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BREEDING VALUE AND THEIR RELATIONSHIP TO THE CUTTING PARTS IN BEEF BULL PROGENY

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Abstract

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The aim of this study was to assess the effect of the relative breeding value of the paternal growth of sires on highly valued parts of carcasses in their progeny. The study was carried out on nine Beef breeds in the Czech Republic. Cutting parts evaluated were: round, strip loin and tenderloin (First class meat); rib, shoulder blade (boneless), fore shank, flank, chuck roll + neck (Second-class meat) and separable fat. For statistical data analysis was used STATISTICA 8 software (Statistica 8, StatSoft Inc., 2008. Tulsa, OK). The data were processed using canonical analysis to evaluate basic relationships in the two groups of selected parameters. The group on the right set consisted of selected cuts. The group on the left set consisted of relative breeding values of paternal growth effect, age, weight and breed.

Correlation analysis of relative breeding value revealed a significant relationship only to separable fat, flank and strip loin. Although this correlation was significant, their value was low. For the other breeding traits there were no significant correlations with different cutting parts. Based on the results of canonical analysis, 10.42% explained variability in the context of the controlled variables of the left set of parameters (breed, RBVseg, age and weight) can be explained using single cuts. We also found that only 5.95% of the explained variability of meat cuts – variables of the right set of parameters can be explained using breed, RBVseg, age and weight.

Key words: meat production, breeding value, cutting parts
Abbreviations: RBVpge = Relative breeding value of paternal growth effect

Introduction

A key factor in cattle breeding is breeding value. The breeding values are predominatly affected by the bull and thus greater or lesser spread of relevant genes (alleles) in the population. In calculating the breeding values however, highly valued meat cuts are not taken into consideration. In this study we focused on evaluating the relations between breeding values of meat production and specific cut parameters in bull carcasses. Negative correlations can reveal deterioration in economically important meat parts of carcasses in one-way breeding in concrete breeding values.

Beef cattle breeding are oriented to meat production. Apart from the intensity of growth, meat quality and share of highly valued parts of carcasses play an important role. A large number of publications have shown that carcass cutability varies greatly between different cattle breeds (Koch et al., 1976, 1979, 1982; Oliver et al., 2010; Dimov 1999, 2000; Sladek and Mikule, 2014; Uzakov and Ospanova, 2014; Marinova et al., 2015). The main problem with comparing cutting parts across different countries is non-existing norms

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for cutting part descriptions, the exception being tenderloin which is defined as a single muscle.

Carcass composition differences due to different feeding conditions have been described by French et al., 2000, 2001; Steen and Kilpatrick 2000; Pieniak-Lendzion et al., 2010; Blanco et al., 2010; Bilik et al., 2009; Brzóska et al., 2010 and other authors. The influence of sex and slaughter age has also been determined as factors which can influence carcass composition (Garret and Hinman, 1971; Knapp et al., 1989; Griffin et al., 1992). Koch et al. (1976) studied the composition and quality characteristics of 1121 steer carcasses obtained after mating Hereford and Angus cows to Hereford, Angus, Jersey, South Devon, Limousin, Charolais and Simmental sires. These studies showed a positive association between growth rate of breed groups and percentage of retail product or bone. A negative association was found between growth rate of breed groups and percentage of fat trim. A negative association between growth rate and percentage of fat in the longissimus resulted in breed groups attaining the same percentage of fat in the longissimus at significantly different average carcass weights. May et al. (1992) studied beef carcass composition of slaughter cattle differing in frame size, muscle score, and external fatness. Cuts were trimmed to 2.54, 1.27, and 0.64 cm of external fat, except for the knuckle, tri-tip, and tenderloin, which were trimmed of all fat. Estimated percentage yield of the major subprimals from the loin and round tended to be higher or relatively equal for heifer carcasses at all trim levels than subprimals from steer carcasses. Portions of cutting parts evaluated in this study were: tenderloin 1.72%, ribs 9.10%; strip loin 3.5%; round 25.13%; flank 5.09% (May et al., 1992). Mario et al. (2006) studied the effect of forage to concentrate ratio on carcass and meat quality of young Podolian bulls. Twenty young organically farmed Podolian bulls (mean body weight of 220 kg ± 45.58 SD) were used. In the high concentrate (HC) group, the forage to concentrate ratio was 60:40% DM, while in the low concentrate (LC) group the forage to concentrate ratio was 70:30% DM. Estimated percentage share of selected type steer carcasses in the groups HC and LC was: Slaughter weight (kg) 377.25 and 352.50; Carcass weight (kg) 197.87 and 181.50; Right side weight (kg) 98.87 and 90.87; Shoulder blade 6.78% and 6.59%; Fore shank 2.53% and 2.54%; Flank 5.56% and 5.57%. A number of studies have also compared the meat quality and carcass traits of different beef breeds (Holló et al., 2008; Hong et al., 2008; Peinado et al., 2009; Ostojić-Andrić et al., 2011; Seenger et al., 2008).

