ULTRASONIC DETECTION OF GROWTH POTENTIAL IN REARED AND FATTENED HEREFORD BULLS*

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The growth ability of two groups of Hereford bulls which were intended for rearing and for fattening was detected in accordance with their age on the basis of detecting live weight and measuring of 5 body measurements. Meatiness of the animals was detected by sonographic measuring of the area of *musculus longissimus lumborum et thoracis* (MLLT, cm^2). From realized findings it results that bulls chosen for rearing reached conclusively higher values ($P \leq 0.05–0.001$) in all watched indicators. Among reared and fattened groups 30% difference in the height of average daily gain, to the benefit of bulls intended for additional rearing, was detected. The area of MLLT detected by sonograph in the age of 360 days in the group of bulls intended for rearing made 68.5 and 64.2 cm^2 and in the group of bulls intended for fattening it was 57.4 and 53.1 cm^2 in the area of 1st resp. 6th lumbar vertebrae. Detected difference was statistically significant ($P \leq 0.05$). Phenotypic correlations between body measurements and area of MLLT were carried out.

cattle; bull; ultrasonograph; area of MLLT; growth ability

INTRODUCTION

At present, increasing concern of farmers and breeders is attributed to commercial system used for accurate prediction of carcass quality and growth parameters in relation to the farm economic aspects.

McLaren et al. (1991) advertise the importance of ultrasonic evaluation of the MLLT area and the layer of subcutaneous fat for increase of meat efficiency of cattle. Bullock et al. (1991) gathered data concerning the ultrasonographic measures, physical measures and condition evaluation of cows. They conclude that these methods can be successfully used for assessment of carcass composition. Polák and Daňo (2002) evaluated growth indicators including the change of the MLLT area measured via ultrasonograph and they suggest the possibility of using ultrasonography like an assistant method or dominant method for classification of carcass bulls. Houghton and Turlington (1992) note that the accurateness of ultrasound prediction of carcass composition is variable and depends on the category of farm animal, on the used instrument and skills and experience of the personnel. Cattle correlative coefficients for layer of subcutaneous fat ($r = 0.45–0.96$) and for the area of MLLT ($r = 0.20–0.94$) were calculated with regard to carcass composition. Crews et al. (2003) approved genetic correlations between layer of fat investigated via ultrasound scanning before slaughter and layer of fat measured on the carcass ($r = 0.79 \pm 0.13$ in bulls category and $r = 0.83 \pm 0.12$ in heifers category). In the area of MLLT correlations were $r = 0.80 \pm 0.11$ in bulls category and $r = 0.54 \pm 0.12$ in heifers category. Genetic correlations between marbling of MLLT investigated in carcass and the rate of intramuscular fat investigated via ultrasound scanning were $r = 0.74 \pm 0.11$ and $r = 0.69 \pm 0.13$. Evrard et al. (1999) measured depth and area of MLLT and the layer of subcutaneous fat in Belgian Blue cattle during the fattening and they investigated important correlations among the area of MLLT and some carcass indicators. Rosler et al. (1996) investigated the area of MLLT via ultrasound scanning on the 1st and 4th lumbar vertebraea and the layer of subcutaneous fat in 143 beef cattle bulls in fattening (at the age of 375 and 470 days). The evaluation of carcass quality and the appreciation of physico-chemical characteristics of the tissue were performed on the group of 45 bulls. The information acquired by ultrasound scanning allowed precise carcass composition assessment, particularly in elderly bulls. Nová et al. (2002) used ultrasound scanning for comparison of the growth ability of the Charolais cattle, Hereford cattle and Aberdeen-Angus cattle. They noted that the highest values at the age of 210 days in the MLLT depth on 1st and 6th lumbar vertebrae were reached by Charolais bulls. At the same time the layer of subcutaneous fat of Charolais bulls was the lowest whereas Hereford bulls reached the highest level. Sakowski et al. (2002) performed ultrasound scans of 64 bulls slaughtered at the age of 15 months and live weight reaching 450 kg. They detected the coefficient of regression ranging between 0.29 and 0.53 at rather high prediction error. Even though the authors claim that this method can be used for selective criteria based on the in-

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Table 1. Live weight of fattened and reared bulls in the age of 300 up to 540 days (kg)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	25	320.8	65.7	27	376.1	45.1	***
360	25	407.4	93.1	27	477.8	48.32	***
420	17	454.9	93.5	19	582.9	55	***
540	9	546.6	19.64				

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

Table 2. Average daily gain (cm)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300–360	24	1.35	0.598	27	2.27	0.363	**
360–420	17	1.37	0.219	19	2.1	0.22	**
420–540	9	1.05	0.399				

