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Evaluation of Gestation Length and Birth Weight of Offspring of Polish Native Cattle Breeds in Context of Estimating Genetic Parameters

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ABSTRACT

Nienartowicz-Zdrojewska A., Sobek Z., Różańska-Zawieja J. (2018): **Evaluation of gestation length and birth weight of offspring of Polish native cattle breeds in context of estimating genetic parameters.** Czech J. Anim. Sci., 63, 323–330.

Research material included data on gestation length of 15 436 cows of Polish native breeds. These were: White Backed (BG; 324 records), Polish Red (RP; 5396 records), Polish Black and White (ZB; 3508 records), and Polish Red and White (ZR; 6208 records). The calvings took place in 2005–2009, and we analysed two calving seasons, lactation number, the degree of calving difficulty, sex, and body weight of newborn calves. The effect of birth year on gestation length and birth weight of offspring was statistically significant, whereas calving season had statistically highly significant effect on both. Gestation length in the analysed breeds was 281.02, 283.35, 280.5, 281.53 for BG, RP, ZB, and ZR, respectively. The birth body weight heritability was 0.13 (RP), 0.33 (ZB) and 0.40 (ZR).

Keywords: pregnancy; birth body weight; heritability; native breed

Intensive selection for productivity improvement in dairy cattle allows for yield increase, but at the same time it negatively affects functional traits – reproduction, health status, and immunity (Whitaker et al. 2005). Increasing production intensity results in decreasing biodiversity due to native breed displacement and decreasing genetic pool within a breed (Van Tassell et al. 2003; Villanuevaa et al. 2010).

The decrease in genetic diversity can be counteracted by reducing inbreeding, by crossbreeding, and by protecting native breeds by means of conservation programmes (Litwinczuk 2011). Protected breeds are valued for their adaptation abilities, fitness, longevity, fertility, and good maternal abilities (Jagusiak 2006). They are also widely used in organic farming.

Protected breed populations can be treated as gene banks. The breeding work on these populations is difficult, as it should aim at maximalisation of genetic diversity, taking into account small population size and high inbreeding (Splan and Sponenberg 2004; Colleau and Avon 2008; Leberg and Firmin 2008).

This is why it is important to monitor not only main production or functional traits, but other traits that have never been selected for before, but still influence health status or reproduction, as well. Gestation length is one of those physiological traits influencing reproduction and characteristic of a given population (Goyache et al. 2002; Coffey et al. 2006; Kumar et al. 2016).

The aim of the research was to examine the breed differences in gestation length and birth body weight of calves of four Polish native cattle breeds and to point out factors substantially affecting them as well as heritability evaluation of the mentioned traits.

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MATERIAL AND METHODS

The database was obtained from a nationwide system SYMLEK, which records information on all dairy breeds in Poland. The analysed data concerned gestation length of 15 436 cows of Polish conservation breeds, including White Backed (BG; 324 records), Polish Red (RP; 5396 records), Polish Black and White (ZB; 3508 records), and Polish Red and White (ZR; 6208 records). The calvings took place in 2005–2009. Offspring came from 2682 bulls: 27 BG, 224 RP, 823 ZB, 1363 ZR. Our analysis included 9709 calves birth body weight records in total. We considered two calving seasons: summer (April–September) and winter (October–March), together with the subsequent lactation number (1–14). The database also included information on sex and birth body weight of the calves. The degree of calving difficulty was evaluated on 1–5 scale, where 1 was for "easy" calving, 2 was for "assistance required", 3 was for "complicated", 4 was for "difficult", and 5 for "miscarriage". In the analysed population the twin calvings in BG, RP, ZB, and ZR accounted for 1.2% (4 pregnancies), 2% (103 pregnancies), 2% (84 pregnancies), and 3% (176 pregnancies), respectively.

