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Screening of backfat thickness and *musculus longissimus lumborum et thoracis* depth of Aberdeen Angus cattle in Czech conditions

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Abstract: The aim of this study was to monitor the Czech Aberdeen Angus population for backfat thickness (BT), *musculus longissimus lumborum et thoracis* (MUSCLE) and live weight (LW) in relation to environmental and genetic conditions. In this study, we also wanted to display the potential for future inclusion of these parameters into national monitoring. Parameters of BT, MUSCLE and LW were measured at 120, 210, and 365 days of age in 769 Aberdeen Angus calves (417 bulls and 352 heifers) on seven farms. Statistical evaluation was performed in the SAS v9.3 software. The bulls achieved significantly higher ($P < 0.01$) weights and larger MUSCLE compared to the heifers, although the heifers had higher BT. The age of the dam at calving significantly influenced the growth ability of tested calves, but it did not influence BT nor MUSCLE. The nested effect of the year-season, farm and sire bulls (or genetic background) significantly affected LW, BT and MUSCLE of tested calves. The use of the same breeding bulls on different farms resulted in significant differences in growth parameters. Our results displayed the potential of nationwide monitoring of MUSCLE and BT of beef breeds, as official parameters of the beef performance testing in the Czech Republic. The inclusion of these globally used traits in the Czech breeding system would allow to predict breeding values for the Czech beef population. This would lead not only to general improvement of MUSCLE in the population, but also to the production of better breeding animals and slaughter animals with higher value.

Keywords: growth ability; ultrasonography; meatiness; fatness; beef calves

The profitability of cattle breeding is based on excellent reproduction results of breeding cows and great growth ability of calves. A lot of parameters within these traits are monitored as a part of the beef performance testing in the Czech Republic. The system for assessing the growth ability and carcass parameters is constantly evolving and can be continuously updated. There are relatively large differences between countries in monitored parameters and in methods of beef performance evaluation (Venot et al. 2009), e.g. routine monitoring of the *musculus longissimus lumborum et thoracis* (MUSCLE) area has already been established in Australia, New Zealand or Scotland but not in the Czech Republic (Duff et al. 2018; Breedplan 2020).

The final product of beef cattle breeding is beef from animals slaughtered at optimal age with appropriate weight, meatiness and fatness (Bures and Barton 2012). These parameters heavily affect monetization in the Czech Republic (Krupova et al. 2020), but also in the world. They are influ-

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enced by a number of factors such as breed, genetic background (Ptacek et al. 2018; Moravcikova et al. 2019), nutrition, technology and others (Mazzucco et al. 2016). Farmers would welcome a possibility to evaluate meatiness and fatness even on live animals, so they could better focus on breeding for these parameters during rearing (Meyer et al. 2005). Various studies pointed out the usefulness of ultrasonography to measure meatiness and fatness without slaughtering the animals (Emenheiser et al. 2014). The development of this body part correlates with the development of other body parts (Stadnik et al. 2011), so it can be used to predict overall meatiness and fatness (Nogalski et al. 2017).

Ultrasound measurement of MUSCLE is done in a precisely defined loin area where ultrasound gel or vegetable oil is applied (Emenheiser et al. 2014) to improve performance. This method has been used in developed cattle breeding countries for many years. From this scan, we can determine backfat thickness (BT), depth of the MUSCLE, and area of MUSCLE (Stadnik et al. 2011). Genetic parameters as well as breeding values (Weber et al. 2012) are already routinely predicted for these parameters in developed cattle breeding countries. Possibilities of BT and MUSCLE monitoring are still being considered in the Czech Republic (Stadnik et al. 2011). Direct utilization of these parameters from the performance testing of developed cattle breeding countries is possible, although in many countries the cattle performance testing is performed at different ages (Venot et al. 2009), which complicates the comparison.

The Czech Republic should have a (technological, expertise, labour, good animal genetics) potential to fully monitor MUSCLE on a nationwide level. Introduction of this monitoring could create the prerequisite to select superior breeding animals and/or slaughter animals with added value. As we suggested in the introduction, there are differences in growth ability and meatiness and fatness parameters based on environmental and genetic conditions. Therefore, differences should be observed among farmers and individual animals within the farm. The aim of this study was to monitor the Czech Aberdeen Angus population for BT, MUSCLE and LW in relation to environmental and genetic conditions. The secondary aim was to create the potential for future inclusion of these parameters in the beef performance testing of the Czech Republic.

MATERIAL AND METHODS

This experiment was carried out in accordance with the Czech legislation for prevention of cruelty to animals (No. 246/1992) and with Directive 2010/63/EU on the protection of animals used for scientific purposes.

Animals and herd management

An experiment was conducted on seven Aberdeen Angus farms in the Czech Republic with approximately 50 to 150 head of cattle per basic herd (altitude: 280–494 m above sea level; average annual temperature: 7.4–8.6 °C; average annual rainfall: 535–946 mm). Data were collected from 2015 to 2017. A total of 769 calves (417 bulls and 352 heifers) born from January to September were included. Semi-intensive cattle breeding system was used on the farms, which meant that most of the calves were born in the stable during winter months. All stables in the test used free stall housing in cubicles on deep bedding. Subsequently, the calves were separated by sex and reared on pasture with their mothers during summer months. Feeding rations in the winter period consisted of silage or haylage with hay, mineral supplements and a small amount of barley. Animals spent summer months on the pasture, with addition of hay and mineral supplements. Animals had *ad libitum* access to drinking water.

Sample collection and analyses

Data on backfat thickness (mm) and the depth of the *musculus longissimus lumborum et thoracis* (mm) were measured by one trained researcher during the routine beef performance testing by the Czech Beef Breeders Association. Trained inspectors of the Czech Beef Breeders Association measured live weight (kg) of tested animals. Czech Beef performance testing follows the French system, in which animals are measured three times at different ages: 90–170 days of age; 171–289 days of age; 290–450 days of age. Subsequently, all recorded data are recalculated to specific, standardized age of 120, 210, and 365 days.

