Factors affecting growth traits of beef cattle breeds raised in Slovakia

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ABSTRACT: Growth traits of purebred calves of six beef breeds (Aberdeen Angus – AA, Blonde d'Aquitaine – BA, Charolais – CH, Hereford – HE, Limousine – LI and Beef Simmental – BS) born from 1998 to 2002 were analysed. Traits under study were birth weight (BW), weight at 120 days (W120), weight at 210 days – weaning weight (WW), weight at 365 days – yearling weight (YW) and average daily gains from birth to 120 days (ADG1), from birth to 210 days (ADG2), from birth to 365 days (ADG3), from 120 to 210 days (ADG4). General linear model with class effects of breed, dam's age at calving, sex, herd-year-season (HYS) and covariation of age at weighing was used for analyses. All effects significantly affected both weight and gain traits except for dam's age that was significant for BW, W120, YW and ADG3, and age at weighing that was significant for W120, WW, YW, ADG2, ADG3, ADG4. Estimated least squares means of growth traits were compared using Scheffe's multiple-range tests. Highest BW (40.57 kg) and W120 (172.43 kg) were found for BA calves. BS calves had highest WW (260.30 kg), YW (424.07 kg), ADG1 (1 154 g), ADG2 (1 053 g), ADG3 (1 054 g) and ADG4 (1 098 g). Highest BW, YW, ADG3 and ADG4 were found for males-singles. Males-twins had highest W120, WW, ADG1 and ADG2. Calves descending from 5–7 years old dams had highest BW, W120, WW, ADG1, ADG2 and ADG4. The proportion of variability of growth traits explained by HYS effect (42.96–71.69%) was high, whereas proportions of variability explained by SEX effect (2.03–5.77%), age of dam (1.02–2.24%) and breed (1.05–2.21%) were low. Residuals accounted for 23.71 up to 53.79% of total variance.

Keywords: beef cattle; pre-, post-weaning growth traits; environmental factors

In Slovakia, beef breeds were introduced after 1990. Because of upgrading which prevails in breeding practice, the purebred population consisting of imports is very limited. Nevertheless, breeding for excellent growth traits has become an important part of selection programmes of purebred beef cattle. Evaluation studies of growth intensity and carcass traits involving meat quality traits of beef cattle were carried out by Kica *et al.* (1999, 2000) and Polák *et al.* (2001) in Slovakia, and by Bartoň *et al.* (2001) and Voříšková *et al.* (2002) in the Czech Republic.

Specification and potential quantification of the influence of factors affecting growth traits are useful for formulating management and selection decisions (Shi *et al.*, 1993; Gutiérrez *et al.*, 1997). According to different sources (Říha *et al.*, 2001; Arango *et al.*, 2002a,b,c), a high variability between breeds was reported. Many papers aimed at the study of factors affecting growth traits can be found. Herd, region, year and month of calving, calving number, type of mating, sex of born calves, muscularity of calves, weaning age, dam's body conformation and dam's age (Říha *et al.*, 1999; Stádník *et al.*, 1999; Goyache *et al.*, 2003 and Jakubec *et al.*, 2003) are the main effects on weight and average daily gains. The effect of dam's age on growth intensity of descendants was confirmed in studies of Van Vleck and Cundiff (1998) and Szabo *et al.* (2002).

Among environmental effects, the most frequently used herd-year-season effect, which represents especially management practices, accounts for the highest proportion of variability of beef growth traits (Přibyl *et al.*, 2000). Studies dealing with nutrition and feeding effects were presented by Liu and Makarechaian (1993), Dymnicki *et al.* (1996, 2001) and Steen and Kilpatrick (2000).

The objective of this study was to analyse main non-genetic factors affecting pre-weaning and post-weaning growth traits of purebred beef calves raised in Slovakia.

