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RESEARCH ARTICLE

The Effect of Gender and Feeding System on the Growth Rate and Blood Parameters of Polish Holstein-Friesian x Limousin Calves

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ABSTRACT

The objective of this study was to determine the effects of gender and calf raising program on daily gains during the rearing period, the body weights of six-month-old calves, blood biochemical and hematological indicators and correlations between those parameters. The experiment materials comprised 87 crossbred Polish Holstein-Friesian x Limousin (PHF x LM) calves. 1 group of calves was fed milk replacer via an automated system, and 2group of calves stayed with suckling cows, which were PHF cows. At the completion of the milk and milk replacer feeding period, bulls, steers and heifers reached body weight of 130, 125 and 120kg, respectively. At the pre-weaning calves kept with suckling cows were characterized by significantly ($P \leq 0.01$) higher daily gains (0.830 vs. 0.718kg/day). At the post-weaning significantly ($P \leq 0.05$) higher daily gains were calves fed milk replacer (0.933 vs. 0.836kg/day). At six months of age, the body weight of calves suckled by suckling cows and fed milk replacer reached 188.9 and 182.3kg, respectively, and their respective average daily gains were 0.835 and 0.798kg/day. Red blood cell, white blood counts and blood glucose concentrations were significantly ($P \leq 0.01$) positively correlated with the body weight of six-month-old calves and daily gains ($r=0.421$ to 0.683). A negative correlation was found between liver function indicators (ALT, AST, ALP) and the growth rate. It can be concluded that the daily gains of calves were affected by the feeding system and the final body weights of calves and their daily gains during the rearing period were affected by calf gender. Higher daily gains and final body weight gained bulls and calves suckled by suckling cows.

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INTRODUCTION

A calf rearing program, in particular the pre-weaning period when calves are fed a liquid diet (Barlett *et al*., 2006), is critical for the growth, development and performance of both dairy and beef cattle (dePassillé *et al*., 2004). The aim of the rearing program is to adapt calves to roughage as quickly as possible. Thus, the animals should be provided with an adequate amount of milk for a specified period of time, and high-quality solid feed should be introduced as soon as possible. In the natural or organic rearing system, newborn calves stay with their mothers or nurse cows, which allow them to express their natural suckling behavior, improve their health and weight gains. Despite its many advantages, the above system is applied only to beef cattle herds. In dairy cattle herds, calves are separated from their mothers after birth, and are fed milk replacers (Jasper and Weary, 2002). To improve calf welfare and to simulate natural conditions, calves are housed in groups and milk replacer is fed with a nipple bucket or an automated feeder since suckling and ad libitum milk intake have been found to improve calf health and increase daily gains (Appleby *et al*., 2001; von Keyserlingk *et al*., 2006). Management system, type of liquid feed and feeding mode may affect the body weights and blood parameters of calves (Earley, 2003; Berry *et al*., 2004), which are indicative of their health and well-being. Due to the growing concern for animal welfare, the natural feeding system that allows calves to suckle their mothers or suckling cows is likely to

become increasingly popular in both dairy (Grøndahl *et al*., 2007 and beef calves.

The aim of this study was to determine the effects of gender and calf raising program on daily gains during the rearing period, the body weights of six-month-old calves, blood biochemical and hematological indicators and correlations between those parameters.

MATERIALS AND METHODS

Animals: The experiment materials comprised 87 crossbred Polish Holstein-Friesian x Limousin (PHF x LM) calves, including 25 bull-calves, 25 steer-calves and 37 heifer-calves. The calves were purchased at two to four weeks of age. During the quarantine period half of the bulls were castrated using a rubber elastrator. The calves were divided into two experimental groups by the analog method. Into group 1 calves were fed milk replacer via an automated system (MR), and into group 2 calves stayed with suckling cows (SC). In both management systems, calves were housed in group pens on straw litter, both during and after milk and milk replacer feeding.

Feeding: Suckling cows were Polish Holstein-Friesian cows culled from the dairy breeding herd. Two calves were suckled ad libitum by one nurse cow. Calves fed milk replacer had access to nipple drinkers twice a day. Daily ration of milk replacer was: at the age of 2-4 weeks (n=8l); 5-7 weeks (n=6l); 8-10 weeks (n=4l); 11-16 weeks (n=3l). Milk replacer was prepared by mixing a powdered formula that in 1 kg contained 22% total protein, up to 0.8% crude fiber and 15% crude fat with water at a 1:8 ratio. During milk and milk replacer feeding, from the second week of life, calves of both groups received the same feed-concentrate and hay ad libitum. At the completion of the milk and milk replacer feeding period, bull-calves, steer-calves and heifer-calves reached body weight of 130, 125 and 120kg, respectively, which was reached after 112 days average. After the milk and milk replacer feeding period, calves were fed grass haylage ad libitum and concentrate in the amount of 2kg/animal/day.