Ultrasonography was used to determine BT and MUSCLE (ALOKA SSD-500 ultrasound

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machine; Hitachi Aloka Medical, Ltd., Tokyo, Japan) with a 3.5-MHz 17.2 cm linear array probe UST5011U-3.5. The probe was put behind the last lumbar vertebra on the left side of the animal body, where vegetable oil was previously applied. This methodology is in accordance with the Breedplan (2020). Using ultrasound gel is possible, although we achieved better image quality with vegetable oil. The ultrasound examination was recorded into the laptop with the Sweex Video Graber USB (Nedis BV, 's-Hertogenbosch, Netherlands) and these videos were evaluated in the program NIS-Elements AR 3.2 (Nikon Corp., Tokyo, Japan). BT and MUSCLE were recalculated in the same manner as live weight. An example of ultrasound scan for BT and MUSCLE is shown in Figure 1.

Statistical analysis

SAS v9.3 was used for statistical analysis (SAS/STAT®; SAS Institute, Inc., Cary, NC, USA). The UNIVARIATE procedure was used to calculate basic statistics. The REGG procedure was used to recalculate BT, MUSCLE and LW of variously old animals to represent values for ages of 120 and 210 days. The CORR procedure was used to calculate Pearson's correlation coefficients. The STEPWISE method and the REG procedure were used for the selection of suitable factors for the model equation used in the MIXED procedure. The best model for the evaluation was selected in accordance with the values of the Akaike information criterion (AIC). A model equation consisted of cumulative effect of the year-season of calves' birth, sex of the calves, age of the dam, farm and nested fixed effect of sire bull on the farm. Only bulls with 10 or more offspring were further evaluated. The Tukey-Kramer method was used for evaluation of the differences in least square means. The model equation used for the evaluation was as follows:

$$Y_{ijklmn} = \mu + YS_i + SEX_j + AGE_k + FARM_l + BULL(FARM)_m + e_{ijklmn} \quad (1)$$

where:

Y_{ijklmn} – dependent variable (BT 120; MUSCLE 120; LW 120; BT 210; MUSCLE 210; LW 210; BT 365; MUSCLE 365; LW 365);

μ – mean value of dependent variable;

YS_i – cumulative fixed effect of i^{th} year-season of calves' birth (i = 1 – December 2014, n = 10; i = 2 – January 2015, n = 30; i = 3 – February 2015, n = 53; i = 4 – March 2015, n = 71; i = 5 – April 2015, n = 31; i = 6 – May 2015, n = 11; i = 7 – December 2015, n = 16; i = 8 – January 2016, n = 41; i = 9 – February 2016, n = 97; i = 10 – March 2016, n = 88; i = 11 – April 2016, n = 38; i = 12 – May 2016, n = 5; i = 13 – December 2016, n = 12; i = 14 – January 2017, n = 51; i = 15 – February 2017, n = 101; i = 16 – March 2017, n = 72; i = 17 – April 2017, n = 34; i = 18 – May 2017, n = 8);

SEX_j – fixed effect of j^{th} sex of the calves (j = bull, n = 417; j = heifers, n = 352);

AGE_k – fixed effect of k^{th} age of the dam (k = 2, n = 88; k = 3, n = 116; k = 4, n = 120; k = 5, n = 102; k = 6, n = 84; k = 7, n = 67; k = 8, n = 45; k = 9, n = 42; k = 10 and more, n = 105);

$FARM_l$ – fixed effect of l^{th} farm (l = 1, n = 106; l = 2, n = 109; l = 3, n = 95; l = 4, n = 105; l = 5, n = 37; l = 6, n = 215; l = 7, n = 102);

$BULL(FARM)_m$ – nested fixed effect of lth of sire bull on the farm (m = 36 bulls on seven farms, some bulls were used on more farms);

e_{ijklmn} – random error.

Significance levels $P < 0.05$, $P < 0.01$, and $P < 0.001$ were used to evaluate the differences between groups.

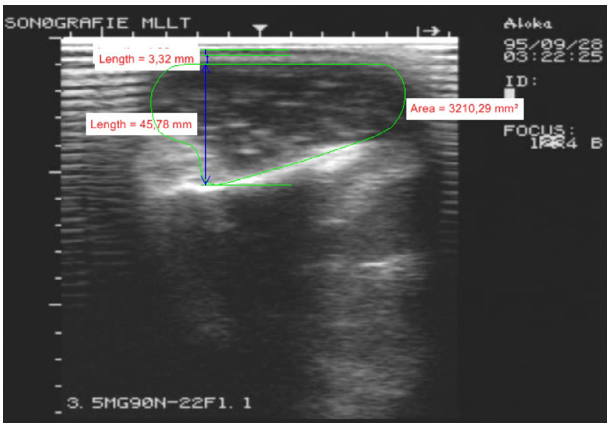

Figure 1. Example of ultrasound scan from the measurement of backfat thickness (BT) and *musculus longissimus lumborum et thoracis* (MUSCLE)

RESULTS

Basic statistics for growth ability described by BT, MUSCLE and LW are shown in Figures 2,

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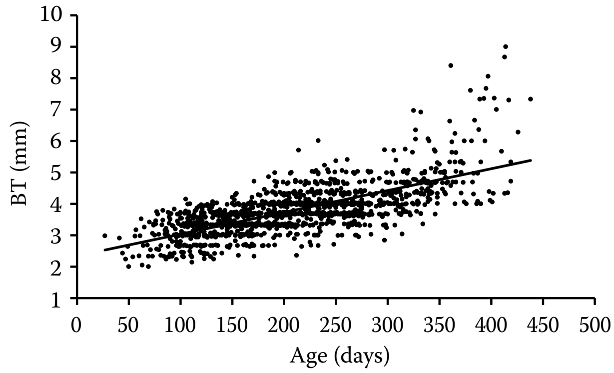