MATERIAL AND METHODS

Performance data on beef breeds from field tests gathered by the State Breeding Institute of the Slovak Republic in the period between 1998 and 2002 were used for analyses. Only purebred animals were considered. The dataset consisted of 118 calves of Aberdeen Angus (AA), 65 calves of Blonde d'Aquitaine (BA), 751 calves of Charolais (CH), 186 calves of Hereford (HE), 141 calves of Limousine (LI) and 365 calves of Beef Simmental (BS). 79 herds were included in the analyses. The average herd size was 20 animals. A traditional cow-calf pasture system was applied. Calves were raised with dams during the weaning period (until the age of 210 days) without additional feeding with concentrate.

Birth weight (BW), weight at 120 days (W120), weight at 210 days (WW), weight at 365 days (YW), and average daily gains from birth to 120 days (ADG1), from birth to 210 days (ADG2), from birth to 365 days (ADG3) and from 120 to 210 days (ADG4) were studied.

General linear model (GLM procedure) as implemented in the statistical package SAS/STAT 8.2 (2002) was applied to study the influence of factors affecting growth traits. Least squares means and standard errors were calculated. Scheffe's multiple-range tests were performed for testing differences between least squares means.

Except for BW when linear regression on age at weighing was omitted, the same statistical model was used for all traits under study:

$$y_{ijkl} = \mu + P_i + G_j + V_k + HYS_l + b(VT_{ijkl} - \overline{VT}) + e_{ijkl}$$

where: y_{ijkl} = observation (BW, W120, WW, YW, ADG1, ADG2, ADG3, ADG4)

μ = intercept

P_i = fixed effect of sex, $i = 1, ..., 4; \sum_i P_i = 0$

G_j = fixed effect of breed, $j = 1, ..., 6; \sum_j G_j = 0$

V_k = fixed effect of dam's age at calving, $k = 1, ..., 5; \sum_k V_k = 0$

HYS_l = fixed effect of herd-year-season of calving, $l = 1, ..., 389; \sum_l HYS_l = 0$

b = linear regression coefficient of y_{ijkl} on age at weighing VT_{ijkl}

e_{ijkl} = residuals, N(0)

There were four levels of sex effect (males-singles, females-singles, males-twins, females-twins), six levels of breed effect (AA, BA, CH, HE, LI, BS), five levels of dam's age at calving (2 years or younger, 3 years old, 4 years old, 5–7 years old, and 8 years old or older dams). The composite herd-year-season effect (HYS) included herd, year and season effects (with 12 levels of season, where 1 level = 1 month). The number of HYS effect levels for each studied trait is given in Table 1. In general, more breeds were raised in most of the herds.

RESULTS

Basic statistics of traits under study are shown in Table 1. Following the values given in Tables 2 and 3, growth traits were influenced statistically highly significantly ($P < 0.001$) by HYS, sex and breed effects. Dam's age at calving influenced BW, W120, YW and ADG3 highly significantly ($P < 0.001$) or significantly ($P < 0.05$). Covariation

Table 1. Basic statistics of data and coefficients of determination for the statistical models

Traits		n	Mean	Standard deviation	Variation coefficient	R^2	HYS
Birth weight (kg)		1 561	34.71	6.74	19.42	0.867	389
Weight at 120 days (kg)		1 024	150.30	30.49	20.27	0.844	281
Weaning weight (kg)		1 110	247.02	47.39	19.19	0.837	272
Yearling weight (kg)		812	397.76	74.11	18.63	0.776	193
Average daily gain	from birth to 120 days (g)	1 092	1 094	238	21.76	0.690	281
	from birth to 210 days (g)	1 231	1 005	233	23.18	0.795	272
	from birth to 365 days (g)	819	974	195	20.02	0.785	193
	from 120 days to 210 days (g)	973	1 059	296	27.95	0.657	272

R^2 = coefficient of determination of the model, HYS = number of levels for HYS effect

