calves and index PA of cow / BW of calf

Factor	Grade	Inside pelvic diameters					
		height [cm]		width [cm]		area [cm^2]	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Course of parturition	1	18.1^{Aa}	0.87	16.8	0.92	305.5^{Aa}	24.3
	2	17.6^{ab}	1.21	16.8	0.90	296.3^{b}	27.8
	3	17.3	0.89	16.6	0.69	288.5^{a}	17.9
	4	16.8^{Ab}	1.20	16.7	0.56	279.1^{Ab}	15.6
Birth season	1	17.6	1.14	16.7	0.77	294.4	25.69
	2	17.7	1.19	16.6	0.82	294.7	22.85
	3	17.8	0.87	16.9	0.96	299.2	22.55
Age at first calving	1	17.4	1.09	16.4^{A}	0.87	285.1^{ab}	23.8
	2	17.8	0.93	16.8^{a}	0.80	298.9^{a}	22.9
	3	17.9	1.38	17.2^{Aa}	0.76	307.6^{b}	25.6
Total average		17.7	1.07	16.8	0.84	296.9	24.6

Factor	Grade	Chest girth [cm]		Cannon circumference [cm]		Body weight of calves [kg]		Pelvis area of cow/ body weight of calf	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Course of parturition	1	193.2	6.61	18.8	0.51	35.9^{AB}	4.77	8.6^{ACD}	1.21
	2	194.3	9.07	18.8	0.62	37.7^{ab}	4.65	7.9^{BDa}	1.01
	3	195.2	7.34	18.8	0.56	40.2^{Aa}	4.35	7.3^{a}	1.02
	4	195.6	5.42	18.9	0.63	41.3^{Bb}	3.90	6.8^{AB}	0.59
Birth season	1	193.7	6.69	18.8	0.52	37.6	4.60	7.8	1.21
	2	192.5	9.76	18.7	0.59	37.1	5.35	7.9	1.51
	3	195.7	7.16	18.9	0.60	38.0	5.01	7.9	1.06
Age at first calving	1	189.6	7.42	18.7	0.49	36.5	5.58	7.7	1.43
	2	194.7	6.97	18.8	0.56	38.0	4.76	7.8	1.17
	3	197.0	8.66	18.9	0.67	38.6	4.02	8.1	1.05
Total average		194.1	7.43	18.8	0.56	37.7	4.92	7.9	1.23

^{aA} – Means with the same subscripts differ significantly: small letters – $p \leq 0.05$; capital letters $p \leq 0.01$.

Table 6 shows the coefficients of phenotypic correlation (r) between the course of parturition and body measurements of heifers. This correlation was the highest ($p \leq 0.01$) in the case of the inner pelvis area: r = -0.37, including height r = -0.41 and width r = -0.24, and the pelvis position, determined by height differences at hips, pins and thurls. A close correlation was also observed between the inner and outer pelvic diameters.

Table 6. Phenotypic correlation coefficients (r) betwen course of parturition and body measurements of cows

Specification	1	2	3	4	5	6	7	8	9	10	11
Course of parturition	-0.41**	-0.24**	-0.37**	-0.30**	-0.18*	-0.14	-0.21*	-0.20*	-0.14	0.06	0.02
1		0.14	0.79**	0.18*	0.27**	0.12	0.04	0.08	0.14	0.04	0.02
2			0.72**	0.06	0.13	0.41**	0.23**	0.39**	0.25**	0.22**	0.25**
3				0.17*	0.27**	0.36**	0.15	0.31**	0.27**	0.24**	0.17*
4					0.66**	0.07	-0.32**	-0.24**	0.05	0.10	0.13
5						0.08	-0.34**	-0.53**	-0.09	0.06	0.10
6							0.73**	0.78**	0.51**	0.34**	0.28**
7								0.87**	0.44**	0.20*	0.07
8									0.50**	0.24**	0.15
9										0.50**	0.28**
10											0.38**
11											

1. Vertical pelvic diameter, 2. Horizontal pelvic diameter, 3. Pelvic area, 4. Height difference hook bone – pin bone, 5. Height difference hook bone – head of femur, 6. Width of hips, 7. Width of buttock, 8. Width of trochanter, 9. Lenght of pelvic, 10. Chest girth, 11. Connon circumference
*** – $p \leq 0.05$; ** – $p \leq 0.01$**