Figure 2. Development of backfat thickness (BT) in relation to the age of tested animals

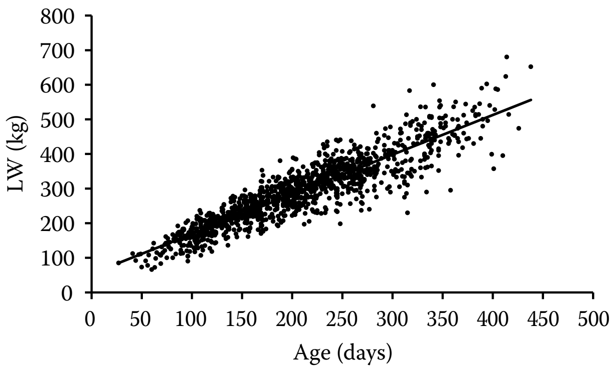

Figure 4. Development of live weight (LW) in the relation to the age of tested animals

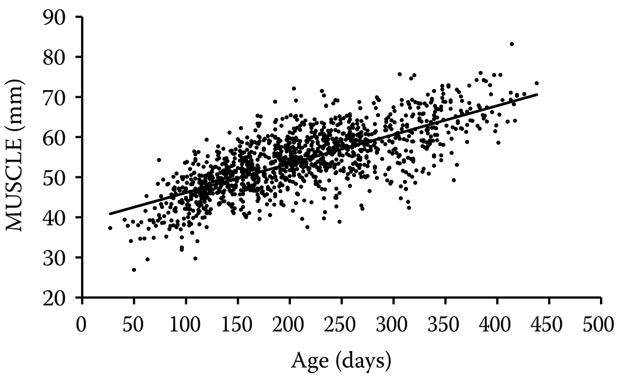

Figure 3. Development of the *musculus longissimus lumborum et thoracis* (MUSCLE) depth in the relation to the age of tested animals

3 and 4. We observed significant correlations between monitored parameters, with the strongest correlation observed for MUSCLE and LW at 365 days of age. Correlations between the other parameters at different ages also showed medium or even strong relations (from r = 0.232 to r = 0.736; P < 0.001). Basic statistics for the MIXED evaluation of growth ability parameters (BT 120; MUSCLE 120; LW 120; BT 210; MUSCLE 210; LW 210; BT 365; MUSCLE 365; LW 365) can be found in Table 1. The model equation was significant for all growth ability parameters (P < 0.001) and explained variability from 47% to 84%. Cumulative effect of the year-season of calving significantly influenced all observed parameters (P < 0.05), except LW 120. Effect of the sex was significant for all evaluated growth ability parameters (P < 0.05), except BT 120. The age of the dam was significant only for MUSCLE 120, LW 120 and LW 210. The effect of the farm was significant for the majority

Table 1. Basic statistics for model evaluation

	Model equation		YS		SEX		AGE		FARM		BULL(FARM)	
	R^2	P	F	P	F	P	F	P	F	P	F	P
BT 120	0.62	< 0.001	3.48	< 0.001	1.85	0.174	1.32	0.234	2.75	0.013	1.71	0.009
MUSCLE 120	0.5	< 0.001	3.38	< 0.001	28.95	< 0.001	2.73	0.006	4.72	< 0.001	1.71	0.009
LW 120	0.54	< 0.001	1.68	0.051	45.18	< 0.001	6.94	< 0.001	0	1	1.89	< 0.001
BT 210	0.47	< 0.001	3.77	< 0.001	23.67	< 0.001	0.87	0.539	1.99	0.066	1.68	0.004
MUSCLE 210	0.52	< 0.001	1.66	0.047	24.71	< 0.001	1.9	0.058	2.06	0.057	1.63	0.007
LW 210	0.54	< 0.001	2.7	< 0.001	49.9	< 0.001	3.18	0.002	1.75	0.108	2.73	< 0.001
BT 365	0.86	< 0.001	1.92	0.02	46.97	< 0.001	1.2	0.3	5.55	< 0.001	1.6	0.028
MUSCLE 365	0.77	< 0.001	1.9	0.022	12.79	< 0.001	0.54	0.827	5.71	< 0.001	1.15	0.277
LW 365	0.84	< 0.001	2.62	< 0.001	21.61	< 0.001	0.23	0.984	9.1	< 0.001	1.5	0.053

120 = 120 days of age; 210 = 210 days of age; 365 = 365 days of age; AGE = fixed effect of the age of the dam; BT = backfat thickness; BULL (FARM) = nested fixed effect of the bull on the farm; FARM = fixed effect of the farm; LW = live weight; MUSCLE = *musculus longissimus lumborum et thoracis* depth; R^2 = coefficient of determination; SEX = fixed effect of the sex of the calves; YS = cumulative fixed effect of year-season of calves' birth

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Table 2. Evaluation of selected effects*

Effect	Level	BT 120	MUSCLE 120	LW 120	BT 210	MUSCLE 210	LW 210	BT 365	MUSCLE 365	LW 365
SEX	bull	3.18	47.90^{A}	198.15^{A}	3.73^{A}	56.62^{A}	305.27^{A}	4.58^{A}	66.92^{A}	494.42^{A}
	heifer	3.23	45.72^{B}	183.95^{B}	3.92^{B}	54.46^{B}	282.82^{B}	5.31^{B}	64.08^{B}	457.58^{B}
AGE	2	3.14	44.82^{a}	173.57^{A}	3.71	53.95	275.77^{A}	5.01	65.55	470.68
	3	3.17	45.84	184.91^{a}	3.86	55.01	291.6	5.19	66.37	472.26
	4	3.17	46.51	195.02^{B,b}	3.87	55.76	294.24	5.09	65.83	477.37
	5	3.26	47.32	196.17^{B,b}	3.78	56.06	293.8	5	64.89	483.34
	6	3.26	46.83	200.25^{B,b}	3.88	56.85	308.18^{B,a}	4.85	65.75	471.35
	7	3.28	48.15^{b}	197.78^{B,b}	3.88	56.27	298.65	4.78	64.72	482.44
	8	3.3	48.78^{b}	199.03^{B,b}	3.83	56.57	297.65	5	67.26	484.69
	9	3.14	47.04	191.11	3.78	55.17	302.45	4.55	63.96	470.53
	10 and older	3.14	45.99	181.59^{b}	3.84	54.22	284.07^{b}	5.05	65.17	471.38