Evaluation was done using the linear mixed model:

$$Y_{ijklmo} = \mu + HYS_i + S_j + L_k + P_l + G_m + \beta\,(x_n - \bar{x}) + e_{ijklmno}$$

where:

Y_{ijklmo} = gestation length (in days)
HYS_i = i^{th} fixed effect of herd-year-birth season
S_j = j^{th} random sire effect
L_k = k^{th} fixed lactation number effect
P_l = l^{th} fixed calving difficulty effect
G_m = m^{th} fixed sex of calf effect
$\beta\,(x_n - \bar{x})$ = fixed regression effect of calf birth body weight
$e_{ijklmno}$ = random error effect

It should be noticed that the SYMLEK system is able to record gestation not longer than 297 days, therefore, there is no easy access to information on pregnancies exceeding this period. This is why at the first stage of our research we analysed the distribution of gestation length trait, using normality test and creating Gaussian curve for the analysed trait. We also determined correlation coefficients for the analysed traits and plotted the regression line. We estimated heritability of gestation length using variance components obtained with REML method. The estimates were done with SAS statistical package (SAS/STAT, Version 9.2, 2010). Heritability was estimated with the REML procedure of SAS.

RESULTS

Gestation length for the analysed cows was 254–297 days, with the mean being 282 days, and the standard deviation equal to 6.33 days. The birth body weight of calves was 18–60 kg, with the mean being 35.86 kg and the standard deviation equal to 4.35. Figures 1 and 2 present breed differences in the mean gestation length (Figure 1) and in the mean birth body weight of calves (Figure 2).

The difference in gestation length of the analysed breeds was statistically highly significant (Figure 1). Birth body weight of ZB and ZR calves

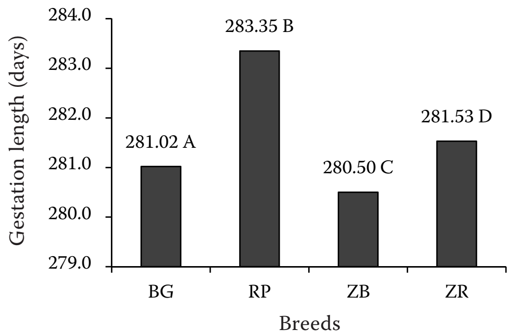

Figure 1. Mean gestation length (in days) of the analysed breeds
BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White
A–Dhighly statistically significant differences ($P \leq 0.01$)

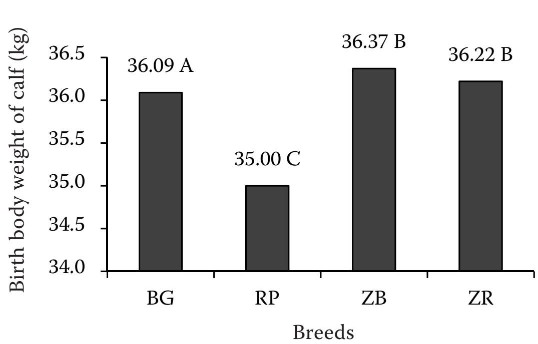

Figure 2. Mean birth body weight (kg) of calves
BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White
A–Chighly statistically significant differences ($P \leq 0.01$)

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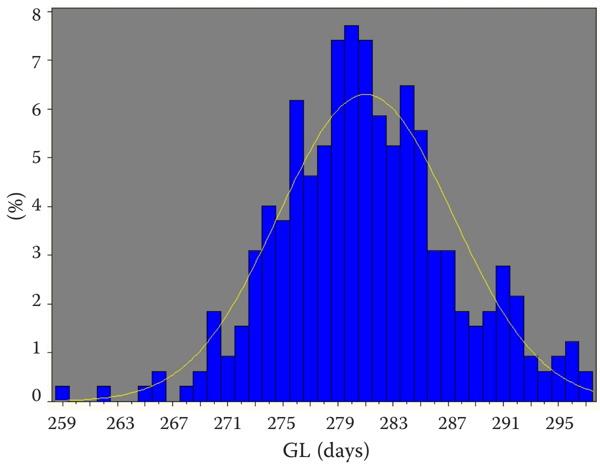

