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The Impact of Selected Breeding and Environmental Factors on the Efficiency of Rearing Calves

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JP conceived and designed the study, and executed the experimental work. IA statistically analyzed the data. ECP wrote the article.

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ABSTRACT

The purpose of the paper was the analysis of the impact of selected breeding and environmental factors on the results of rearing heifers of the phf red-white variety. The research included 133 cows and heifers and their offspring, *i.e.* 116 calves only from single pregnancies. The calves were weighed and the zoometric measurements were carried out on the day of birth, at the age of 1 month and 6 months, and daily increments were calculated in the analyzed periods. Data regarding cows included: BCS condition, body weight, height at the back, hip width, order of calving, age of calving heifers, and data on the type of valuation and country of origin of the bull (calf's father). It was found that the high vitality of the calves is statistically significantly (at $p \leq 0.01$) affects: the height at the back (> 150 cm) and the width in the hips of cows (> 63 cm). The Dutch and German fathers' heifers were significantly smaller than other peers (at $p \leq 0.01$). The mother's weight before birth was significantly influenced by the daily increase in calves at the age of 1 month.

INTRODUCTION

In recent years, we have seen great breeding progress in all branches of animal production and especially in milk production. Great emphasis is put on the profitability of production, which is associated with the increase in the efficiency of future cows. One of the key factors affecting the increase in the profitability of milk production is the rearing of its own calves and heifers, which still in many farms in Poland is a stage of savings and smaller use of own resources. The main task of farms specializing in cattle breeding is proper rearing of calves (Czerniawska-Piątkowska *et al*., 2018). Many environmental and breeding factors play an important role in the rearing of calves. From environmental factors, the greatest impact on rearing calves has, among others, the birth season in which the calf is born and begins its development, quality of nutrition and well-being, especially in the first days of life. Mistakes made during rearing have a negative impact on the immune system, digestive system, mammary gland development, health and condition of the animal, its efficiency, which in the future results in lower production efficiency.

The purpose of the paper was to analyze the impact of selected breeding and environmental factors on the results of rearing heifers of the Polish breed Holstein Friesian red-white variety.

MATERIALS AND METHODS

This study was carried out on an agricultural holding in the Opolskie voivodeship. The analysis of cows and calves was done in 2015. Random 133 cows of the Polish Holstein-Friesian red-white variety were selected for the study. The animals were fed with the TMR system and were kept in a free-standing system. The study involved 116 calves from single pregnancies, and all cows and heifers before calving (about 2-3 weeks). The following features were analyzed: BCS cow's condition, (scale from 1 to 5 points), where 1 point for very skinny cow, 2 for thin, 3 for cow in average condition, 4 for thick, 5 points for very fat. In the study, cows were divided into two groups, thin and average cows (3 -3.5 points) and thick and very fat (5-6 points) cows. The body and mass measurements

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of cows were arranged in groups: body weight: <700 kg, 700-800 kg and> 800kg; height at the back: <150 cm, ≥150 cm; width at the hips: <60 cm, ≥63 cm. Cows were divided into 4 age groups according to the order of calving (1, 2, 3, 4 and further) and heifers due to their age during delivery in months: <24 and ≥ 24 months. The research used data regarding the father of the calf; father's country of origin and the type of valuation of its breeding value. The calves were kept in igloas. The studies included three periods: at birth, after one month of life and at the age of 6 months. They consisted of weighing the calves and zoom measurements with a tape and a zoometric stick, *i.e.* the height at the back, the width of the hips, the oblique length of the torso, the spiral circumference of the thigh and the circumference of the chest. At birth, the calf viability was also determined (1 - normal, vigilant, 2 - weak, apathetic, 3 - very weak). The time of doubling the birth weight of calves in days and daily gains from birth to one month of life, from birth to 6 months and from 1 month to 6 months were calculated. The results are summarized in Tables I, II and III, mean values and standard deviation were calculated. Significance of differences between groups was estimated using the one-way analysis of variance, using the Duncan multiple range test with the Statistica® PL program.

Table I.- The effect of various factors on body size, weight and calf viability on the day of birth ($\bar{x}$ ±SD).