Body weight: Calves were weighed at two-week intervals, starting from the arrival day till the end of sixth month, before the morning feeding, using an electronic scale. Average daily gains were calculated by dividing body weight gain in the period between successive weighing by the number of days in the period.

Blood sampling and analysis: The average age of calves during the first blood sampling was 33 days and the second and blood sampling 112 days. Blood was sampled from the jugular vein. Hematological parameters were determined in whole blood within two hours after sampling, on the Mindray BC2800Vet automatic hematology analyzer. Biochemical parameters were determined in blood serum obtained by centrifugation at 3000rpm for 10min on the automatic biochemistry analyzer Mindray BS120.

Statistical analysis: The data were processed statistically using Statistica ver.10 software (Statsoft, 2010). The effects of feeding system (MR, SC) and calf gender (bull-calves, steer-calves, heifer-calves) on daily gains, body weights at six months of age and selected blood parameters of calves were determined by ANOVA. The significance of differences in the measured values was evaluated by a Duncan's test. The coefficients of Pearson's correlation between daily gains during the rearing period and the body weights of six-month-old calves and selected blood parameters at the beginning and at the end of the milk and milk replacer feeding period were calculated.

RESULTS

Growth rate: Immediately after purchase and allocation to experimental groups, the daily gains of all calves decreased, irrespective of the management system (Fig. 1). The average daily gains of calves have been increasing in both groups since eight weeks of age. Higher gains were noted in the group of calves suckled by suckling cows, in comparison with their counterparts fed milk replacer from 8 to 16 week of life. Whereas after 16 week this tendency was opposite - higher gains were noted in the group of calves fed milk replacer. In this time calves suckled by suckling cows were also characterized by a higher decrease in daily gains than artificially fed calves. Bull-calves reached higher daily gains than steer-calves and heifer-calves (Fig. 2). Castration contributed to a decrease in daily gains. Steers and heifers were characterized by lower average daily gains than bulls over the entire rearing period.

Performance: The average final body weight of six-month-old calves was 186.1 kg (Table 1). Calves from SC group were characterized by slightly higher final body weights than calves fed milk replacer (188.9 vs. 182.3 kg), but the noted difference was statistically non-significant. Heifers were significantly ($P \leq 0.01$) lighter than bulls and steers ($P \leq 0.05$). At the end of the rearing period, bull-calves were by approximately 5kg heavier than steer-calves, yet the observed difference was statistically non-significant. The final body weights of calves raised under both systems were similar, which resulted from their daily gains at successive stages of rearing. During the milk and milk replacer feeding period, the average daily gain of calves reached 0.778 kg. Over that period, suckled calves were characterized by significantly ($P \leq 0.01$) higher daily gains than artificially fed calves. In the period from weaning to six months of age, significantly ($P \leq 0.05$) higher average daily gains were observed in calves fed milk replacer, compared with suckled calves. Differences in daily gains between bulls, steers and heifers were noted at each stage of rearing, but the effect of calf category on daily gains was significant only with respect to total daily gains determined for the entire rearing period. The daily gains of heifers (0.761 kg) were significantly lower compared with bulls ($P \leq 0.01$) and steers ($P \leq 0.05$). The calf gender x feeding system interaction affected the body weights and daily gains of calves (Fig. 3). In the group fed milk replacer, steers were characterized by higher body weight at six months of age, and higher average daily gains during the rearing period than bulls. In the SC group, bulls had the highest final body weight at the end of rearing (205 kg), and the difference was significant ($P \leq 0.01$) relative to heifers.

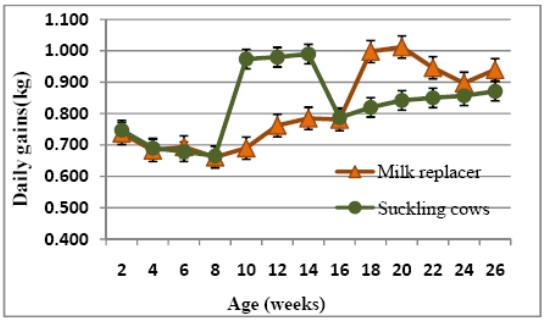

Fig. 1: The effect of feeding system on the daily gains of calves.