Other studies were carried out to characterize carcass, muscle and meat quality characteristics from cull cows and bulls. Jurie et al. (2006) described carcass and muscle characteristics in four French breeds of beef cull cows between 4 and 9 years of age.

Most studies have focused on the evaluation of carcasses (according to SEUROP) in relation to sex, quality of feed and level of hybridization. Říha et al. (2007) studied the cut parameters of carcasses in terms of conformity to the SEUROP classification. Monitoring was carried out on 54 samples of meat breeds, divided into heifers, bulls and bullocks. The influence of cattle category on quality parameters of carcass was examined by Filipčík et al. (2008). These authors reported that length and depth dimensions of cattle carcasses were the best evaluated in the carcasses of cows. The largest meat proportion of rounds was measured in carcasses of steers whereas in heifers the meat proportion of rounds was the smallest. Evaluation of cattle carcass classification (according to SEUROP) and qualitative parameters of beef meat was studied by Šubrt et al. (2008a, 2008b). Their conclusions were that current classifications of carcass do not take into account parameters of meat quality. The only evaluated variable was degree of fattening which had a positive relation to content of intramuscular fat and meat energy value.

Prediction of breeding values for tenderness of market animals was studied by Barkhouse et al. (1996). Data were tenderness measures in steaks from 237 bulls (Group II) and on 1431 related steers and heifers (market animals, Group I) from Angus, Hereford, Pinzgauer, Brahman, and Sahiwal crosses. The range in predicted breeding values of bulls for market animal tenderness was small, from –.34 to .32 kg for market animal shear force.

The effect of the meat yield breeding values of sires on highly valued parts of carcasses in their progeny was studied by Bezdíček et al. (2010). The study was carried out on Czech Fleckviehs, a dual-purpose milk-beef production breed. The correlation analysis showed significant negative relationships only for the relative breeding values of trading classes and rib ($r = -0.2079$); relative breeding values of net daily gain with strip loin ($r = -0.2433$). Although strip loin is an important first-class meat cut, the correlation is rather low. Correlations between other meat cuts with breeding values were non-significant.

Concrete tools for breeding and selection for carcass traits have been described by Vleck et al. (1992) who genetically evaluated sires and dams using an animal model for carcass traits based on measurements on 682 slaughtered crossbred steers. The authors conclude that for traits with large breed differences, selection of the proper breed should be done before selection within the breed.

The aim of this study was to assess the genetic relationships between breeding values in beef cattle and carcass traits in order to prevent the negative influence of selection of valuated carcass parts.