Table 2. Analysis of covariance for weights

Sources of variance	Birth weight df	Birth weight mean squares	Weight at 120 days df	Weight at 120 days mean squares	Weaning weight df	Weaning weight mean squares	Yearling weight df	Yearling weight mean squares
Herd-year-season	388	96***	256	2 310***	256	5 647***	183	10 813***
Breed	5	4 706***	5	15 382***	5	93 738***	5	213 624***
Sex	3	244***	3	1 802***	3	6 058***	3	84 320***
Age of dam	4	40***	4	456*	4	658	4	3 892*
Linear regression on weighing age	–	–	1	127 146***	1	151 175***	1	140 775***

df = degrees of freedom; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Table 3. Analysis of covariance for average daily gains

	Average daily gain from							
	birth to 120 days		birth to 210 days		birth to 365 days		120 days to 210 days	
Sources of variance	df	mean squares	df	mean squares	df	mean squares	df	mean squares
Herd-year-season	241	167 883***	267	156 925***	186	83 908***	219	232 813***
Breed	5	432 825***	5	2 095 521***	5	1 446 368***	5	569 176***
Sex	3	88 702***	3	202 725***	3	492 298***	3	578 048***
Age of dam	4	2 480	4	30 143	4	38 869**	4	16 225
Linear regression on weighing age	1	59 881	1	1 14 326**	1	40 171*	1	438 499***

df = degrees of freedom; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

of age at weighing also highly significantly or significantly influenced all traits except for ADG1.

For weight traits, differences between breeds, classes of sex effect and dam's age are summarized in Table 4. Highest BW was found for BA calves. BWs for other breeds were in the following order: CH, BS, AA, HE and LI. Differences between BA and other breeds were highly significant ($P < 0.001$) or significant ($P < 0.05$). Male-single calves had highest BW and significantly differed from the remaining groups of sex effect. Lower BWs were found for males-twins and females-singles. Females-twins had the lowest BW. Dams aged 5–7 years produced calves of highest BW. BW of calves of the youngest dams was lower by 0.58 kg than BW of calves of 5–7 years old dams. The oldest dams produced calves of lowest BW (by 1.46 kg less than BW of calves of 5–7 years old dams). Statistically significant differences were found in BWs between calves of oldest and youngest cows and cows aged 5–7 years, respectively.

Calves of BA had the highest W120. Lowest W120s were found for HE and LI (by 39.83 kg and 29.20 kg less than W120 of BA calves). Differences were statistically significant. Highest W120s were found for males-twins and females-twins. However, only males-twins differed statistically highly significantly from males-singles and females-singles. Calves of dams aged 5–7 years had the highest W120. On the contrary, calves of the youngest cows had the lowest W120. According to dam's age, differences in W120 were significant only between calves of 5–7 years old and 2 years old or younger cows.

WW was highest for calves of BS breed, followed by BA, AA and CH breeds. Calves of HE and LI had the lowest WWs (by 70.68 kg and 40.09 kg less than WW of BA, respectively). WWs for BS, BA, AA and CH calves differed highly significantly from WWs for HE and LI calves. Males-twins had the highest WW even though they did not differ significantly from males-singles. However, both males-twins and males-singles differed significantly from females-twins. Weaning weights of calves increased along with increasing age of dams until the age of 5–7 years. Calves of the youngest cows had the lowest WW (by 23.15 kg less than WW