120 = 120 days of age; 210 = 210 days of age; 365 = 365 days of age; AGE = fixed effect of the age of the dam; BT = backfat thickness; LW = live weight; MUSCLE = *musculus longissimus lumborum et thoracis* depth; SEX = fixed effect of the sex of the calves

*Data are presented as least square means

[A,B,a,b]Different letters in columns indicate statistical significance A, B = $P < 0.01$; a, b = $P < 0.05$

of the evaluated growth ability parameters, except for LW 120, BT 210, MUSCLE 210 and LW 210. Nested fixed effect of the sire bull on the farm was significant ($P < 0.01$) for all growth parameters at 120 and/or 210 days of age and BT 365.

The calves born during January and February, or in later years of evaluation achieved better growth parameters compared to the calves born later in the season and in earlier years of our evaluation. Results for the sex and the age of the dam are presented in Table 2. Tested bulls achieved significantly higher LW (+14.20 kg, +22.45 kg, and/or +36.84 kg; $P < 0.01$) and MUSCLE during all measurements ($P < 0.01$) although heifers had higher BT at 120, 210 and 365 days. Effect of the age of the dam was significant only for some growth parameters. The age of the dam influenced growth parameters, but only up to 210 days. An increase in values for BT, MUSCLE and LW was observed for calves born to seven- or eight-year-old dams. Much better results for MUSCLE 120, MUSCLE 210, LW 120 and LW 210 were obtained in the calves from older cows (five to nine years of age) when compared to younger cows (two to four years of age).

The results for fixed effect of the farm and nested fixed effect of sire bull on the farm for evaluated growth parameters are presented in Tables 3, 4 and 5. In our evaluation, we observed relatively large differences in all observed growth parameters between individual farms, due to slight differences in the breeding environment. The differences were statistically significant ($P < 0.05$ to $P < 0.01$) in some cases.

The results for nested fixed effect of sire bull on the farm are presented in Tables 3, 4 and 5. We observed numerous significant differences between sire bull's offspring within individual farms in growth ability parameters (BT 120 ranged from 3.08 mm to 3.58 mm; MUSCLE 120 ranged from 44.92 mm to 49.55 mm; LW 120 ranged from 182.24 kg to 199.10 kg; BT 210 ranged from 3.55 mm to 4.01 mm; MUSCLE 210 ranged from 52.77 mm to 57.79 mm; LW 210 ranged from 280.95 kg to 321.38 kg; BT 365 ranged from 4.75 mm to 5.73 mm; MUSCLE 365 ranged from 63.03 mm to 72.70 mm; LW 365 ranged from 427.50 kg to 553.01 kg). A lot of sire bulls were used on evaluated farms, but only a small number of bulls was used in more than one herd. We also found significant differences in growth ability of the offspring that had the same father but that were reared on different farms. However, these differences are not mentioned in the tables to achieve better clarity. This imbalance may be caused by different nutrition, different numbers of offspring on tested farms and various epigenetic factors.

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Table 3. Evaluation of the effect of the farm and nested effect of sire bulls on monitored parameters* at 120 days of age

FARM	BT 120	MUSCLE 120	LW 120	SIRE BULL	BT 120	MUSCLE 120	LW 120
1	3.13^{A}	$52.77^{A,a}$	182.24^{A}	1	3.14	45.48	$169.99^{A,a}$
				7	3.09	45.58	186.74^{B}
				8	2.88	43.12	178.87^{b}
2	3.12^{A}	53.56^{A}	189.04	2	3.16^{a}	44.34	186.66
				4	3.01	44.92	184.55
				5	3.23^{A}	46.43	183.26^{a}
				9	3.31	46.44	200.27^{b}
				10	3.16^{a}	46.61	190.62
				22	2.87^{B}	45.97	185.71
				23	$2.77^{B,b}$	47.41	194.27
3	3.21^{A}	56.32^{b}	195.36	12	3.16	47.82	196.89
				20	3.57^{A}	53.19^{A}	219.4^{A}
				28	2.95^{B}	45.35^{B}	165.75^{B}
				35	3.17	47	192.89
4	$3.08^{A,a}$	53.55^{A}	192.34	3	$2.97^{A,a}$	48.27	183.98^{a}
				6	3.23^{B}	49.52	201.30^{A}
				11	3.32	$51.28^{A,a}$	205.94^{A}
				14	2.99^{A}	44.75^{B}	195.16
				16	3.04	47.08^{b}	196.39^{a}
				17	3.31^{B}	50.88^{A}	$210.66^{A,b}$
				19	3.05	49.04	209.49^{A}
				20	3.11	48.63	197.18
				25	3.14^{b}	47.95^{b}	176.73^{a}
				31	3.01	45.99^{B}	163.60^{B}
5	3.58^{B}	$57.34^{B,b}$	$198.48^{B,a}$	13	3.73^{A}	50.77^{A}	201.32^{a}
				26	3.04	48.54	190.64^{b}
				28	$2.98^{B,a}$	42.64^{B}	191.48
				36	3.49^{b}	49.87	201.97^{a}
6	$3.28^{A,b}$	57.79^{B}	199.1^{B}	9	3.58	46.05	214.43
				14	3.78	$55.26^{A,a}$	$249.11^{A,a}$
				18	$3.99^{A,a}$	54.53	204.14^{b}
				22	3.27^{b}	45.76^{B}	194.47^{B}
				23	3.30^{b}	48.84^{b}	201.57^{b}
				24	3.30^{b}	48.05^{b}	193.89^{B}
				26	3.06^{B}	51.41	212.37^{b}
				27	3.41	52.04^{c}	220.22
7	3.27^{A}	54.9^{a}	$182.85^{A,b}$	15	3.2	45.29^{a}	194.63^{A}
				18	2.91^{a}	42.57	171.71
				26	3.29	44.68	$147.93^{B,a}$
				30	$3.49^{A,b}$	45.45^{a}	196.62^{A}
				32	2.88^{B}	40.25^{b}	157.44^{B}
				33	3.25	46.36^{a}	176.26^{b}