Materials and Methods

Investigation of the correlation between breeding value of meat production and meat cuts of carcass was studied in bulls of beef breeds. The monitoring included bulls from hybridization with Beef breeds: Aberdeen Angus, Blonde d´Aquitaine, Belgian Blue, Galloway, Charolais, Limousine, Piemontese, Beef Simmental and Highland. The following cut parameters were used: Rib, Shoulder blade, Fore shank, Flank, Round, Strip loin, Tenderloin, Chuck roll+Neck, Sep. fat, First class meat and Second class meat. The first class meat group was: Shoulder blade, Round, Strip loin and Tenderloin. The second class meat group was: Rib, Fore shank, Flank, Chuck roll+Neck. Studied were 651 hybrid bulls. The largest number of animals evaluated were the breeds of Charolais (250 pieces) and Blonde d´Aquitaine (97 pieces). The smallest numbers were the Belgian Blue (11 pieces) and Highland (21 pieces). This corresponds to the small percentage of these breeds in the Czech Republic.

Slaughter took place over 213 to 978 days. Highly valued meat was weighed (in kg) and presented in percent from halfbody carcasses (HC).

First, the data were analyzed using canonical analysis to determine se basic relationships in the two groups of selected parameters. The group on the right set consisted of selected cuts. The group on the left set consisted of relative breeding values of paternal growth effect, age, weight and breed. A detailed correlation analysis was then performed for each parameter in the two groups. Basic correlational statistics (correlation coefficient, p-value of model fit) were calculated as a description of derived relationships. The next step in the data analysis was to estimate multivariate relationships between each meatinnes part and sample of selected parameters, to estimate the effect of trading class on cut. General linear models (GLM) according to the design described below (one fixed categorical effect – breed, three fixed continuous variables) were used for this purpose.

$$Y_{ijkl} = \mu + RBVpge_i + A_j + W_k + B_l + e_{ijkl}$$

Y_{ijkl} = estimate value of each cut,

μ = mean value,

$RBVpge_i$ = Relative breeding value of paternal growth effect,

A_j = Age at slaughter (in days),

W_k = Weight (in kg),

B_l = Breed,

e_{ijkl} = residual error.

As a last step in the analysis of cuts and routinely recorded parameters, hierarchical and cluster analysis (with 1-r criterion for clusters' joint) were done. The resulting hierarchical tree shows mutual relationships of cuts and aggregation parameters of meat yield based on correlations. For statistical data analysis, we used STATISTICA 8 software (Statistica 8, StatSoft Inc., 2008. Tulsa, OK).

Calculation of breeding values was made by the Animal Model and is published by ČSCHMS. For calculation of breeding values were used growth capability (weight at birth, in 120 days and 365 days) and kinship between animals. Further factors were taken into account: environment, contemporaris, calf sex and age at calving of the mother. The evaluation included maternal effect which takes into account the effect of mothers on the growth of offspring.

Results and Discussions

Table 1 presents the count of animals (according to fathers), that were used in the calculation. The largest number of animals evaluated were from the strains of Charolais (250 pieces) and Blonde d´Aquitaine (97 pieces). The smallest numbers were the Belgian Blue (11 pieces) and Highland (21 pieces). The total number of animals included in the calculations was 651.

Table 1
Count of animals according of fathers

	Count
Aberdeen Angus	42
Blonde d´Aquitaine	97
Belgian Blue	11
Galloway	64
Charolais	250
Limousine	59
Piemontese	41
Beef Simmental	66
Highland	21
Total	651

Table 2 present the basic statistical data for examined traits. The table shows the average values and standard deviations. The age of slaughtered animals, and their corresponding weight ranged from 213 days (200.30 kg) to 978 days (1022.40 kg). An important indicator in terms of meat yield is the proportion of first and second-class meat, or specific meat cuts of carcass. The average proportion for the first-class meat from HC was 31.17% (min. 22.91% max 38.36%), for the second-class meat was 28.78% (min. 21.16% max 35.44%).