Table 4. Least squares means and standard errors for weights

	Birth weight (kg)			Weight at 120 days (kg)			Weaning weight (kg)			Yearling weight (kg)		
	n	μ_i	$s(\mu_i)$	n	μ_i	$s(\mu_i)$	n	μ_i	$s(\mu_i)$	n	μ_i	$s(\mu_i)$
Breed												
Aberdeen Angus (1)	117	35.39	0.59	85	160.32	3.30	74	254.45	8.86	57	355.26	8.92
Blonde d'Aquitaine (2)	57	40.57	0.74	42	172.43	4.33	48	256.39	9.17	43	419.10	9.51
Charolais (3)	726	37.89	0.29	506	156.25	1.67	570	252.88	7.18	459	399.51	3.94
Hereford (4)	185	29.33	0.51	95	132.60	3.11	120	185.71	8.41	31	292.09	9.99
Limousine (5)	138	28.84	0.54	73	143.23	3.51	65	216.30	9.01	43	284.47	9.63
Beef Simmental (6)	338	36.31	0.35	223	158.70	1.97	233	260.30	7.51	179	424.07	4.83
Multiple-range test	1:2,3,4,5***, 2:3*, 2:4,5,6***, 3:4,5,6***, 4:6***, 5:6***			1:4,5***, 2:4,5***, 2:6*, 3:4,5***, 4:6***, 5:6***			1:4,5***, 2:4,5***, 3:4,5***, 4:5,6***, 5:6***			1:2,3,4,5,6***, 2:4,5***, 3:4,5,6***, 4:6***, 5:6***		
Sex												
Males-singles (1)	627	36.64	0.28	401	149.54	1.55	423	239.62	7.23	292	394.27	4.42
Females-singles (2)	756	33.36	0.26	488	146.52	1.46	550	231.69	7.09	397	353.17	3.74
Males-twins (3)	114	34.72	0.35	78	164.32	3.37	85	245.05	8.40	75	384.14	7.64
Females-twins (4)	64	32.17	0.51	57	155.30	3.82	52	234.33	9.15	48	318.07	9.19
Multiple-range test	1:2,3***, 1:4*, 2:3***			1:3***, 2:3***			1:2*, 2:3*			1:2,4***, 2:3,4***, 3:4***		
Age of dam												
Two years or younger (1)	202	34.68	0.48	146	148.08	2.78	161	224.11	7.93	113	342.73	6.87
Three years (2)	486	34.50	0.35	316	152.67	1.99	360	230.52	7.43	260	355.27	4.90
Four years (3)	289	34.36	0.41	187	155.07	2.53	201	234.74	7.57	138	362.00	6.22
Five to seven years (4)	402	35.26	0.36	255	156.43	2.10	276	247.26	7.59	231	370.11	5.14
Eight years or older (5)	182	33.80	0.48	118	155.36	2.85	112	244.73	8.28	70	381.97	7.93
Multiple-range test	1:5**, 4:5*			1:4*			1:2*,1:4,5***, 2:4*, 3:4*			1:4,5***, 2:4*, 2:5***		

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Table 5. Least squares means and standard errors for average daily gains

	Average daily gain from birth to 120 days (g)			Average daily gain from birth to 210 days (g)			Average daily gain from birth to 365 days (g)			Average daily gain from 120 to 210 days (g)		
	n	μ_i	$s(\mu_i)$	n	μ_i	$s(\mu_i)$	n	μ_i	$s(\mu_i)$	n	μ_i	$s(\mu_i)$
Breed												
Aberdeen Angus (1)	81	1 064	29	76	1 013	46	51	873	24	53	1 004	45
Blonde d'Aquitaine (2)	47	1 123	36	48	983	48	44	1 020	26	34	1 076	52
Charolais (3)	566	1 105	14	618	1 012	37	456	975	11	513	1 046	18
Hereford (4)	68	976	31	134	731	43	37	700	28	71	876	38
Limousine (5)	64	1 080	32	78	814	45	44	700	26	56	919	43
Beef Simmental (6)	266	1 154	16	277	1 053	39	181	1 054	13	246	1 098	21
Multiple-range test	1:6*, 2:4*, 3:4***, 4:6***			1:4,5***, 2:4,5***, 3:4,5***, 4:5***, 5:6***			1:2,3,4,5,6***, 2:4,5***, 3:4,5,6***, 4:6***, 5:6***			2:4*, 3:4***, 3:5*, 4:6***, 5:6***		
Sex												
Males-singles (1)	442	1 073	14	477	955	37	287	973	12	380	1 060	19
Females-singles (2)	499	1 051	12	600	903	37	409	867	10	453	1 003	18
Males-twins (3)	94	1 152	27	100	990	43	74	938	21	90	1 018	35
Females-twins (4)	57	1 060	33	54	903	47	49	772	23	50	932	44
Multiple-range test	1:3*, 2:3***			1:2***, 2:3***			1:2,4***, 2:3,4***, 3:4***			1:2,4*		
Age of dam												
Two years or younger (1)	137	1 033	25	168	870	41	114	843	19	130	966	31
Three years (2)	329	1 071	17	407	933	38	262	861	13	323	1 015	23
Four years (3)	201	1 090	22	222	940	39	142	884	17	173	995	28
Five to seven years (4)	301	1 123	18	308	988	39	233	912	14	247	1 031	25
Eight years or older (5)	124	1 102	24	126	958	42	68	936	21	100	1 021	34
Multiple-range test	1:4***, 2:4*			1:2,3,4,5***, 2:4***			1:4,5***, 2:4,5***			–		