Figure 3. Distribution of gestation length (GL) values (%) for White Backed (BG) cattle

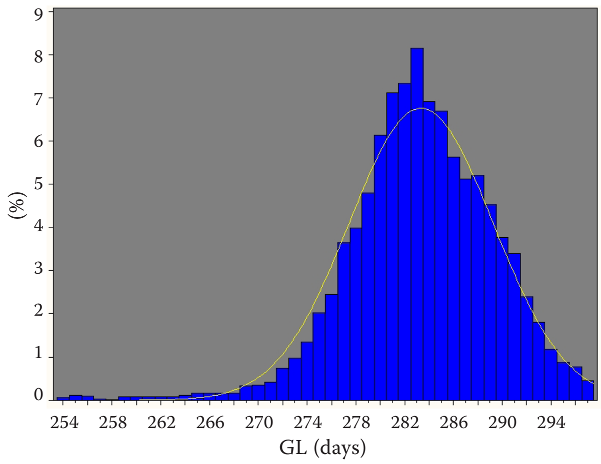

Figure 4. Distribution of gestation length (GL) values (%) for Polish Red (RP) cattle

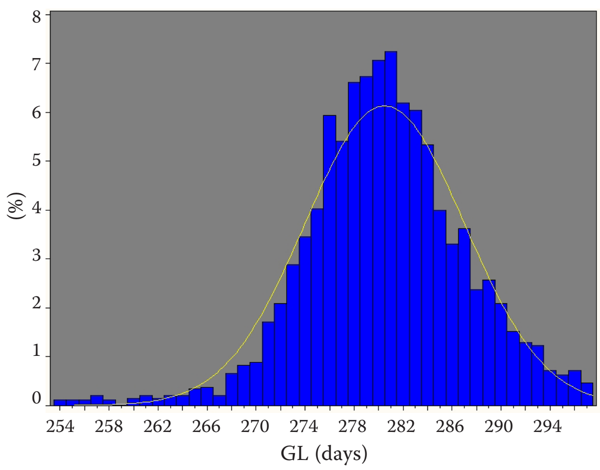

Figure 5. Distribution of gestation length (GL) values (%) for Polish Black and White (ZB) cattle

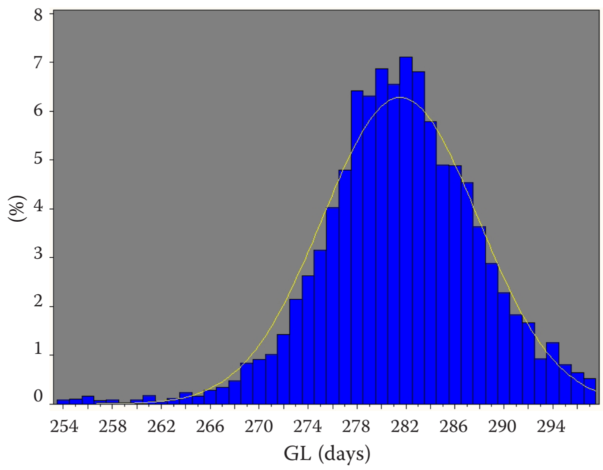

Figure 6. Distribution of gestation length (GL) values (%) for Polish Red and White (ZR) cattle

did not differ statistically, whereas the difference between RP and BG calves, and the remaining breeds (Figure 2) was statistically highly significant. The highest mean gestation length and at the same time the lowest mean birth body weight of calves were estimated for RP cattle.

Figures 3–6 present the value distribution for gestation length for the following breeds: White Backed (Figure 3), Polish Red (Figure 4), Polish Black and White (Figure 5), and Polish Red and White (Figure 6). Figure 7 presents gestation length values for all the analysed cows, regardless of breed. It is worth noticing that the distribution is normal for gestation length for the analysed breeds, and for the total population as well, however it definitely moves more towards the maximum day number.