Feature	n	Weight	Calf's viability	Height at back	Hips width	Spiral thigh circumference	Slanting length of the torso	Chest circumference
BCS condition of the cow								
3 – 3.5	43	40.23 ± 5.17	1.28 ± 0.51	84.60 ± 3.89	19.63 ± 1.07	84.70 ± 4.63	73.02 ± 5.73	81.12 ± 4.04
4 - 5	73	40.44 ± 6.16	1.16 ± 0.37	84.82 ± 5.02	19.49 ± 1.52	84.48 ± 5.25	74.22 ± 6.48	81.77 ± 5.22
Body mass of the cow								
<700	16	40.06 ± 5.51	1.31 ± 0.60	85.63 ± 3.50	19.50 ± 1.10	85.00 ± 4.99	72.87 ± 5.84	81.87 ± 4.11
700 – 800	73	40.37 ± 5.66	1.16 ± 0.37	84.37 ± 4.89	19.53 ± 1.35	84.38 ± 4.87	73.64 ± 5.89	81.23 ± 5.03
>800	21	40.52 ± 5.51	1.23 ± 0.45	85.22 ± 4.48	19.59 ± 1.60	84.77 ± 5.54	74.66 ± 7.32	82.11 ± 4.68
Cow's height at back								
<150 cm	66	40.32 ± 6.02	1.26 ± 0.47	84.38 ± 4.55	19.41 ± 1.44	84.24 ± 5.06	72.30 ± 6.48 B	81.26 ± 4.64
≥150 cm	50	40.56 ± 5.53	1.14 ± 0.35	85.22 ± 4.70	19.72 ± 1.28	84.98 ± 4.97	75.72 ± 5.31 A	81.88 ± 5.05
Cow's hips width								
<63 cm	56	39.79 ± 5.22	1.13 ± 0.38 B	85.00 ± 4.58	19.57 ± 1.22	84.18 ± 4.82	74.71 ± 5.25	81.63 ± 5.03
≥63 cm	60	40.90 ± 6.28	1.28 ± 0.45 A	84.50 ± 4.68	19.52 ± 1.51	84.92 ± 5.20	72.90 ± 6.93	81.43 ± 4.63
Calving order								
1	38	39.45 ± 4.69	1.21 ± 0.47	84.82 ± 3.20	19.24 ± 1.24	83.45 ± 5.03	72.53 ± 5.13	80.97 ± 3.94
2	28	40.75 ± 6.37	1.21 ± 0.41	84.85 ± 5.81	19.89 ± 1.10	85.68 ± 4.88	74.82 ± 7.03	81.61 ± 5.80
3	18	40.33 ± 5.68	1.11 ± 0.32	83.72 ± 4.48	19.50 ± 1.72	84.61 ± 4.91	73.44 ± 5.20	82.66 ± 4.13
4 and further	32	41.13 ± 6.59	1.25 ± 0.44	85.13 ± 4.07	19.63 ± 1.5	84.88 ± 5.12	74.53 ± 7.09	81.47 ± 5.25
Age of 1st calving of heifers								
<24 months	10	37.70 ± 4.81	1.00 ± 0	85.10 ± 2.64	19.30 ± 1.06	83.50 ± 4.88	73.60 ± 3.98	81.10 ± 4.07
≥24 months	28	40.07 ± 3.96	1.28 ± 0.53	84.71 ± 3.41	19.21 ± 1.32	83.43 ± 5.17	72.14 ± 5.50	80.93 ± 3.96
Father's country of origin								
USA and CA	46	41.09 ± 4.79	1.17 ± 0.38	84.72 ± 4.04	19.78 ± 1.13	85.11 ± 4.29	74.24 ± 5.16	82.4 ± 3.77
Poland	24	40.87 ± 6.88	1.25 ± 0.53	84.71 ± 5.17	19.5 ± 1.69	84.38 ± 5.21	72.63 ± 6.10	82.33 ± 5.98
NDL and DE	36	38.83 ± 6.3	1.19 ± 0.40	84.69 ± 5.23	19.33 ± 1.43	83.72 ± 5.94	73.97 ± 6.99	79.75 ± 5.17
Others	10	41.3 ± 6.99	1.3 ± 0.48	85.1 ± 4.01	19.3 ± 1.34	85.5 ± 4.11	73.7 ± 8.38	81.7 ± 3.27
Bull's valuation								
Genomic	73	42.5 ± 5.83	1.22 ± 0.45	85.01 ± 4.42	19.58 ± 1.39	84.63 ± 5.16	73.85 ± 6.37	81.15 ± 4.74
Traditional	43	45.6 ± 5.80	1.19 ± 0.39	84.28 ± 4.95	19.49 ± 1.35	84.44 ± 4.81	73.65 ± 6.00	82.16 ± 4.92

The mean within the column and the factor marked with different letters differ significantly: lowercase letters - $p \leq 0.05$, uppercase letters - $p \leq 0.01$.