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

of 5–7 years old dams). When WWs of the oldest cows were compared with WWs of 5–7 years old dams, the difference was 2.53 kg in favour of calves of 5–7 years old dams.

Highest YWs were found for calves of BS, BA and CH. Markedly lower YWs were found for calves of HE and LI (by 127.01 kg and 134.64 kg less than YW of BA calves, respectively). Males-singles had the highest YW and exceeded males-twins. Females-twins had the lowest YW. As for WWs, there was not a significant difference between males-singles and males-twins. Both males-singles and males-twins, however, differed statistically highly significantly from females-singles and females-twins. Calves of the oldest cows had the highest YW. YW of calves coming from 5–7 years old cows was insignificantly lower. Calves of 2 years old or younger cows and 3 years old cows had the lowest YW (by 27.38 kg and 14.84 kg less than YW of 5–7 years old cows, respectively) and differed significantly from the groups of the oldest cows mentioned above.

Table 5 shows differences in average daily gains between breeds, groups of sex and age of dams. Calves of BS breed had the highest ADG1, ADG2, ADG3 and ADG4 with values as follows: 1 154 ± 16 g, 1 053 ± 39 g, 1 054 ± 13 g, 1 098 ± 21 g. ADGs for AA, CH and BA calves were higher than 1 000 g except for ADG3 (AA, CH) and ADG2 (BA). HE and LI calves differed significantly in ADGs which were lower than 1 000 g except for ADG1 of LI calves. Males-twins had the highest ADG1 and ADG2, while males-singles had the highest ADG3 and ADG4, respectively. ADGs increased along with increasing dam's age. Highest ADG1, ADG2, ADG4 were found for calves of 5–7 years old cows and highest ADG3 was found for calves of the oldest cows. Except for ADG4, significant differences were found between calves descending from younger dams and calves descending from older dam groups.

Table 6 shows variance ratios calculated for factors affecting growth traits. A large proportion of variability was caused by HYS effect, which accounted for 37.73 (YW) up to 71.69% (ADG2) of total variance. The variance ratio of sex effect ranged from 3.26 to 5.77%. Variance ratios of dam's age and breed effects were lower, ranging from 1.02 to 2.24% and 1.05 to 2.21%, respectively. Residual variance ranged from 23.71 to 53.79%. Coefficients of determination for used models are given in Table 1. The model for birth weight fitted best (with the highest coefficient of determination, R^2 = 0.867).

DISCUSSION

The effects of HYS, sex, breed, dam's age and age at weighing on growth traits were confirmed in beef breeds raised in Slovakia. The results are in accordance with findings of Dadi *et al.* (2002) and Goyache *et al.* (2003), who analysed growth traits of beef calves raised in South Africa and Spain, respectively.

The estimates of least squares means showed significant differences between the studied breeds. Calves of Beef Simmental, Charolais, AA and Blonde d'Aquitaine showed a great potential for growth intensity traits. These findings were in agreement with results reported by Dymnicki *et al.* (1996) and Dadi *et al.* (2002). Similarly, Jakubec *et al.* (2003) reported high weights and average daily gains for Blonde d'Aquitaine, Charolais and BS calves that were higher in comparison with calves raised in Slovakia (except for birth weights). Říha *et al.* (2001) found out the highest beef traits for Charolais calves. However, their analyses did not include Blonde d'Aquitaine and BS breeds. Přibyl *et al.* (2003) reported differences between 14 breeds raised in the Czech Republic. Charolais and