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

dividual power-ratio model. C r e w s et al. (2002) examined bulls heifers and oxen after weaning via ultrasonograph at the age of 1 year and just before slaughter. Ante-slaughter ultrasound scanning showed standard errors in prediction lower than 4.95 cm2 for the area of MLLT and 1.15 mm or less for the layer of subcutaneous fat. These results showed that ultrasound scanning between weaning and 1 year old cattle offer equally exact predictions that correspond with the characteristics of carcass of bulls, heifers and oxen. S t e e n (1991) states that higher protein intake results into more intensive growth although this was not found at the carcass of the higher level of fat. P o l á k et al. (2001) investigated the MLLT depth and 13 body measurements in the Slovak Simmental cattle. G r i n g s et al. (1996) studied the growth potential of bulls of Charolais and Hereford sires.

MATERIAL AND METHODS

The growth ability of Hereford bulls (27 bulls intended for rearing, 25 bulls intended for fattening) was assessed according to the age on the basis of live weight detections, daily gain and 5 body measures (lower back height, width of the loins measured via Wilkinson's compass and tape on 1st and 6th lumbar vertebrae). Ultrasonograph Aloka SSD-500 with UST-5011U (3.5 MHz) probe was used for measurement of the area (cm^2) and depth (cm) of MLTT (*musculus longissimus lumborum et thoracis*) in order to examine meatiness. Fat content on the basis of subcutaneous fat layer (cm) was examined using UST-5820U (5 MHz) probe. These measurements were carried out on the 1st and 6th lumbar vertebrae. All measurements and live weight detection via weighting were performed at the age of 300, 360, 420 days and in fattened animals at the age of 540 days (before slaughter) at the 15-day interval. Correlation coefficients among individual indicators were statistically calculated in the SAS statistical program using a linear model:

$$y_{ij} = \mu + U_i + VEK_j + U * VEK_{ij} + e_{ij}$$

where: y_{ij} – the indicator studied
μ – set average
U_i – influence of i-th nutrition level, i = 1, 2
VEK_j – influence of j-th age, j = 300, 360 and 420 days
$U * VEK_{ij}$ – nutrition level – age interaction
e_{ij} – residue

RESULTS AND DISCUSSION

Live weight and daily gain

Live weight of bulls intended for fattening ranged from 321 kg at the age of 300 days to 455 kg at the age of 420 days. As documented in Table 1, bulls intended for next rearing have obviously higher growth potential. Both groups of bulls were bred on the same farm at different nutrition levels. The feed rations of fattened bulls contained lower energy and protein content. The differences were observed in live weight at the age of 300 and 420 days. The differences observed were 17.8% and 28.1%, respectively, between the two groups. Growth intensity measured on the basis of daily gain was about 26–28% higher in bulls intended for rearing; see Table 2. S t e e n (1991) states higher growth intensity as a result of higher protein intake.

Lower back height

Body frame of watched groups of bulls is characterized by the lower back height. At the beginning of observation at the age of 300 days the lower back height is in fact the same in both groups (see Table 3). The lower back height ranged from 120.3–121.8 cm to 127.5–130.2 cm at the age of 300 days and at the age of 420 days, re-

Table 3. Lower back height (cm)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	25	120.3	3.63	27	121.8	2.58	
360	25	122.7	0.83	27	125.5	2.71	**
420	17	127.5	1.15	19	130.2	3	*
540	9	138	1.94				

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

Table 4. MLLT area on 1st lumbar vertebra (cm^2)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	22	41.45	8.42	12	48.87	7.07	
360	23	57.4	11.21	13	68.49	15.27	*
420	17	69.89	19.79	5	83.15	20.43	*
540	8	73.98	5.61				

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

Table 5. MLLT area on 6th lumbar vertebra (cm^2)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	22	36.43	7.33	12	43.9	8.2	
360	23	53.09	13.06	13	64.2	8.27	**
420	17	60.27	12.82	5	72.33	13.8	*
540	8	67.52	4.76				

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

Table 6. Layer of subcutaneous fat on 1st lumbar vertebra (cm^2)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	22	0.66	0.13	12	0.74	0.14	
360	23	0.77	0.22	13	0.95	0.16	**
420	17	0.77	0.22	5	0.98	0.23	*
540	8	0.91	0.4				

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

spectively. Significant difference ($P \leq 0.05$–0.01) in the lower back height between watched groups was found at the age of 360 and 420 days. Body frame of both groups of bulls at the age of 300 days was the same. Live weight of bulls intended for rearing of the same age was higher.