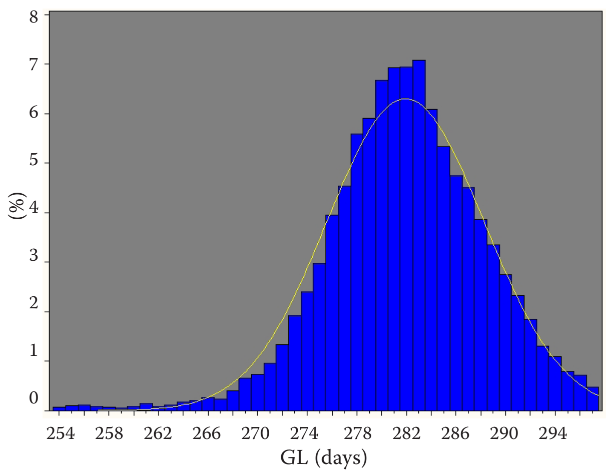

Figure 7. Distribution of gestation length (GL) values (%) for analysed cows regardless of breed

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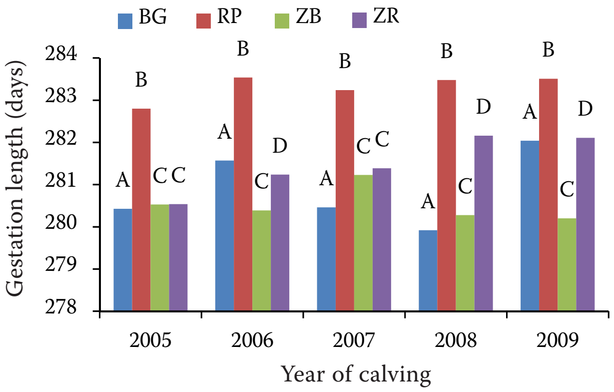

Figure 8. Gestation length (in days) for analysed breeds in subsequent years
BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White
means marked with identical letters are not significantly different
A–Dhighly statistically significant differences ($P \leq 0.01$)

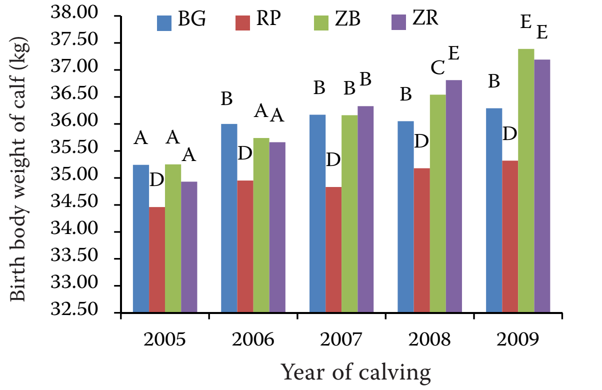

Figure 9. Calf birth body weight (kg) for anlysed breeds in subsequent years
BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White
means marked with identical letters are not significantly different
A–Ehighly statistically significant differences ($P \leq 0.01$)

The year of calving had a statistically significant effect on gestation length and highly significant effect on calf birth body weight. The breed differences in gestation length for subsequent years are presented in Figure 8, and the differences in birth body weight of calves born in 2005–2009 are presented in Figure 9. For gestation length no obvious trend has been noted (Figure 8). The statistically significant differences among average calf body weight values in subsequent years within breed groups were at the same time statistically highly significant for all the four breeds (Figure 9).

Calving season had a highly significant effect on gestation length and a statistically significant effect on calf birth body weight. The average gestation length for cows calving in summer was 282.2 days and it was statistically significantly higher than the average gestation length for cows calving in winter (281.8 days). The information on gestation length and birth body weight for different breeds, according to calving seasons, is presented in Table1.