Table 6. Proportion of variance explained by different effects

Source of variance	Birth weight	Weight at 120 days	Weaning weight	Yearling weight	Average daily gain from birth to 120 days	birth to 210 days	birth to 365 days	120 to 210 days
Total	100	100	100	100	100	100	100	100
Age of dam	2.24	1.20	1.15	1.66	1.02	1.24	1.52	1.07
Sex	3.26	3.32	3.94	5.77	2.43	2.27	4.83	2.03
Breed	2.21	1.16	1.10	1.05	1.21	1.09	1.16	1.17
Herd × year × season	55.74	57.8	62.21	37.73	60.79	71.69	42.96	59.37
Residual variance	36.55	36.52	31.60	53.79	34.55	23.71	49.53	36.36

Simmental had the highest weights at 120, 210 and 365 days of age. These results are in partial accordance with findings about differences between beef breeds raised in Slovakia even though the differences reported by Přibyl *et al.* (2003) were larger.

Results reported for sex effect correspond with those of Říha *et al.* (1999), Jakubec *et al.* (2003) and Goyache *et al.* (2003). When birth weights of calves raised in Slovakia were compared, both males-singles and males-twins had higher birth weights than females-singles and females-twins. Říha *et al.* (1999) reported higher birth weights, weight at 120 days, weaning weights and average daily gains for males and singles. However, males-twins in Slovakia grew faster in the pre-weaning period and achieved the highest weight at 120 days, weaning weight and average daily gain from birth to 120 and 210 days. Higher growth intensity in twins could be due either to a smaller number of twins involved in the analyses or to "milk stealing" behaviour of twin calves.

Goyache *et al.* (2003) reported the highest weaning weight for calves descending from 7–11 years old cows (calving 5–9). This is in agreement with findings of Říha *et al.* (1999) and Jakubec *et al.* (2003). Except for birth weight, Přibyl *et al.* (2003) reported highest weights and fastest growth for calves of 5–7 years old dams. In general, the highest weights were reported for calves descending from mature dams aged 5–8 years, which is in accordance with the analyses of calves raised in Slovakia. Lowest weights were reported for calves of first-calf dams (2-year old or younger cows). This could be explained by the fact that young dams need an additional energy for finishing their own growth. In comparison with mature dams, cows of higher age usually produce calves of lower birth weight as production ability decreases along with the increasing age of the dam. Rumph and Van Vleck (2004) reviewed findings about the influence of dam's age on birth weight and weaning weight. According to their study, both traits are affected by dam's age and therefore adjustment factors are necessary for accurate national genetic evaluation.

Variance ratios for effects of sex (almost 6%), breed (2.2%) and dam's age (2.2%) as well as HYS effect (almost 72%) were similar to those reported by Jakubec *et al.* (2003). Higher variance ratios of HYS effect may be due to a high number of herds involved in the analyses and high herd variability in both management practice and regional conditions. When herd, year and month effects were separately involved in the analyses, Přibyl *et al.* (2000) reported lower proportions of variability 48% (herd), 20% (year) and 5% (month) explained by these effects. The composite (herd × year × month) effect accounted for 73% of variability. Parallel consideration of the above effects (herd + year + month) caused a slightly lower proportion of variability (52%) in comparison with composite effect. However, involving the herd × year × month effect instead of separate effects of herd, year and month brings about a possible hazard for evaluations because of the absence of contemporaries in some months. A possible way how to avoid this situation is to group similar months and to create classes consisting of a sufficient number of observations. According to Přibyl *et al.* (2003) analyses, forming seasons (S) from months of identical conditions, composite HYS effects accounted for 64% of variability. In total, effects of HYS, calf sex and age of dam at calving jointly explained the highest proportion of variability (56–78%) of growth traits.

CONCLUSIONS

In general, the factors included in linear models for growth traits affect growth traits significantly, which is in agreement with the findings reported in literature. Based on the data available for analyses, the obtained results will serve as a relevant set-up in developing the model for genetic evaluation of growth traits in beef breeds raised in the Slovak Republic.

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