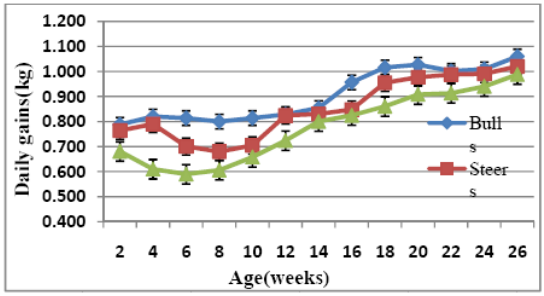

Fig. 2: The effect of gender on the daily gains of calves.

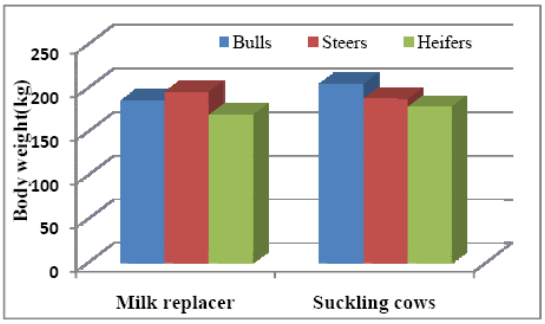

Fig. 3: The effect of the feeding system x gender interaction on the body weight of calves.

Blood parameters: Calves blood parameters are shown in Table 2. All calves had WBC counts above the normal ranges and elevated AST levels. The calf gender and feeding system had a significant (P≤0.01) effect on hemoglobin (Hb) levels, and gender had a significant (P≤0.05) effect on the activity level of acid phosphatase (ALP). Both factors had a significant (G - P≤0.05; FS - P≤0.01) effect on total protein level. There was a tendency to higher activity levels of acid phosphatase (ALP) and ALT in calves that stayed with nurse cows than in those fed milk replacer, but these differences weren't significant. Suckled calves had also significantly (P≤0.01) higher blood glucose levels.

Correlation: Six of nine blood parameters were significantly correlated with the body weights of six-month-old calves or with daily gains during the rearing period (Table 3). RBC and WBC counts at the age of 33 days were significantly (P≤0.01) correlated with the body weights of calves aged six months and daily gains during the rearing period; the coefficients of correlation (r) ranged from 0.421 to 0.478. A significant (P≤0.01) positive correlation was found between glucose-an energy metabolism marker (at the age of 112 days) -and daily gains at each stage of rearing and the body weights of six-month-old calves. A negative correlation was observed between total serum protein at the end of the milk and milk replacer feeding period and daily gains in the pre-weaning and post-weaning periods. ALT level at the age of 33 days and AST level at the age of 112 days were significantly (P≤0.05) negatively correlated with the body weights of calves aged six months and daily gains during the rearing period.

DISCUSSION

Growth rate: The decrease of daily gains after purchase and allocation to experimental groups resulted from the fact that calves had to adapt to group housing and learn how to suckle suckling cows or use automated feeders. The results of previous research show that the size and type (stable vs. dynamic) of calf groups are important considerations (Pedersen *et al*., 2009). Similar to our results were reported by Grøndahl *et al*. (2007) who found that Norwegian Red calves allowed to suckle their mothers up to 6-8 weeks of age were characterized by higher daily gains, compared with calves fed artificially according to the recommendations. In the present study, a decrease in daily gains observed in both groups at weaning was followed by an increase. Calves suckled by suckling cows were characterized by a higher decrease in daily gains than artificially fed calves which could be due to higher milk intake in suckled calves and less adaptation to eating solid feed. Also Blanco *et al*. (2000) demonstrated that calves whose daily milk intake was 7.8kg until weaning at 90 days of age were characterized by low concentrate intake after transition to solid feed. In a study by Bilik *et al*. (2013), calves fed large amounts of milk consumed small amounts of solid feed. In our study, calves suckled by suckling cows had lower average daily gains than calves fed milk replacer until the end of the rearing period (six months of age).

Steers were characterized by lower average daily gains than bulls over the entire rearing period. However, the differences were not statistically significant. Androgens are responsible for the rate of growth and development of external sexual traits (growth of muscles in the neck and shoulder regions) (Dayton and White, 2014). Therefore, differences between steers and bulls productivity reveal predominantly after puberty (Keane, 1999). Also, Warnock *et al*. (2012) reported that castration causes a reduction in the daily weight gain for only 14 days. Similar differences in daily gains between young bulls and steers were also reported by Mach *et al*. (2009) and Micol *et al*. (2009).