Compared with the results of other authors there is agreement mainly in the share of tenderloin. These studies found

Table 2
Basic statistically analysis of studied meat traits in beef cattle

	Average	Minimum	Maximum	s_x
RBVpge	99.64	75.00	122.00	8.89
Age (days)	610.26	213.00	978.00	368.32
Weight (kg)	603.11	200.30	1022.40	108.53
Rib	9.97	5.31	15.24	1.26
Shoulder blade, boneless	7.11	4.84	11.36	0.94
Separable fat	2.06	0.17	7.26	1.15
Fore shank	3.46	1.34	6.31	0.86
Flank	4.1602	1.91	6.54	0.66
Round	18.51	12.03	26.32	2.14
Strip loin	4.14	1.34	7.21	1.04
Tenderloin	1.42	0.91	2.10	0.25
Chuck roll & Neck	11.19	5.08	18.35	2.04
First class meat	31.17	22.91	38.36	2.83
Second class meat	28.78	21.16	35.44	2.21

the share of tenderloin 1.3974% (all animals) ranged from 1.2691 to 1.7264%: May et al. (1992) 1.722% and Griffin et al. (1992) 1.65%. The cutting part of Strip loin was found in this study to be 4.1101% (ranging from 3.7095 to 4.4052%). May et al. (1992) present 3.5% and Griffin et al. (1992) found 3.27%. In meat traits Fore shank was found in this study to range from 2.6991 – 3.2329%. Mario et al. (2006) present 2.53%. In evaluation of the ribs, we found in this study a range of 9.3399 – 10.9322%. May et al. (1992) found an average value of 9.102%. These figures agree with the findings of the present study.

Based on the results of canonical analysis (Table 3) 10.42% explained variability in the context of the controlled variables of the left set of parameters (breed, RBVseg, age and weight) can be explained using single cuts. We also found that only 5.95% of explained variability of meat cuts – variables of the right set of parameters can be explained using breed, RBVseg, age and weight. The parameters for meat cuts contain a higher proportion of unexplained variability within the set design of the evaluation and this corresponds with other results. Summary parameters of the left set contain 10.42% variability which can be explained by linear combinations of meat cuts. In essence, this explanation based on a weighted sum of parts of the carcass, assumes that a substantial part of these sum parameters (with the exception of the genetic potential of their parents, their own performance, etc.) will be made up of the process of cutting the carcass. Conversely, the lower percentage of explained variability in meat cuts using linear combinations of the left set of parameters reflects the fact that the breeding of beef cattle is not a priori based on the proportion of individual cuts of carcass.

Analysis of single partial correlations of parameters of both groups was the next step in the analysis of the data. The correlation and pattern of the regression curves of the studied traits are listed in Table 4 and Figures 1 and 2. The correlation analysis of relative breeding value (RBVpge) revealed a significant relationship only to separable fat (r = –0.0821), flank (r = –0.1585) and strip loin (–0.0909) – Table 4. Although this correlation was significant, the value was small. The correlation was negative, showing that higher breeding value leads to decrease in the proportion of separable fat, flank and strip loin. Although strip loin is a highly valued meat first-class meat cut, the correlations found were low. The correlation between the other meat cuts and breeding value was not significant. Similar conclusions are also evident from Figure 1 which shows the pattern of the regression

Table 3
The results of canonical analysis

	L	R
Count of variable	4	9
Variability	100.000%	56.1153%
All redundancy	10.4158%	5.95033%
Variable: 1	Breed	Rib
2	RBVpge	Shoulder blade, boneless
3	Age (days)	Separable fat
4	Weight (kg)	Fore shank
5		Flank
6		Round
7		Tenderloin
8		Strip loin
9		Chuck roll & Neck

Table 4

Correlation analysis of studied meat cut traits and breeding value, age and weight

	Rib	Shoulder blade, boneless	Separable fat	Fore shank	Flank	Round	Strip loin	Tender-loin	Chuck roll & Neck	First class meat	Second class meat
RBVpge	.0436	.0249	–.0821	–.0394	–.1585	–.0632	–.0909	–.0102	.0131	–.0703	–.0290
	p = .272	p = .529	p = .038	p = .320	p = .000	p = .110	p = .022	p = .797	p = .742	p = .076	p = .465
Age (days)	.1201	.0180	.0080	–.1785	–.1061	–.1445	–.1044	–.0251	–.0195	–.1405	–.0571
	p = .002	p = .650	p = .840	p = .000	p = .007	p = .000	p = .008	p = .527	p = .623	p = .000	p = .149
Weight (kg)	.1784	.2468	–.1208	–.1911	–.1039	–.1022	–.0916	–.0550	.4258	–.0306	.3967
	p = .000	p = .000	p = .002	p = .000	p = .009	p = .010	p = .021	p = .165	p = 0.00	p = .440	p = 0.00