DISCUSSION

In the herd of Holstein–Friesian heifers examined in the studies, 46% of deliveries were difficult and required assistance. Similar results concerning the course of parturition in heifers of this breed were obtained by other researchers [9, 19]. Hansen *et al.* [9] found out that the size of cows had no effect on the quality of calving. No such correlation was observed in own investigations, either. High frequency of complicated deliveries was connected with relatively high birth weight of calves, and the structure of the birth canal in heifers. Similarly as in other studies [15, 23], in own research labor complications resulted from high fetus weight and a smaller pelvis area. Reklewska *et al.* [19] report that high fetus weight causes delivery complications and has no influence on placenta expulsion. According to Sakowski *et al.* [20], the reason for delivery complications is too low body weight of calves. Expulsion of the fetal membranes, similarly as in own investigations, was connected mainly with the course of parturition and fetus sex. Placenta detachment may be caused by the absence of uterine contraction and pushing on the side of abdominal muscles after exhausting labor, or uterus injury [1].

Own results are consistent with those obtained by Mangurkar *et al.* [14] for a population of 8 500 Holstein–Friesian heifers, showing a close correlation between the vitality of newborn calves and the course of parturition. The perinatal mortality of calves delivered after very difficult labor was 30.2%.

Hoffman *et al.* [12] found out that complicated deliveries were rare when the pelvis area of heifers before parturition was 260–270 cm^2. Similar observations were made by Daccarett *et al.* [5] and Bortone *et al.* [2]. In own studies the pelvis area after parturition varied from 224 to 370 cm^2 (296.9 cm^2 on average). It seems that this wide variation in the pelvis area affected labor – it was confirmed by a significant correlation ($p \leq 0.01$) between the course of parturition and pelvis area ($r = -0.37$).

The easiness of delivery is highly significantly correlated with the pelvic diameters, especially inner. An equally high correlation was noted by Wollert *et al.* [23] and Johnson *et al.* [13], whereas Naazie *et al.* [15] observed no direct effect of the pelvic canal size on labor. The dependence between the inner pelvic diameters and the course of parturition, stated in own research, may be applied for forecasting the quality of approaching delivery, as well as for determining the optimal body size in reproductive heifers.

Another significant correlation was found between the course of parturition and the difference in height at hips and thurls ($r = -0.18$), and at hips at pins ($r = -0.30$). This is connected with the fact that an increase in the first difference results in a more spacious pelvic inlet, whereas in the other – in a more spacious outlet. This is confirmed by the studies conducted by Tyczka *et al.* [22], and a significant correlation ($r = 0.27$) between the pelvis inclination and inner height. According to Philipsson [18], a steep ("roof-like") position of the rump makes labor much easier. Such a position, compared with a horizontal position of the pelvis, makes the pelvic

outlet bigger – the outlet is limited by the end of the pubic symphysis at the bottom and by the sacral bone at the top. A too narrow outlet may lead to complications during labor, in spite of relative flexibility of the sacroiliac joint.

The birth season had no considerable effect on the course of parturition, although heifers born in autumn and winter were characterized by slightly worse parameters of the pelvis structure and position. The differences in skeleton development could be affected by heifer nutrition in the first period of life, connected with the birth season.

Dobicki *et al.* [6] claim, following Hollo and Horwath, that the most difficult labor is observed in heifers with narrow pelvises, regardless of their age at calving. In the investigations carried out by Gnyp [8], the occurrence of difficult deliveries was significantly higher, and labor complications were twice more frequent, in Holstein-Friesian crossbred heifers aged 25 months than in three months older ones. The situation was similar in own research – a more advanced age at the first calving, compared with that considered optimal [6, 10], was positively correlated with the pelvic diameters, and had a favorable influence on the course of parturition.

CONCLUSIONS

1. The frequency of difficult labor was growing with an increase in the fetus weight and a decrease in the size of the pelvic canal.
2. The dependence observed in the investigations, may be applied for forecasting the quality of approaching delivery, as well as for determining the optimal body size in reproductive heifers.
3. It was found that a steep ("roof-like") position of the rump in Holstein-Friesian heifers can make labor much easier.
4. A more advanced age at the first calving had a favorable influence on the size of the pelvic canal and the course of parturition.

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