Performance: Higher daily gains of suckled calves than artificially fed calves could be due to higher milk intake in the former. According to Blanco *et al.* (2000), von Keyserlingk *et al.* (2006) and Orihashi *et al*. (2012), calves provided with larger amounts of milk or enriched milk replacer gain more body weight during the pre-weaning period. The effect of rearing program on the daily gains of calves was also reported by Lowman *et al*. (1993). In their study, between six and nine months of

Table 1: The effects of gender and feeding system on calves performance

Specification	Gender (G)			Feeding system (FS)		SEM	Significance of differences		
	Bulls	Steers	Heifers	Milk replacer	Suckling cows		G	FS	GxFS
Body weight at the age of 182 days(kg)	196.5^{A}	191.4^{a}	175.5^{Bb}	182.3	188.9	2.48	xx	-	xx
Average daily gain(kg):									
Pre-weaning	0.855	0.800	0.715	0.718	0.830	0.029	-	xx	-
Post-weaning	0.912	0.933	0.847	0.933	0.836	0.024	-	x	-
Over all	0.876^{A}	0.848^{a}	0.761^{Bb}	0.798	0.835	0.014	xx	-	xx

^{XX}-P≤0.01; ^{X}-P≤0.05; Mean values denoted by different letters in rows within trait are significantly different at: A.B-P≤0.01; a.b-P≤0.05

Table 2: The effects of genger and feeding system on selected blood hematological and biochemical parameters of calves

Indicators	Blood sampling	Gender (G)			Feeding system (FS)		SEM	Significance of differences		
		Bulls	Steers	Heifers	Milk replacer	Suckling cows		G	FS	GxFS
RBC(10^{12}/L)	1*	9.02	9.72	9.26	9.75	8.70	0.71	-	-	-
	2**	10.36	10.57	10.61	10.62	10.36	0.40	-	-	-
Hb (g/dL)	1	10.20	11.85	11.17	10.92	10.53	0.73	xx	xx	-
	2	10.85	11.35	10.86	10.92	10.91	0.40	-	-	x
HCT(%)	1	32.65	36.85	36.23	36.04	32.92	2.75	-	-	-
	2	33.08	34.38	34.65	34.45	33.29	1.17	-	-	-
WBC(10^{9}/L)	1	9.34	9.35	9.59	8.14	10.42	1.09	-	-	xx
	2	13.75	13.78	20.13	13.82	18.64	7.09	-	-	-
ALT(U/L)	1	16.01	14.98	16.14	15.33	16.09	1.04	-	-	-
	2	16.94	15.25	15.00	12.41	19.33	5.01	-	-	-
AST(U/L)	1	71.45	74.00	69.57	76.90	70.74	2.08	-	-	-
	2	88.53	57.25	70.29	80.88	74.61	14.90	-	-	-
ALP(U/L)	1	163.18	198.50	173.71	157.89	180.64	28.26	x	-	xx
	2	120.88	119.75	154.14	133.41	134.67	12.94	-	-	-
GLU(mg/dL)	1	73.55	80.00	81.57	71.78	81.27	15.81	-	-	-
	2	59.00	59.75	66.00	54.59	68.78	18.62	-	xx	-
TP(g/dL)	1	5.32	5.10	5.40	5.39	5.14	0.11	x	xx	x
	2	6.11	5.70	5.19	5.99	5.97	0.31	-	-	-
TG(mg/dL)	1	13.24	12.74	20.04	11.70	19.11	11.52	-	-	-
	2	24.04	17.21	24.65	23.72	23.30	14.22	-	-	-

1* first blood sampling; 2** second blood sampling; ^{XX}-P≤0.01; ^{X}-P≤0.05

Table 3: Coefficients of correlation between selected blood parameters and body weights of six-month-old calves and daily gain during the rearing period