In winter gestation was longer for all the analysed breeds (Table 1). There are no distinct trends for calf birth body weight, as for BG and ZR calves born in summer the values of this trait were higher than for those born in winter. For RP and ZB calves the trends were the opposite.

Due to culling the number of records in each class was gradually decreasing. For each of the first three

Table 1. Gestation length and calf body weight according to calving season

Breed	Season	Gestation length (days)	SD	Birth body weight of calf (kg)	SD
BG	S	280.85^{A}	6.63	36.26^{a}	3.78
	W	281.23^{A}	5.95	35.88^{a}	2.85
RP	S	283.30	5.85	34.95^{b}	4.46
	W	283.40	5.96	35.04^{b}	4.48
ZB	S	280.36^{b}	6.58	36.24	4.38
	W	280.62^{b}	6.44	36.49	4.62
ZR	S	281.37^{C}	6.36	36.33	4.10
	W	281.70^{C}	6.34	36.12	4.12

BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White, S = summer season (1/4–30/9), W = winter season (1/10–31/3), SD = standard deviation
a–bstatistically significant differences ($P \leq 0.05$), A–Chighly statistically significant differences ($P \leq 0.01$)

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Table 2. Mean gestation length and birth body weight of calves according to calving difficulty

Calving difficulty	Gestation length (days)	*n*	SD	Calf birth body weight (kg)	*n*	SD
1	281.68^{A}	5903	6.35	35.87^{A}	3966	4.31
2	282.18^{B}	9186	6.18	35.85^{A}	5584	4.33
3	280.39^{C}	312	7.97	36.05^{B}	155	5.87
4	279.08^{D}	12	7.34	36.00^{B}	4	3.74
5	255.61^{E}	23	10.17			

n = number of animals, SD = standard deviation
$^{A–E}$highly statistically significant differences ($P \leq 0.01$)

lactations there were over 2300 records, whereas in the 13th and 14th lactation there were only several dozen records. Gestations in the 10th lactation were the longest and they lasted 2.9 days longer on average than the shortest gestation in heifers. Birth body weight of calves was increasing gradually from 34.2 kg in the 1st lactation to 36.97 kg in the 11th lactation. In lactations 12–14 we noticed some fluctuations in mean birth body weight, however this was not confirmed statistically due to small number of observations.

The general trend to lengthen the period of pregnancy and the increasing weight of the calves with the subsequent calving has been observed.

Another factor under analysis was the degree of calving difficulty, coded 1–5. In Table 2 we present the effect of calving difficulty on gestation length and birth body weight of calves, regardless of breed.

Most calvings were either easy or required little human assistance, and also birth body weight was rather low (35.87 kg and 35.85 kg, respectively). Heavier calves (36 kg on average) were born as a result of difficult calvings and those requiring human assistance. The differences between birth body weight of calves in these two groups (easy or little assistance calving vs difficult and complicated calving) were statistically highly significant.

While analysing particular breeds (Figure 10), we found the effect of calving difficulty on gestation length to be similar. However, as far as birth body weight is concerned, the results vary depending on breed (Figure 3). The difference may result from various numbers of observations within the classes.

For BG group birth body weight of calves was increasing proportionally to calving difficulty. Within the RP breed the calves born from difficult calvings were significantly lighter than the calves born from the calvings coded 1–3. For the ZB cattle we observed the opposite trend. Within the group of ZR cows there seemed to be no effect of birth body weight on calving difficulty.

For the analysed group of cows single pregnancies prevailed. For BG, RP, ZB, and ZR multiple pregnancies accounted for 1.2%, 2% (for both RP and ZB), and 3%, respectively. Multiple pregnancies were statistically significantly shorter than single pregnancies and also birth body weight differences were highly significant. Calves born from multiple pregnancies weighed 5 kg less on average (Table 3).