Area of MLLT

The area of MLLT was detected on living animals on 1st and 6th lumbar vertebrae. As we can see (Tables 4, 5) the increase of the MLLT area is observed in both groups. In the fattened group the MLLT area on 1st lumbar vertebra increased from 41.45 cm^2 at the age of 300 days to 69.89 cm^2 at the age of 420 days; it is 68.6% increase. In the reared bulls group the increase of the MLLT area from 48.78 cm^2 to 83.15 cm^2 was detected during the same period. Significant increase of the MLLT area was observed on 6th lumbar vertebra from 36.43 cm^2 to 43.5 cm^2 at the age of 300 days and from 60.27 cm^2 to 72.33 cm^2 at the age of 420 days. At the age of 360 and 420 days watched groups of bulls differ at statistical significance $P \leq 0.05$–0.01. MLLT areas results detected were compared to findings of Crews et al. (2003), Evrard et al. (1999), Rosler et al. (1996) and found appropriate.

Layer of subcutaneous fat

The layer of subcutaneous fat was measured by the same way as the area of MLLT on the 1st and 6th lumbar

Table 7. Layer of subcutaneous fat on 6th lumbar vertebra (cm^2)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	22	0.6	0.14	12	0.74	0.14	
360	23	0.84	0.29	13	0.93	0.23	
420	17	0.94	0.19	5	1.04	0.31	
540	8	1.3	0.08				

* = $P \leq 0.05$; ** = $P \leq 0.01$, *** = $P \leq 0.001$

Table 8. Width of the loins on 1st lumbar vertebra – compass (cm)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	25	25.7	2.44	27	27.74	1.95	**
360	25	28.8	2.96	27	31.33	2.08	***
420	17	31.5	3.54	19	35.79	2.74	***
540	9	33.2	0.83				*

* = $P \leq 0.05$; ** = $P \leq 0.01$, *** = $P \leq 0.001$

Table 9. Width of the loins on 6th lumbar vertebra – compass (cm)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	25	29.9	2.45	27	32.3	1.81	**
360	25	32.7	3.21	27	35.6	2.15	***
420	17	35.4	0.85	19	39.9	2.66	***
540	9	38,1	1.05				

* = $P \leq 0.05$; ** = $P \leq 0.01$, *** = $P \leq 0.001$

Table 10. Width of the loins on 1st lumbar vertebra – tape (cm)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	25	33.3	2.85	27	35.7	1.81	**
360	25	35.8	3.71	27	38.6	2.44	***
420	17	38.1	3.27	19	42.5	2.22	***
540	9	43.2	1.86				

* = $P \leq 0.05$; ** = $P \leq 0.01$, *** = $P \leq 0.001$

Table 11. Width of the loins on 6th lumbar vertebra – tape (cm)

Category	Fattening			Rearing			Significance
Age of	n	$\bar{x}$	$s_{\bar{x}}$	n	$\bar{x}$	$s_{\bar{x}}$	
300	25	36.7	3.52	27	39.8	2.04	***
360	25	40.2	4.15	27	43.3	2.58	***
420	17	42.4	4.04	19	47.2	2.64	***
540	9	48.1	1.45				

* = $P \leq 0.05$; ** = $P \leq 0.01$, *** = $P \leq 0.001$

vertebrae. From the results in Tables 6 and 7, we conclude the difference on 1st and 6th lumbar vertebrae in both groups. The layer of subcutaneous fat found on 1st lumbar vertebra in group of fattened bulls at the age of 300 and 420 days at the beginning of measuring was 0.66 cm and 0.77 cm respectively. The layer of subcutaneous fat found on 1st lumbar vertebra in group of reared bulls at the age of 300 days and 420 days at the beginning of

Table 12. Phenotypic correlations in observed traits in both groups of bulls at the age of 300 days

	Front width of the loins – compass (cm)	Back width of the loins – compass (cm)	Front width of the loins – tape (cm)	Back width of the loins – tape (cm)	Lower back height (cm)	Live weight (kg)	MLLT area on 1st lumbar vertebra (cm^2)	MLLT area on 6th lumbar vertebra (cm^2)
Front width of the loins – compass (cm)	1	0.942 ***	0.922 ***	0.905 ***	0.609 ***	0.931 ***	0.818 ***	0.854 ***
Back width of the loins – compass (cm)		1	0.923 ***	0.941 ***	0.571 **	0.911 ***	0.754 ***	0.814 ***
Front width of the loins – tape (cm)			1	0.951 ***	0.705 ***	0.95 ***	0.864 ***	0.885 ***
Back width of the loins – tape (cm)				1	0.654 ***	0.94 ***	0.858 ***	0.841 ***
Lower back height (cm)					1	0.709 ***	0.575 **	0.743 ***
Live weight (kg)						1	0.859 ***	0.912 ***
MLLT area on 1st lumbar vertebra (cm^2)							1	0.923 ***
MLLT area on 6th lumbar vertebra (cm^2)								1