RESULTS AND DISCUSSION

Table I show the effect of various factors on body size, weight and calf viability on the day of birth. On the basis of the conducted research, it was found that calves born from cows with larger body sizes obtained a higher birth weight. Cows with better condition (4-5 points) gave birth to calves by 0.21 kg heavier than thinner cows (3-3.5). A similar difference in the weight of born calves is visible taking into account the weight of the cow and its height at the back and width of the hips. The cows with the highest body weight (> 800kg) gave birth to calves by 0.15 kg and 0.46 kg heavier than cows in the other two weight ranges of 800-700 kg and <700 kg. Higher cows (≥ 150 cm) gave birth to calves by 0.24 kg heavier than lower cows (<150 cm). Taking into account the width of the hips of the cows, it was observed that cows "wide in hips" (≥ 63 cm) gave birth to calves with a higher body weight (by 1.11 kg) than cows with "narrow hips". However, significant differences were not found. Other studies have shown a significant effect of the condition, weight and size of the cow's body on the weight of the calf on the day of birth (Nogalski *et al*., 2000). Topal *et al*. (2010) showed that the body condition score (BCS2) of the dam during birth is one of the most important factors affecting the birth weight of calves.

In our own research it was observed that newborns from cows differing in body weight, height at the back and width in the hips were characterized by similar dimensions and body mass. Higher and heavier cows bore calves with larger body dimensions than lower and lighter cows. High cows in comparison with their low peers gave birth to significantly higher calves (at $p \leq 0.01$) in the range of oblique body length (by 3.42 cm).

Table II.- Influence of various factors on body size and weight at the age of one month of the calf and daily increases in the first month of life ($\bar{x}$ ±SD).

Feature	n	Body weight	Daily gains	n	Height at back	Hips width	Spiral thigh circumference	Slanting length of the torso	Chest circumference
Cow's BCS									
3 - 3.5	16	47.94 ± 5.04	0.314 ± 0.15	15	88.4 ± 3.44	20.33 ± 1.05	88.8 ± 3.91	80.2 ± 3.82	86 ± 3.36
4 – 5	34	48.57 ± 6.32	0.285 ± 0.14	34	88.3 ± 4.28	20.56 ± 1.38	90.2 ± 5.68	78.53 ± 5.11	87.26 ± 5.37
Body mass of the cow									
<700	7	49.14 ± 7.15	0.431 ± 0.16 A	7	89.71 ± 3.86	20.57 ± 0.98	90.29 ± 3.95	80.14 ± 2.91	87.71 ± 2.81
700 – 800	30	47.78 ± 5.04	0.251 ± 0.14 B	29	88.28 ± 3.30	20.52 ± 1.21	90.03 ± 4.72	79.10 ± 4.55	86.93 ± 5.14
>800	13	49.31 ± 7.27	0.322±0.12AB	13	87.69 ± 5.45	20.38 ± 1.61	88.92 ± 6.87	78.30 ± 6.12	86.31 ± 5.25
Cow's height at back									
<150 cm	27	49.06 ± 6.92	0.271 ± 0.16	27	87.63 ± 3.92	20.44 ± 1.48	89.07 ± 5.48	78.41 ± 5.89	87.61 ± 3.92
≥150 cm	23	47.57 ± 4.44	0.317 ± 0.12	22	89.18 ± 4.03	20.56 ± 1.01	90.64 ± 4.81	79.82 ± 2.86	88.95 ± 4.01
Cow's hips width									
<63	24	47.97 ± 5.80	0.325 ± 0.16	23	88.04 ± 3.40	20.39 ± 0.94	89.22 ± 4.34	79.43 ± 3.10	88.01 ± 3.35
≥63	26	48.73 ± 6.08	0.267 ± 0.14	26	88.58 ± 4.53	20.58 ± 1.53	90.27 ± 5.90	78.69 ± 5.92	88.49 ± 4.48
Calving order									
1	19	47.76 ± 6.29	0.336 ± 0.18	18	88.33 ± 3.99 AB	20.39 ± 1.04	89.33 ± 4.99	79.56 ± 3.63	86.67±4.60AB
2	9	47.77 ± 4.92	0.240 ± 0.09	9	90.00 ± 3.80 A	20.90 ± 0.78	91.56 ± 3.90	80.22 ± 4.06	87.88±4.08AB
3	9	47.88 ± 6.43	0.249 ± 0.08	9	86.22 ± 4.71 B	19.78 ± 1.48	87.33 ± 6.70	77.78 ± 7.58	83.89 ± 4.54 B
4 and further	13	50 ± 5.93	0.303 ± 0.15	13	88.52 ± 3.42 AB	20.85 ± 1.57	90.85 ± 4.93	87.38 ± 4.50	88.54 ± 5.35 A
Father's country of origin									
USA and CA	20	49.50±6.08AB	0.317 ± 0.15	20	88.85 ± 4.00	20.55 ± 1.32	89.8 ± 5.03	78.7 ± 4.05	87.55 ± 5.10
Poland	9	49.56±4.56AB	0.289 ± 0.19	9	88.78 ± 3.19	21 ± 1.22	91.56 ± 3.68	80 ± 4.41	87.44 ± 4.69
NDL and DE	18	45.81±4.97 B	0.278 ± 0.11	17	87.18 ± 4.36	20 ± 1.17	88.18 ± 6.05	78.82 ± 5.60	85.47 ± 4.39
Others	3	52.67±10.11A	0.260 ± 0.23	3	90 ± 4.58	21.33 ± 1.15	93.33 ± 2.52	79.67 ± 7.50	88.67 ± 6.81
Bull's valuation									
Genomic	30	47.12 ± 6.61	0.291 ± 0.14	29	87.66 ± 4.11	20.38 ± 1.18	88.24 ± 5.15 B	78.62 ± 5.33	85.79 ± 4.32
Traditional	20	50.25 ± 4.12	0.230 ± 0.15	30	89.30 ± 3.74	20.65 ± 1.42	92.00 ± 4.53 A	79.65 ± 3.88	88.45 ± 5.24