In the analysed case the number of newborn heifers was slightly higher than the number of newborn bulls (7868 and 7484, respectively). Bulls were born after pregnancies that were 1 day longer on average (Tables 4–5), and this difference was

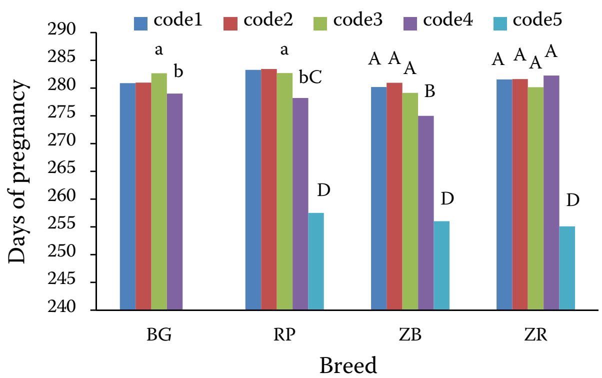

Figure 10. Mean gestation length (in days) according to calving difficulty
BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White
codes: 1 = easy calving, 2 = assistance required, 3 = complicated, 4 = difficult, 5 = miscarriage
means marked with identical letters are not significantly different
$^{A–D}$highly statistically significant differences ($P \leq 0.01$)
$^{a–b}$statistically significant differences ($P \leq 0.05$)

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Table 3. Mean gestation length and birth body weight of calves born from single and multiple pregnancies

Breed	Number of calves	*n*	Frequency (%)	Gestation length (days)	Calf birth body weight (kg)
BG	1	320	98.8	281.15^{A}	36.17^{A}
	2	4	1.20	270.00^{B}	31.75^{B}
RP	1	5292	98.1	283.42^{A}	35.13^{A}
	2	103	1.90	280.11^{B}	29.55^{B}
ZB	1	3424	97.6	280.60^{A}	36.54^{A}
	2	84	2.40	276.40^{B}	30.59^{B}
ZR	1	6032	97.2	281.64^{A}	36.40^{A}
	2	176	2.80	277.80^{B}	31.18^{B}

BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White, *n* = number of animals
^{A,B}highly statistically significant differences ($P \leq 0.01$)

Table 4. Gestation length (in days) and birth body weight (kg) of heifers and bulls

Sex	Trait	*n*	Mean	SD
Bull	gestation length	7484	282.39^{A}	6.38
Heifer	gestation length	7868	281.56^{B}	6.14
Bull	calf birth body weight	2713	36.68^{A}	4.35
Heifer	calf birth body weight	6996	35.54^{B}	4.31

n = number of animals, SD = standard deviation
^{A,B}highly statistically significant differences ($P \leq 0.01$)

statistically highly significant. Birth body weight of bulls was statistically significantly higher than that of heifers (1.14 kg on average), and the standard deviation for body weight of bulls was higher. This trend was observed for the total analysed population (Table 4) and within breed groups (Table 5) as well.

In Table 6 we present heritability coefficients for gestation length for particular breeds.

Gestation length heritability was 0.17–0.59. The BG breed was excluded from the analysis because of small number of individuals in sire groups. Birth body weight heritability was 0.13–0.40.

DISCUSSION

There are many environmental and genetic factors influencing gestation length in cows (Cole et al. 2005). Piedrafita et al. (2000) analysed gestation length in Pyrenean Brown cattle population (native meat breed), taking into account sex and birth body weight of calves, calving season, and lactation number. These factors had a significant influence on gestation length, which was 288.7 days on average. King et al. (1985) found out that as far

Table 5. Gestation length and birth body weight of heifers and bulls of analysed breeds

Breed	Sex	*n*	Gestation length (days)	SD	Calf birth body weight (kg)	SD
BG	B	143	282.58^{A}	6.55	36.04	3.45
	H	181	279.78^{B}	5.89	36.01	3.39
RP	B	2599	283.79^{a}	6.09	35.85^{A}	4.66
	H	2774	283.01^{b}	5.58	34.71^{B}	4.37
ZB	B	1666	281.05^{A}	6.51	37.28^{a}	4.60
	H	1822	280.09^{B}	6.32	36.00^{b}	4.42
ZR	B	3076	281.92	6.33	36.91^{A}	3.95
	H	3091	281.22	6.24	35.93^{B}	4.14