Indicators	Blood sampling	Body weight at theage of 182days (kg)	Average daily gain (kg)		
			Pre-weaning	Post-weaning	Over all
RBC(10^{12}/L)	1*	0.426^{XX}	0.148	0.208	0.421^{XX}
	2**	-0.136	-0.267	-0.117	-0.134
Hb (g/dL)	1	0.108	-0.140	0.182	0.107
	2	0.250	0.054	0.222	0.251
WBC(10^{9}/L)	1	0.475^{XX}	0.199	0.045	0.478^{XX}
	2	0.093	0.228	0.207	0.093
ALT(U/L)	1	-0.391^{X}	-0.266	-0.466^{XX}	-0.389^{X}
	2	-0.157	-0.253	-0.182	-0.158
AST(U/L)	1	-0.041	-0.058	0.023	-0.042
	2	-0.352^{X}	-0.337^{X}	-0.356^{X}	-0.352^{X}
ALP(U/L)	1	-0.253	-0.135	0.014	-0.253
	2	0.173	0.502^{XX}	0.219	0.174
GLU(mg/dL)	1	0.277	0.252	0.169	0.275
	2	0.511^{XX}	0.683^{XX}	0.507^{XX}	0.512^{XX}
TP(g/dL)	1	0.362^{X}	0.263	0.217	0.361^{X}
	2	-0.234	-0.417^{XX}	-0.400^{XX}	-0.232
TG(mg/dL)	1	0.172	0.110	-0.039	0.172
	2	0.010	0.033	0.030	0.010

1* first blood sampling; 2** second blood sampling; ^{XX}-P≤0.01; ^{X}-P≤0.05

age, suckling calves reached significantly (P≤0.01) higher average daily gains than calves fed milk replacer. Better results of suckled calves can be explained by the positive influence of natural stimulation on digestibility and absorption of nutrients. In addition, contact with the cow may have an impact on weight gain, which was also reported by Krohn *et al.* (1999).

Bull-calves were always characterized by the highest daily gains, followed by steer-calves and heifer-calves. The lowest body weight of heifers was due to their lowest body weight at birth. Gregory *et al.* (1992) were found that birth weight of heifers is on average 7% lower than bulls. Therefore, in the next few months of life, they are lighter than bulls, which were also reported by Minick *et al*. (2001). Similarly, Krupa *et al*. (2005) confirmed a lower weight at birth and less weight gain from birth to weaning of heifers with comparison to bulls. The same trend was reported by Lowman *et al*. (1993).

Blood parameters: The majority of blood hematological and biochemical parameters was characteristic for calves up to 0.5 years old (Brun-Hansen *et al*., 2006; Mohri *et al*., 2007; Tóthová *et al*. 2014). Leukocyte counts exceeded the wide normal limits (4-12 x $10^{9/}$L) are frequently a sign of an inflammatory response.

Calf gender and rearing system had a significant (P≤0.01) effect on hemoglobin levels. Lower HGB concentrations in suckled calves could be related to a lower Fe content of milk, compared with milk replacer. Stasiuk and Przybyłowski (2012) reported that the Fe content in milk from cows raised in Poland (HF breed) is approximately6.14mg/kg DM (3.85-7.79), and declared by the manufacturer content of the Fe in one kg of milk replacer is 120 mg. Taking into account the lower daily gains of suckled calves after weaning, it can be assumed that the cause of higher levels of glucose could be a higher level of weaner stress than in calves fed milk replacer. The initial response to stress is a release of hormones from the adrenal gland. The adrenal hormone cortisol functions to increase gluconeogenes is resulting in increased blood glucose (Mudroň *et al*., 2005). Other authors (Kamiya *et al*., 2009; Orihashi *et al*., 2012) also demonstrated that management system, feed type and feeding mode may affect the blood parameters of calves.

Correlation: In a study by Chang'a *et al*. (2012), conducted in Tanzania, low blood protein levels and Hb

counts were associated with reduced body weights of calves, and the coefficient of correlation between body weight and serum Hb concentrations was statistically highly significant. Such a correlation was not observed in the present study.

Conclusion: It can be concluded that the daily gains of calves were affected by the feeding system during and after milk and milk replacer feeding. However, the management system had no significant effect on the body weights of six-month-old calves and daily gains from birth to six months of age. The final body weights of calves and their daily gains during the rearing period were affected by calf gender.

All calves had WBC counts above the normal ranges and elevated AST levels. Calves that were kept with suckling cows were characterized by higher activity levels of ALP and ALT, compared with cows fed milk replacer. RBC and WBC counts and blood glucose concentrations were significantly ($P \leq 0.01$) positively correlated with the body weight of six-month-old calves and daily gains during the rearing period. A negative correlation was found between liver function indicators and the feeding system.

Authors' contribution: ZWG, ZN, CP conceived and designed the experiment and analyzed the data.MSS, PP, RW executed the experiment and analyzed the blood and serum samples. All authors interpreted the data, critically revised the intellectual content of the manuscript and approved the final version.

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