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

Table 13. Phenotypic correlations in observed traits in both groups of bulls at the age of 360 days

	Front width of the loins – compass (cm)	Back width of the loins – compass (cm)	Front width of the loins – tape (cm)	Back width of the loins – tape (cm)	Lower back height (cm)	Live weight (kg)	MLLT area on 1st lumbar vertebra (cm^2)	MLLT area on 6th lumbar vertebra (cm^2)
Front width of the loins – compass (cm)	1	0.949 ***	0.811 ***	0855 ***	0.629 ***	0.888 ***	0.713 ***	0.821 ***
Back width of the loins – compass (cm)		1	0.763 ***	0.826 ***	0.642 ***	0.872 ***	0.712 ***	0.844 ***
Front width of the loins – tape (cm)			1	0.974 ***	0.777 ***	0.888 ***	0.587 **	0.666 ***
Back width of the loins – tape (cm)				1	0.797 ***	0.923 ***	0.59 **	0.718 ***
Lower back height (cm)					1	0.805 ***	0.445 *	0.533 ***
Live weight (kg)						1	0.66 ***	0.816 ***
MLLT area on 1st lumbar vertebra (cm^2)							1	0.902 ***
MLLT area on 6th lumbar vertebra (cm^2)								1

$^{*} = P \leq 0.05$; $^{**} = P \leq 0.01$, $^{***} = P \leq 0.001$

measuring was 0.74 cm and 0.98 cm respectively. The differences among groups were statistically significant on the level $P \leq 0.05$–0.01 at the age of 360 and 420 days. There is no difference statistically significant among the groups in the layer of subcutaneous fat on 6th lumbar vertebra.

Body measurements

The exterior dimensions of loins were measured via tape measure and Wilkinson's compass on 1st and 6th lumbar vertebrae (see Tables 8, 9, 10, 11 for results). In both groups we can see that loins' beefiness has in-

Table 14. Phenotypic correlations in observed traits in both groups of bulls at the age of 420 days

	Front width of the loins – compass (cm)	Back width of the loins – compass (cm)	Front width of the loins – tape (cm)	Back width of the loins – tape (cm)	Lower back height (cm)	Live weight (kg)	MLLT area on 1st lumbar vertebra (cm^2)	MLLT area on 6th lumbar vertebra (cm^2)
Front width of the loins – compass (cm)	1	0.957 ***	0.943 ***	0.957 ***	0.77 ***	0.964 ***	0.941 ***	0.909 ***
Back width of the loins – compass (cm)		1	0.927 ***	0.968 ***	0.847 ***	0.975 ***	0.936 ***	0.954 ***
Front width of the loins – tape (cm)			1	0.948 ***	0.796 ***	0.903 ***	0.887 ***	0.908 ***
Back width of the loins – tape (cm)				1	0.816 ***	0.942 ***	0.908 ***	0.917 ***
Lower back height (cm)					1	0.845 ***	0.738 ***	0.842 ***
Live weight (kg)						1	0.902 ***	0.918 ***
MLLT area on 1st lumbar vertebra (cm^2)							1	0.936 ***
MLLT area on 6th lumbar vertebra (cm^2)								1

* = $P \leq 0.05$; ** = $P \leq 0.01$, *** = $P \leq 0.001$

creased. Bulls intended for fattening reached measures of 14.41–15.53% (tape measure) and 12.57–18.39% (compass). Bulls intended for rearing reached measures of 18.59–19.04% (tape measure) and 23.53–29.02% (compass). The reared bulls group reached significantly higher values during the whole watched period. At the age of 300 days the differences in loins' beefiness were at the significance level $P \leq 0.01–0.001$ and at the age of 360 and 420 days the significance level $P \leq 0.001$.

Phenotypic correlative dependence of watched indicators

Phenotypic correlative dependence of watched indicators of both groups of bulls are stated in Tables 12, 13, 14. Measurement of growth intensity of MLLT area included ultrasound scanning on 1st and 6th lumbar vertebrae, tape measure and compass measure of the exterior dimension of MLLT from the left to the right vertebra ledge (cm). The combination of the methods secured accurate results of growth intensity. The measured dimensions were included in the correlative dependence calculation. Significant statistical dependencies ($P \leq 0.001$) proved the measurement of MLLT area on 6th lumbar vertebra to be the most accurate. Close and conclusive correlative dependencies were found among MLLT dimensions measured via ultrasound scanning, tape measure and compass. Dependence of the MLLT area in the lower back height and live weight was detected. Measuring of MLLT on 6th lumbar vertebra via ultrasound scanning is to be recommended according to statistical results. Rosler et al. (1996), Crews et al. (2002) and other authors found similar tendencies and dependencies. The results proved that ultrasonographic measurement can be used successfully for objective estimation of body beefiness.