The mean within the column and the factor marked with different letters differ significantly: lowercase letters - $p \leq 0.05$, uppercase letters - $p \leq 0.01$.

The order of calving and the age of the first calving in the heifers also had an effect on the birth weight of the calves. Heifers calving before the age of 24 months bore calves lighter by 2.37 kg than "older" heifers (over 24 months). Similar trends were observed in the case of deliveries in cows, the gave birth to 1.68 kg of lighter calves than cows in 4 lactation. Similar dependencies were found in the studies of Kuczaja (2004a), where the calves of cows giving first birth were significantly lighter than calves of cows in 2nd and 3rd lactation by 2.7 kg. Similar results were also reported by Thevarnanoharan *et al.* (2001), stating that females in the earlier parities produced lighter calves than those in the later parities. In other studies carried out on meat cattle, significant differences were found in the body weight of calves born depending on the order of mother's delivery (Przysucha *et al.*, 2007). Other authors report contradictory results regarding the impact of age and effect of subsequent calving on calves' birth weight. Hickson *et al.* (2015), Eyduran *et al.* (2008) and earlier Matika *et al.* (2003) think that the age of cows has a significant impact on the mass of calves, while the Cemal *et al.* (2005) and Thieme *et al.* (1999) contradict this.

The average values of body weight and calves' measurement did not differ significantly considering the country of origin of the calf's father and the type of its valuation. It can be seen that calves of genomically valuated bulls were born 3.1 kg lighter than calves after fathers with a conventional valuation. In the studies of Kuczaja *et al.* (2004) showed no significant influence of the father on the calves' birth weight. Similar results were also obtained by Heins *et al.* (2010).

Table III.- Influence of various factors on the weight of the calf at the age of 6 months, daily increases between birth and 6 months, between 1 month and 6 months and the time of doubling the body weight ($\bar{x}$ ±SD).