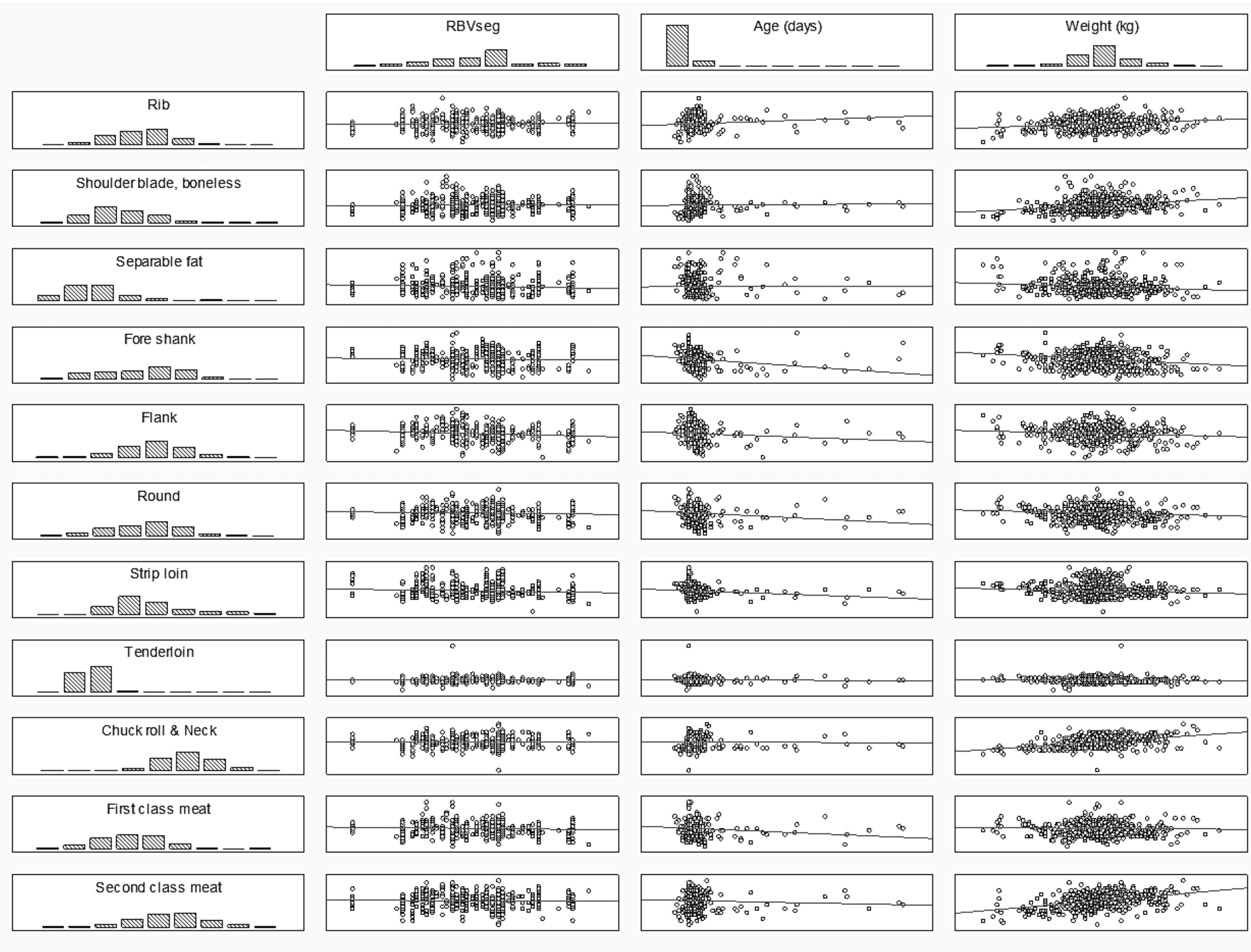

Fig. 1. Correlations between studied meat cut traits and breeding values, weigth and age