120 = 120 days of age; BT = backfat thickness; MUSCLE = *musculus longissimus lumborum et thoracis* depth; LW = live weight; FARM = fixed effect of the farm; SIRE BULL = nested fixed effect of the sire bull on the farm; LSM = least square means

*Data are presented as least square means

^{A,B,a,b}Different letters in the column of FARM indicate statistical significance A, B = $P < 0.01$; a, b = $P < 0.05$; different letters in the column of SIRE BULL indicate statistical significance between bulls within individual farms A, B = $P < 0.01$; a, b = $P < 0.05$

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Table 4. Evaluation of the effect of the farm and nested effect of sire bulls on monitored parameters at 210 days of age*

FARM	BT 210	MUSCLE 210	LW 210	SIRE BULL	BT 210	MUSCLE 210	LW 210
1	$3.64^{A,a}$	$52.77^{A,a}$	280.95^{A}	1	3.67^{a}	52.61	279.87
				7	3.45^{A}	57.01^{A}	288.35
				8	3.68^{b}	52.39^{a}	272.58
				20	3.98^{B}	55.69	295.36
				26	3.86	56.34	275.59
				29	$3.47^{A,c}$	$51.30^{B,b}$	285.68
2	$3.87^{B,b}$	53.56^{A}	296.69	2	$3.75^{A,a}$	51.7	289.24
				4	3.98^{b}	54.07	296.75
				5	3.64^{A}	53.26	309.88^{A}
				9	4.13^{B}	57.35^{A}	307.36
				10	4.31^{B}	57.42^{A}	305.31
				20	3.8	54.83	298.83
				28	3.4^{A}	47.32^{B}	273.79^{B}
3	3.86^{b}	56.32^{b}	$321.38^{B,a}$	12	3.89	57.34^{a}	329.09^{A}
				20	3.71^{a}	57.29	337.13^{A}
				28	3.81	52.4^{b}	262.64^{B}
				35	4.01^{b}	56.29	313.31
4	$3.55^{A,a}$	53.55^{A}	288.34^{A}	3	3.54^{a}	52.94^{A}	273.79^{A}
				6	3.59^{a}	55.06	297.67
				11	3.18^{A}	51.13^{A}	265.88^{A}
				14	$4.27^{B,b}$	$63.23^{B,a}$	$343.92^{B,a}$
				16	3.55^{a}	51.74^{A}	299.47
				17	3.68	55.85	311.68
				19	3.36^{A}	49.21^{A}	287.51^{b}
				20	3.75	55.97	296.78
				21	3.81	56.77	311.3
				25	3.74	57.5	281.53^{b}
				31	3.64^{a}	54.6^{b}	260.73^{A}
				34	3.89	54.61^{b}	284.3^{b}
5	4.01^{B}	$57.34^{B,b}$	305.32^{B}	13	4.08^{A}	57.95	306.29
				20	4.14	58.65	295.15
				21	4.21	57.64	325.85^{a}
				26	3.5^{B}	57.34	281.18^{b}
				28	3.98	56.87	295.26
				36	3.79	56.7	314.75
6	3.99^{B}	57.79^{B}	287.65^{b}	7	3.85^{A}	$61.24^{A,a}$	216.44
				9	$4.65^{B,a}$	53.32^{B}	191.71^{A}
				14	3.54^{b}	56.93	276.41^{B}
				18	3.84	59.04	193.35^{A}
				20	3.49^{b}	$61.93^{A,a}$	308.89
				21	4.25^{B}	$61.13^{A,a}$	$333.77^{C,a}$
				22	3.88	55.12^{b}	291.16^{B}
				23	4.08	56.55^{b}	307.6
				24	4.01^{d}	59.43	317.19
				26	3.22^{C}	53.59^{B}	259.09^{b}
				27	4.33^{B}	56.5^{b}	$350.57^{C,a}$

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Table 4 to be continued

FARM	BT 210	MUSCLE 210	LW 210	SIRE BULL	BT 210	MUSCLE 210	LW 210
				15	3.67[a]	54.43	301.43
				18	3.78	54.83	306.28
				20	3.81	52.05	282.44[a]
7	3.77[b]	54.9[a]	301.01	26	4.22[b]	57.65[a]	274.86[a]
				30	3.86	56.57	317.66[b]
				32	3.63[a]	51.98[b]	279.98
				33	3.94	56.82	300.05

210 = 210 days of age; BT = backfat thickness; FARM = fixed effect of the farm; LSM = least square means; LW = live weight; MUSCLE = *musculus longissimus lumborum et thoracis* depth; SIRE BULL = nested fixed effect of the sire bull on the farm

*Data are presented as least square means

[A–C,a–c]Different letters in the column of FARM indicate statistical significance A, B = $P < 0.01$; a, b = $P < 0.05$; different letters in the column of SIRE BULL indicate statistical significance between sire bulls within individual farms A–C = $P < 0.01$; a–c = $P < 0.05$