Feature	n	Body weight at 6 months of age	Gains between first month and 6 months	Gains between birth weight and 6 months	Time of doubling the weight (days)
Cow's BCS					
3 - 3.5	6	171.58 ± 21.16	0.791 ± 0.13	0.71 ± 0.11	103.74 ± 5.25
4 – 5	19	167.97 ± 26.66	0.792 ± 0.15	0.70 ± 0.13	98.92 ± 15.59
Body mass of the cow					
<700	1	170.00	0.743	0.713	96.12
700 – 800	16	172.1 ± 23.02	0.817 ± 0.13	0.718 ± 0.12	99.93 ± 13.34
>800	8	162.19 ± 30.74	0.747 ± 0.16	0.669 ± 0.14	100.85 ± 16.59
Cow's height at back					
<150 cm	21	167.26 ± 25.65	0.782 ± 0.14	0.696 ± 0.13	99.56 ± 14.36
≥150 cm	4	177.00 ± 23.17	0.842 ± 0.15	0735 ± 0.13	102.78 ± 12.39
Cow's hips width					
<63	9	179.39 ± 18.18	0.854 ± 0.10	0.763 ± 0.08	93.19 ± 9.51
≥63	16	162.91 ± 26.93	0.757 ± 0.15	0.668 ± 0.13	103.95 ± 14.67
Calving order					
1	7	174.29 ± 15.67	0.827 ± 0.08	0.742 ± 0.07	91.8 ± 10.29
2	1	161.00	0.789	0.664	100.30
3	9	167.33 ± 29.78	0.786 ± 0.17	0.697 ± 0.13	98.45 ± 13.84
4 and further	8	166.75 ± 29.89	0.768 ± 0.17	0.678 ± 0.16	109.11 ± 13.59
Father's country of origin					
USA and CA	11	178 ± 20.14	0.847 ± 0.11	0.751 ± 0.10	96.41 ± 10.01
Poland	7	165 ± 14.17	0.757 ± 0.80	0.675 ± 0.09	105.08 ± 14.30
NDL and DE	6	157.83 ± 40.03	0.732 ± 0.22	0.651 ± 0.19	100.91 ± 20.30
Others	1	161.00	0.789	0.663	100.3
Bull's valuation					
Genomic	13	169.96 ± 32.94	0.804 ± 0.18	0.713 ± 0.16	97.48 ± 15.89
Traditional	12	167.63 ± 13.59	0.779 ± 0.09	0.691 ± 0.08	102.88 ± 11.31

The mean within the column and the factor marked with different letters differ significantly: lowercase letters - $p \leq 0.05$, uppercase letters $p \leq 0.01$.

Table II presents the influence of various factors on the body dimensions and mass of calves at the age of 1 month and on its daily increases. Calves from genomically valuated fathers and those from Germany and the Netherlands were significantly lighter ($p \leq 0.01$) than others. There was also a significant effect ($p \leq 0.01$) of the cow's weight before delivery on the daily gains of calves in 1 month of life. The fastest growth of calves was from cows <700 kg (0.431 kg/day), then from cows> 800 kg (0.322 kg/day) and the slowest in case of calves from cows weighing 700-800 kg (0.251 kg/day). Numerous studies confirm that the weight of a cow at birth has a significant impact on the correct growth and development and daily gains of calves during rearing (Przysucha *et al*., 2002, 2003; Bahashwan, 2016).

A certain regularity was observed (Table II) that calves from cows in the third lactation were significantly smaller ($p \leq 0.01$) in terms of height at the back and chest circumference than calves after mothers in 2 and 4 lactation. Conflicting results have been demonstrated by Przysucha *et al*. (2007), where calves after cows that gave birth for the third and fourth time gave birth to large calves showing favorable gains in rearing.

The study shows (Table III) that calves from BCS weaker cows and lower body weight at the age of 6 months were heavier than calves born after thicker cows. In Przysucha *et al*. (2007), an inverse relationship was found; the calves of the Salers variety after thicker mothers were larger and had better growths during the rearing period.

It was also shown that calves after American and Canadian bulls at the age of six months were the hardest and fastest growing, and doubled their body weight by an average of 6 days earlier than heifers of a different origin. Similarly, the difference was observed in calves born after genomically valuated father, they were 2.33 kg heavier than daughters of bulls valuated traditionally and doubled their body weight by 5.4 days faster. This is due to the fact that using genomically valuated bulls we obtain a lower degree of kinship by a larger genetic pool, greater health of offspring and, consequently, better results in rearing.

Based on the research, it was found that the calves' body dimensions were significantly influenced by the high vitality of the calves ($p \leq 0.01$): cross height (> 150 cm) and hips width (> 63 cm). The Dutch and German fathers' waffles were significantly smaller ($p \leq 0.01$) than other peers. For a better daily increase in calves at the age of 1 month, the maternal weight before delivery had a significant impact ($p \leq 0.01$). Measurements of the spiral thigh circumference were more favorable for calves coming from the traditional valuation of breeding value of cattle ($p \leq 0.01$). It was also shown that calves after American and Canadian bulls at the age of six months were the hardest and fastest growing, as well as doubled their body weight by an average of 6 days earlier than heifers of a different origin. The weight of the mother before calf birth can significant impact the daily weight gain of the calves in the 1 month.

Statement of conflict of interest

Authors have declared no conflict of interest.

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