B = bull, H = heifer, BG = White Backed, RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White, *n* = number of animals, SD = standard deviation
^{a,b}statistically significant differences ($P \leq 0.05$), ^{A,B}highly statistically significant differences ($P \leq 0.01$)

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Table 6. Heritability (h^2) of gestation length and birth body weight for the analysed breeds

Breed	*n*	Gestation length	Calf birth body weight
RP	5373	0.17	0.13
ZB	3487	0.46	0.33
ZR	6167	0.59	0.40

RP = Polish Red, ZB = Polish Black and White, ZR = Polish Red and White, *n* = number of animals

as embryo transfer (ET) gestations are concerned, gestation length in donor cows younger than 4 years was about 3 days shorter than in older donor cows.

Both McGuirk et al. (1998) and McClintock et al. (2003) proved that in summer calves were born after shorter gestation. However, earlier research done by Silva et al. (1992) showed that temperature and seasonal feedstuff did not have a significant effect on gestation length. On the other hand, we found out that gestation length of cows calving in summer was highly significantly longer than of those calving in winter.

Another factor influencing gestation length is the number of calves born. According to Echternkamp et al. (2007) twin and multiple pregnancies were shorter (6.8 days shorter for twins). The analysis conducted in the present research proved the difference in gestation length for single and multiple pregnancies to be 4 days on average. The only exception is BG breed with twin pregnancies being even 11 days shorter.

Gestation length also depends on cow health status. Hansen et al. (2004) reported that gestation length is correlated with calving difficulty and with miscarriage occurrence. The extreme values of this trait are connected with stillbirth calvings. Perinatal problems are taken into account in present genetic evaluation programmes (Norman et al. 2009). Both environmental and genetic factors have great influence on reproduction and fecundity. Environment can be controlled in some part, so the breeder can have an influence on fecundity improvement by rational herd management (Whitaker et al. 2005; De Vries 2006).

In Poland there are four protected cattle breeds. The first one (since 1999) to be subject to conservation programme has been Polish Red cattle, then White Backed (2004), Polish Red and White (2008), and in 2009 – Polish Black and White (Litwinczuk 2011). Native breeds maintenance is very important as they are reservoir of genetic diversity. These breeds possess unique traits and abilities that have been lost in highly productive, specialised cattle breeds due to intensive selection.

Local breed cattle products are high-quality, specific, and unique in character (Litwinczuk et al. 2006). Calving is mostly either easy or with little human assistance (9186 and 5903, respectively, which makes 97.8% of all calvings), whereas complicated calving was reported only in 312 cases (2%), and miscarriages and difficult calving – in 40 cases (0.3%).

Norman et al. (2009) estimated heritability coefficient of gestation length in U.S. dairy cattle (Brown Swiss, Jersey, Holstein-Friesian (HF)) to be 0.33–0.36 depending on breed.

Jamrozik et al. (2005) reported that the range of gestation length heritability coefficient may be wide, depending on breed – from 0.27 to 0.45. Hansen et al. (2004) estimated gestation length heritability in Danish HF population to be 0.42, whereas Coffey et al. (2006) analysing birth body weight of HF calves obtained h^2 = 0.45 to 0.53, which was definitely higher than presented in our research.

CONCLUSION

Breed and lactation number had a statistically highly significant effect on gestation length and on birth body weight of calves. Birth year had a statistically significant effect on gestation length and birth body weight, and birth season had a statistically highly significant effect on the analysed traits. Heritability coefficients of gestation length for RP, ZB, and ZR breeds were 0.17, 0.46, and 0.59, respectively. Heritability coefficients of birth body weight of calves for RP, ZB, and ZR were 0.13, 0.33, and 0.4, respectively.

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