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Stanovení růstového potenciálu u chovných a vykrmovaných býků plemene hereford pomocí ultrasonografu.

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Růstová schopnost vykrmovaných a chovných býků plemene hereford (I. skupina – odchov 27 ks, II. skupina – výkrm 25 ks) byla posuzována podle věku na základě zjišťování živé hmotnosti a průměrných denních přírůstků a měření pěti tělesných rozměrů: výška v kříži, šířka beder měřená páskovou mírou a Wilkinsonovým kružidlem v oblasti 1. a 6. bederního obratle. Pro posouzení zmasilosti zvířat byla zjišťována plocha (cm^2) a výška (cm) *musculus longissimus lumborum et thoracis* (MLLT) ultrasonografem Aloka SSD-500 se sondou UST-5011U (3,5 MHz). Dále byla zjišťována protučnělost na základě měření výšky podkožního tuku sondou UST-5820U (5 MHz). Měření svalu MLLT i výšky podkožního tuku byla prováděna na úrovni 1. a 6. bederního obratle. Zvířata byla měřena a vážena ve věku 300, 360 a 420 dní a vykrmovaná zvířata i ve věku 540 dní (před porážkou) v intervalu 15 dní. Korelační závislosti mezi jednotlivými ukazateli byly vypočteny pomocí statistického programu SAS – lineárním modelem.

Obě skupiny býků byly chovány na jedné farmě s rozdílnou úrovní výživy, vykrmovaní býci byli krmeni krmnou dávkou s nižším obsahem energie a dusíkatých látek. Rozdíl v živé hmotnosti mezi sledovanými skupinami byl 17,8 % ve 300 dnech věku a 28,1 % ve 420 dnech věku. Intenzita růstu zjišťovaná na základě denních přírůstků byla o 26–28 % vyšší u skupiny plemenných býků. Tělesný rámec (výška v kříži) býků obou sledovaných skupin do věku 300 dnů byl shodný. Průkazný rozdíl ($P \leq 0,05–0,01$) ve výšce v kříži byl mezi skupinami zjištěn ve věku 360 a 420 dní. S rostoucím věkem lze u obou skupin pozorovat zvětšování osvalení beder – u býků ve výkrmu o 14,41–15,53 % (měřeno páskou), resp. 12,57–18,39 % (kružidlem) a u chovných býků 18,59–19,04 % (páskou) a 23,53–29,02 % (kružidlem). Skupina chovných býků dosahovala průkazně vyšších hodnot v průběhu celého období sledování. Ve věku 300 dní byly rozdíly mezi skupinami v osvalení beder na hladině významnosti $P \leq 0,01–0,001$ a ve věku 360 až 420 dní na hladině významnosti $P \leq 0,001$. Plocha MLLT na 1. bederním obratli vzrostla u vykrmované skupiny ze 41,45 cm^2 ve věku 300 dnů na 69,89 cm^2 ve věku 420 dnů, což je nárůst o 68,6 %. U skupiny odchovávaných býků byl během tohoto období zjištěn nárůst plochy MLLT ze 48,87 cm^2 na 83,15 cm^2, tj. o 70,1 %. Obdobně lze za stejné období pozorovat výrazné zvětšení plochy MLLT zjišťované na 6. bederním obratli z 36,43 cm^2 a 43,5 cm^2 ve 300 dnech věku na 67,27 cm^2 a 72,33 cm^2 ve 420 dnech věku. Plocha MLLT ve věku 360 a 420 dnů se statisticky průkazně lišila ($P \leq 0,05–0,01$). Výška podkožního tuku byla na počátku měření ve 300 dnech věku na 1. bederním obratli 0,66 cm u býků ve výkrmu a 0,74 cm u býků v odchovu a ve věku 420 dní 0,77 cm ve výkrmu a 0,98 cm u chovných zvířat. Rozdíly mezi skupinami byly průkazné ($P \leq 0,05–0,01$) ve 360 dnech a 420 dnech věku. Ve výšce podkožního tuku na 6. bederním obratli nebyl mezi skupinami zjištěn statisticky průkazný rozdíl.

Dále byly zjištěny průkazné kladné fenotypové korelace mezi tělesnými rozměry a plochou MLLT.

skot; býk; ultrasonograf; plocha MLLT; růstová schopnost

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