Table 5. Evaluation of the effect of the farm and nested effect of sire bulls on monitored parameters at 365 days of age*

FARM	BT 365	MUSCLE 365	LW 365	SIRE BULL	BT 365	MUSCLE 365	LW 365
				1	5.25[A]	65.76[A]	438.71[A]
				7	3.81[B,a]	58.47[B,a]	368.9[B,a]
1	4.84[A]	64.03[A]	427.5[A]	8	4.94[b]	64.72	439.73[A]
				20	4.1[C]	61.17	366.57[B]
				26	4.43	63.18[b]	375.19
				29	4.21	64.05[b]	429.14[b]
				2	4.94	61.23[A]	498.44
2	4.87	64.87	491.45	9	5.04[a]	71.74[B]	511.95[A]
				10	4.21[b]	57.57[A]	437.48[B]
				3	4.96[a]	63.48[a]	428.35
				6	4.82	65.35	458.09[A]
				11	4.81	63.11	421.71
				14	4.44[b]	59.18[A,b]	438.47
				16	4.83	64.04	457.99[a]
4	4.75[A]	63.39[A,a]	436.08[A,a]	17	4.85	66.77[B]	462.81[A]
				19	4.35[b]	62.83	440.41
				20	4.40[b]	61.94	412.15
				21	5.02[A]	65.8[B]	435.48
				25	4.06[B]	61.63	404.62[B,b]
				31	4.88[a]	64.72[a]	417.15
				34	4.65[C]	62.06	400.23[B,b]
				13	5.29	73.18[A]	523.32[A]
5	5.12	68.74[b]	511.17[B]	20	4.75[a]	61.24[B,a]	456.74[B]
				26	5.18	67.52[b]	529.49[A]
				28	5.4[b]	66.71	511.63

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Table 5 to be continued

FARM	BT 365	MUSCLE 365	LW 365	SIRE BULL	BT 365	MUSCLE 365	LW 365
6	4.9^{a}	72.7^{B}	553.01^{B}	14	5.18	71.24^{a}	603.29^{a}
				18	5.07^{A,a}	72.66	524^{A}
				22	4.76^{A,b}	74.48	555.98^{A}
				23	6.3^{B}	83.20^{A,b}	664.79^{B,b}
				24	5.04^{A,a}	74.06	542.54^{A}
				26	5.26	69.89^{B}	510.1^{A}
7	5.73^{B,b}	63.03^{A,a}	466.74^{A,b}	15	5.69^{A}	63.46	490.63^{A,a}
				18	6.30^{A,a}	64.49^{a}	489.71
				20	3.81^{B}	54.78^{A,b}	352.87^{B}
				26	5.21^{b}	60.79	391.13^{b}
				30	5.88^{b}	64.87^{B}	493.76^{A,a}
				32	4.68^{C}	59.24	427.51^{b}
				33	6.25^{A}	64.79^{B}	464.17

365 = 365 days of age; BT = backfat thickness; FARM = fixed effect of the farm; LSM = least square means; LW = live weight; MUSCLE = *musculus longissimus lumborum et thoracis* depth; SIRE BULL = nested fixed effect of the sire bull on the farm

*Data are presented as least square means

[A–C,a–c]Different letters in the column of FARM indicate statistical significance A, B = $P < 0.01$; a, b = $P < 0.05$; different letters in the column of SIRE BULL indicate statistical significance between sire bulls within individual farms A–C = $P < 0.01$; a–c = $P < 0.05$

DISCUSSION

Ultrasound methods to assess meatiness and fatness (Duff et al. 2018) have been developed and used around the world for many years, as a prerequisite for prediction of breeding values (Lopes et al. 2016). In some countries, an assessment system for MUSCLE, BT and marbling have been in place for several years (Hassen et al. 2004; Breedplan 2020). Greiner et al. (2003) pointed out that ultrasonography can be used as an accurate tool for estimating carcass traits in live cattle. However, measurements should be taken by an experienced, well-trained staff, with only small differences in accuracy between years. As Barton et al. (2006) pointed out, meatiness and fatness are valued parameters in terms of monetization; therefore, the Czech Republic should seek to include a routine evaluation of these parameters into beef performance testing to allow estimation of breeding values like in the United Kingdom (Breedplan 2020).

In our study, the bulls achieved significantly higher weights and MUSCLE compared to the heifers, which was also observed in the study of Hassen et al. (2004). The effect of the year-season of calving significantly influenced our results, which is in accordance with many studies (Barton et al. 2006; Tousova et al. 2018). One of the reasons could be genetic progress as was suggested by the authors.

Carcass quality parameters are influenced by breeds of fattened cattle, used technology and other factors (Barton et al. 2006). We observed significant differences between individual farms, which was also shown in the study of Sri Rachma Aprilita Bugiwati et al. (1999). Sri Rachma Aprilita Bugiwati et al. (1999) found differences in BT and MUSCLE area in the local Japanese Brown cattle breed due to the year and season of calving. Our results also suggested that older cows are most suitable for production of fattened calves, which is probably caused by their maturity and adulthood (Cortes-Lacruz et al. 2017). On the other hand, younger cows are genetically better, but they are not fully able to achieve their genetic predispositions. These cows have less milk and smaller calves, but can provide faster genetic progress on a farm.

The effect of the farm and hence of the level of environmental factors, management and nu-

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trition on the growth ability of young cattle until the age of one year was confirmed by Taylor et al. (2018). Incidence of infections and diseases on individual farms in the test could also be an important factor, because it could negatively influence growth rate. Some individuals can be more resistant or were not exposed to a disease or an infection, and thus their growth is not negatively influenced by it. The growth of fully tolerant individuals is not affected, whereas the growth of sensitive ones decreases greatly (Kause and Odegard 2012).