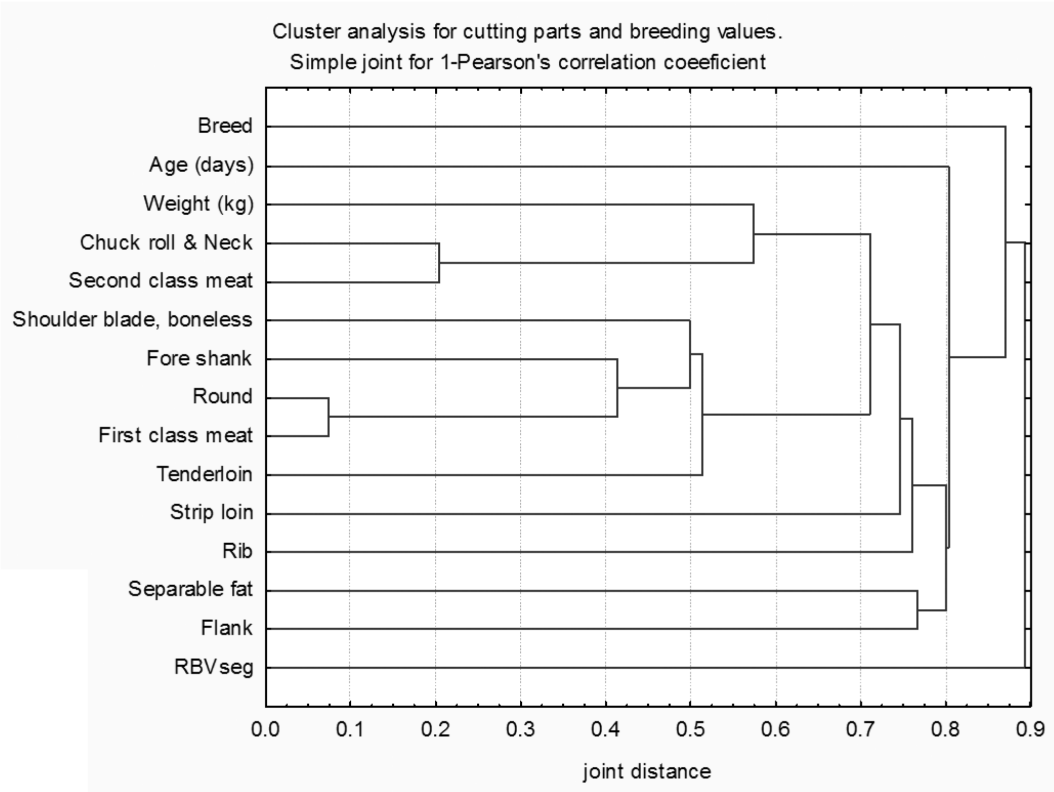

Fig. 2. Cluster analysis dendrogram for studied parameter

curve. From these charts (1 and 2) and also Table 4, a low degree of dependence to independence of single meat cuts on breeding value is apparent. Only in the case of separable fat, flank and strip loin have significant but low regression coefficients been reported.

Correlations of age and weight with cutting parts showed the same pattern. First-class meat has significantly negatively correlates with increasing age (r = –0.1405). This also corresponds with the correlation between age or weight and specific meat cuts of first-class meat. For instance, a significantly negative correlation was found (age/weight) in round (r = –0.1445/–0.1022) and in strip loin (r = –0.1044/–0.0916). With increasing weight, there is a significant increase in the proportion of second class meat (r = 0.3967), mainly due to the contribution of shoulder blade (r = 0.2468) and chuck roll and neck (r = 0.4258).