The growth ability (MUSCLE, BT, LW) of calves significantly differed based on genetic predispositions of their fathers, which was also confirmed in Tousova et al. (2018) or on rams by Ptacek et al. (2018). This was further confirmed by the inheritance coefficients calculated by Bouquet et al. (2010). Moreover, these authors observed not only differences between carcass parameters of beef cattle breeds, but also numerous significant relationships between parameters of muscularity, weight and feed intake. Ultrasonography is a useful tool to attest heritability for certain traits of meatiness and fatness on live animals (Yokoo et al. 2008). In general, beef breeds vary in MUSCLE, BT and LW development due to the breed differences at the age of maturity (Meyer et al. 2005).

In our results, we characterized the growth curve of MUSCLE and BT depending on age and weight. Pires et al. (2017) also confirmed a positive relationship between weight after rearing and muscle development. In the study on the Blonde d'Aquitaine breed and Czech Fleckvieh crossbreds Stadnik et al. (2011) showed a significant influence of age, individualism, genetics, sex and birth season on MUSCLE development. In this study the authors measured MUSCLE area and loin dimensions, but these parameters were closely related to MUSCLE depth and its development during rearing. Hassen et al. (2004) found strong genetic (r = 0.91–0.97) and phenotypic (r = 0.64–0.85) correlations between ultrasound measurements at various ages (from 27 to 62 weeks) in the Aberdeen Angus breed. Pinheiro et al. (2011) pointed out the suitability of measuring BT and MUSCLE in younger animals for further estimation of breeding values. This corresponds with the possibilities of Czech farmers, when most animals are available for measuring during and right after rearing, which was true even of our experiment.

Many studies confirmed the relationship between growth ability parameters, BT, MUSCLE and meatiness, fatness, and/or meat quality (Bures and Barton 2012). There is no genetic antagonism between the longissimus muscle area and the backfat thickness. If those traits were introduced into breeding programs, they would quickly respond to the selection pressure (Yokoo et al. 2008). In addition, the selection for increased muscle mass in beef cattle has a cumulative positive effect on carcass yield and no negative effect on mineral content, pH decline or colour stability (McGilchrist et al. 2016).

Quality of beef and its variability are among the main problems of beef production. Consumer requirements for beef have increasingly shifted towards safety, high quality, nutritive value, and products from sustainable farming practices (Hocquette et al. 2014). Improved consumer trust, economic benefits and predictive relation to carcass yield/dressing percentage are the main reasons for developing quality evaluation systems for live animals (Tait 2016).

CONCLUSION

MUSCLE, BT and LW showed linear development with age, although MUSCLE and BT showed higher variations during the test compared to LW. Observed variations suggest that the inclusion of MUSCLE and BT monitoring might prove to be expedient for complex evaluation. Growth ability, meatiness and fatness (defined by MUSCLE, BT and LW) were affected by a number of effects during rearing. The results confirmed the effect of genotype on the monitored parameters. However, a strong effect of breeding environment was also confirmed when we observed significant differences in muscle development between sons from one father on different farms. From our results we can see that some breeding environments are more suitable for certain genotypes, which allows them to reach their full genetic potential for growth rate and carcass quality. For the development of MUSCLE and BT it is necessary to take into account epigenetic factors which would allow farmers to achieve better results for fattening and to improve their competitiveness. Our initial results created a prerequisite for further review of possible future application of MUSCLE and BT

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monitoring in the official breeding practice of the Czech Republic. Some European countries have already introduced such monitoring, therefore its inclusion in official Czech breeding practices would be advantageous for Czech farmers who often sell their beef in the European market.

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Conflict of interest

The authors declare no conflict of interest.

REFERENCES

Barton L, Rehak D, Teslik V, Bures D, Zahradkova R. Effect of breed on growth performance and carcass composition of Aberdeen Angus, Charolais, Hereford and Simmental bulls. Czech J Anim Sci. 2006 Feb 1;51(2):47-53.

Bouquet A, Fouilloux MN, Renand G, Phocas F. Genetic parameters for growth, muscularity, feed efficiency and carcass traits of young beef bulls. Livest Sci. 2010 Apr 1; 129(1-3):38-48.

Breedplan [Internet]. Amidale (Australia): Agricultural Business Research Institute. [2020]- [cited 2020 Aug 28]. Available from: https://breedplan.une.edu.au/about/what-we-do/.

Bures D, Barton L. Growth performance, carcass traits and meat quality of bulls and heifers slaughtered at different ages. Czech J Anim Sci. 2012 Jan 1;57(1):34-43.

Cortes-Lacruz X, Casasus I, Revilla R, Sanz A, Blanco M, Villalba D. The milk yield of dams and its relation to direct and maternal genetic components of weaning weight in beef cattle. Livest Sci. 2017 Aug 1;202:143-9.

Duff C, van der Werf JHJ, Parnell PF, Clark SA. Comparison of two live-animal ultrasound systems to predict carcass intramuscular fat and marbling in Australian Angus cattle. In: Proceedings of the 11th World Congress on Genetics Applied to Livestock Production. Auckland (New Zealand): Massey University; 2018. 4 p.

Emenheiser JC, Tait RG Jr, Shackelford SD, Kuehn LA, Wheeler TL, Notter DR, Lewis RM. Use of ultrasound scanning and body condition score to evaluate composition traits in mature beef cows. J Anim Sci. 2014 Sep 1; 92(9):3868-77.

Greiner SP, Rouse GH, Wilson DE, Cundiff LV, Wheeler TL. The relationship between ultrasound measurements and carcass fat thickness and longissimus muscle area in beef cattle. J Anim Sci. 2003 Mar 1;81(3):676-82.

Hassen A, Wilson DE, Rouse GH, Tait RG Jr. Partitioning variances of growth in ultrasound longissimus muscle area measures in Angus bulls and heifers. J Anim Sci. 2004 May 1;82(5):1272-9.

Hocquette JF, Van Wezemael L, Chriki S, Legrand I, Verbeke W, Farmer L, Scollan ND, Polkinghorne R, Rodbotten R, Allen P, Pethick DW. Modelling of beef sensory quality for a better prediction of palatability. Meat Sci. 2014 Jul 1;97(3):316-22.

Kause A, Odegard J. The genetic analysis of tolerance to infections: A review. Front Genet. 2012 Dec 14;3: 9 p.

Krupova Z, Krupa E, Wolfova M. Economic weights of current and new breeding objective traits in Aberdeen Angus. Czech J Anim Sci. 2020 Mar 31;65(3):77-85.

Lopes FB, da Silva MC, Magnabosco CU, Narciso MG, Sainz RD. Selection indices and multivariate analysis show similar results in the evaluation of growth and carcass traits in beef cattle. PloS One. 2016 Jan 20;11(1): 21 p.

Mazzucco JP, Goszczynski DE, Ripoli MV, Melucci LM, Pardo AM, Colatto E, Rogberg-Munoz A, Mezzadra CA, Depetris GJ, Giovambattista G, Villarreal EL. Growth, carcass and meat quality traits in beef from Angus, Hereford and cross-breed grazing steers, and their association with SNPs in genes related to fat deposition metabolism. Meat Sci. 2016 Apr 1;114:121-9.

McGilchrist P, Greenwood PL, Pethick DW, Gardner GE. Selection for increased muscling in Angus cattle did not increase the glycolytic potential or negatively impact pH decline, retail colour stability or mineral content. Meat Sci. 2016 Apr 1;114:8-17.

Meyer DL, Kerley MS, Walker EL, Keisler DH, Pierce VL, Schmidt TB, Stahl CA, Linville ML, Berg EP. Growth rate, body composition, and meat tenderness in early vs. traditionally weaned beef calves. J Anim Sci. 2005 Dec 1; 83(12):2752-61.

Moravcikova N, Kasarda R, Vostry L, Krupova Z, Krupa E, Lehocka K, Olsanska P, Trakovicka A, Nadasky R, Zidek R, Belej L, Golian J. Analysis of selection signatures in the beef cattle genome. Czech J Anim Sci. 2019 Dec 22; 64(12):491-503.

Nogalski Z, Pogorzelska-Przybylek P, Bialobrzewski I, Modzelewska-Kapitula M, Sobczuk-Szul M, Purwin C. Estimation of the intramuscular fat content of m. longissimus thoracis in crossbred beef cattle based on live animal measurements. Meat Sci. 2017 Mar 1;125:121-7.

Pinheiro TR, Mercadante MEZ, Albuquerque LG, Cyrillo JNSG, Branco RH. Phenotypic and genetic parameters

https://doi.org/10.17221/274/2020-CJAS

compared during repeated measures of longissimus muscle area and subcutaneous fat thickness in Nelore cattle. Genet Mol Res. 2011 Nov 29;10(4):2944-52.

Pires BC, Tholon P, Buzanskas ME, Sbardella AP, Rosa JO, da Silva LOC, de Almeida Torres RA Jr, Munari DP, de Alencar MM. Genetic analyses on bodyweight, reproductive, and carcass traits in composite beef cattle. Anim Prod Sci. 2017 Feb 24;57(3):415-21.

Ptacek M, Duchacek J, Schmidova J, Stadnik L. Response to selection of a breeding program for Suffolk sheep in the Czech Republic. Czech J Anim Sci. 2018 Jul 29; 63(8):305-12.

Sri Rachma Aprilita Bugiwati TD, Harada H, Fukuhara R. Effects of genetic and environmental factors on ultrasonic estimates of carcass traits of Japanese Brown cows. Asian-Australas J Anim Sci. 1999 Jun 1;12(4):506-10.

Stadnik L, Dvorakova J, Louda F. The intensity of MLLT area changes and development of the selected body parts muscling in bulls and heifers of Blonde d'Aquitaine cattle and its crossbreeds during rearing period. Iran J Appl Anim Sci. 2011 Sep 1;1(3):155-60.

Tait RG Jr. Ultrasound use for body composition and carcass quality assessment in cattle and lambs. Vet Clin Food Anim Pract. 2016 Mar 1;32(1):207-18.

Taylor RF, McGee M, Kelly AK, Grant J, Crosson P. A comparison of production systems and identification of profit drivers for Irish suckler beef farms. Int J Agric Manag. 2018 Jan 1;6(3-4):100-10.

Tousova R, Duchacek J, Gasparik M, Ptacek M, Kitzler L. Analysis of growth intensity and carcass characteristics of WagyuAberdeen Angus crossbred steers. Acta Univ Agric Silvic Mendelianae Brun. 2018 Aug 31;66(4):897-903.

Venot E, Fouilloux MN, Forabosco F, Fogh A, Pabiou T, Moore K, Eriksson JA, Renand G, Laloe D. Beef without borders: Genetic parameters for Charolais and Limousine interbeef genetic evaluation of weaning weights. Interbull Bulletin. 2009;40:55-60.

Weber KL, Thallman RM, Keele JW, Snelling WM, Bennett GL, Smith TPL, McDaneld TG, Allan MF, Van Eenennaam AL, Kuehn LA. Accuracy of genomic breeding values in multibreed beef cattle populations derived from deregressed breeding values and phenotypes. J Anim Sci. 2012 Dec 1;90(12):4177-90.

Yokoo MJ, Albuquerque LG, Lobo RB, Bezerra LAF, Araujo FRC, Silva JAV, Sainz RD. Genetic and environmental factors affecting ultrasound measures of longissimus muscle area and backfat thickness in Nelore cattle. Livest Sci. 2008 Sep 1;117(2-3):147-54.

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