Similar results for longissimus muscle were reported by Scarth et al. (1973) and Hiner and Bond (1971). The proportion of LM decreased with age. Hiner and Bond (1971) also reported decrease during the 36 months' growing period for the semimembranosus, rectus femoris and adductor muscles. De-Siles et al. (1977) compared the proportions of round between two groups with different weights. The proportion of trimmed round was non-significantly lower in heavier animals. In contrast to first-class meat, the proportion of separable fat increased significantly with the increasing age (r = 0.2360) and weight (r = 0.2951). These trends are also evident from Figure 2, showing the pattern of the regression curve. These results are in general, consistent with those reported by Arthaud et al. (1977) and Scarth et al. (1973). Similar results were also found by Bezdíček et al. (2010). The correlation analysis in this study showed significant negative relationships only for the relative breeding values of trading classes and the rib (r = –0.2079) and relative breeding values of net daily gain with strip loin (r = –0.2433). In beef cattle, there was no significant increase of separable fat with age or increase in the proportion of second class meat. This is in contrast with Czech Fleckvieh breed (Bezdíček et al., 2010).

Table 5 shows the one-test of significance for a single model of single meat cuts and coefficients r^2. In all cases, the models show significant differences between the predicted values and residuals and are significant for all studied variables. In this case there was a significant effect of breeding value only for Separable fat (RBVpge).

Table 5
Basic statistical parameters of linear models for studied meat cuts

Parameter	r^2	p	RBVpge	Age (days)	Weight (kg)	Breed
Rib (% of HC)	0.1586	0.00	0.1974	0.1421	0.00004***	0.00***
Shoulder blade, boneless (% of HC)	0.3074	0.00	0.7385	0.3301	0.00***	0.0049**
Separable fat (% of HC)	0.2816	0.00	0.0021**	0.6051	0.0048**	0.00***
Fore shank (% of HC)	0.5311	0.00	0.8112	0.070	0.00***	0.00***
Flan (% of HC)	0.3479	0.00	0.0213*	0.4036	0.0122*	0.00***
Round (% of HC)	0.5279	0.00	0.4734	0.2304	0.0516	0.00***
Strip loin (% of HC)	0.3797	0.00	0.9734	0.1572	0.0635	0.00***
Tenderloin (% of HC)	0.3380	0.00	0.4451	0.6981	0.2756	0.00***
Chuck roll+Neck (% of HC)	0.5472	0.00	0.4079	0.0003***	0.00***	0.00***
First class meat (% of HC)	0.4861	0.00	0.4739	0.0911	0.9229	0.00***
Second class meat (% of HC)	0.4944	0.00	0.3825	0.0006***	0.00***	0.00***

$p < 0.001$***; 0.01**; 0.05*
RBVpge = Relative breeding value of paternal growth effect

The effect of weight (or age) at the time of slaughter on proportion of single meat cuts is, in the combined linear relation to cuts in many cases significant or highly significant (except for Second class meat) – Table 5. Evaluation of the effect of breed showed a very significant effect (mainly 0.001).

A dendrogram made using cluster analysis performed on the basis of mutual correlations (Figure 2) shows the close dependence of round and first class meat and also of chuck roll+neck and second class meat. The correlation analysis in the dendrogram also shows that relative breeding value of paternal growth effect has no relationship with meat cuts.

Conclusion

The correlation analysis of relative breeding value of paternal growth effect (RBVpge) revealed a significant relationship only to separable fat, flank and strip loin. Although this correlation was significant, their values were small. Correlations with different cutting parts were non-significant for the other traits of breeding values. Correlations of age and weight with cutting parts showed the same pattern. First-class meat significantly negatively correlates with increasing age. This also corresponds with a correlation between age or weight and specific first class meat cuts. For instance, significantly negatively correlation was found in age/weight and round and strip loin. With increasing weight, in meat cattle breeds there is increasing contribution of second class meat, mainly shoulder blade and chuck roll and neck.

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