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EVALUATION OF BODY MEASUREMENTS OF LIMOUSIN HEIFERS IN SOME WESTERN HUNGARIAN FARMS

JÁNOS TŐZSÉR[1], RITA VERTSÉNÉ ZÁNDOKI[2]*, ANDREA KOSZTOLÁNYINÉ SZENTLÉLEKI[2], BENCE TARR[3], MÁRTON SZŰCS[4]

[1] Albert Kázmér Faculty of Agricultural and Food Sciences of Széchenyi István University
Department of Animal Science**,** Mosonmagyaróvár, Hungary
ORCID: https://orcid.org/0000-0002-5632-1765
[2]Hungarian University of Agriculture and Life Sciences, Szent István Campus
Institute of Animal Husbandry, Gödöllő, Hungary
e-mail: vertsene.zandoki.rita@uni-mate.hu, ORCID: https://orcid.org/0009-0007-8097-4196
ORCID: https://orcid.org/0009-0005-1319-5315
[3]Hungarian University of Agriculture and Life Sciences, Szent István Campus
Institute of Technical Sciences Gödöllő, Hungary
ORCID: https://orcid.org/0009-0004-1790-9234
[4]Association of Hungarian Limousin and Blonde d' Aquitaine Breeders, Budapest, Hungary

*Levelező szerző/Corresponding author

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ABSTRACT

Body weight and body measurements are important economic traits in beef cattle sector and can be used as selection factors. At young ages they give information on the maturity of the animals. Body measurements (withers height, tail height, width at shoulders, back length, width at hip bones, pin width) of Limousine heifers (n=313; age: 429.2 days) were taken on six Transdanubian farms in Hungary by skilled technicians with standardized equipment under appropriate conditions. Statistical analysis was made by SPSS 24.0. Normal distribution of data was confirmed by Shaphiro-Wilks test. The GLM model was focused on the intercept, the effect of herds (n=1 to 6) and covariant factors (age or live weight). The results showed that body measurement data of heifers in the same region can be evaluated by GLM which contains the effect of herd and age or weight as covariant. All components involved in the models were proven to have significant effects ($P<0.001$). Regarding their age, heifers of all herds were adequately developed both in live weight (69.6%) and height measurements (84-93%) compared to reference values of mature cows, ensuring a strong basis for successful breeding work in the future. The farm with the heaviest (505.7 kg) heifers had lower values for withers- (118.8 cm) and tail height (127.8 cm), and narrower shoulder (30.6 cm) which draws attention to the fact that large weight is not necessarily paired with a large frame.
Keywords: body measurements, Limousin breed, heifers, GLM model

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INTRODUCTION

Origin of Limousin breed

In the opinion of most researchers, Limousin cattle originated in France: carvings found in Lascaux cave, near Montignac (a small town situated on the Vézère river and has been the capital of the canton of Montignac since 1790) are very similar to the present appearance of Limousin breed.
The place of origin is the west of the French Highlands, between Middle and Southwest France, a region that has both disadvantageous climate and poor-quality granite soil (The Cattle Site, 2022). As a result of the harsh environmental conditions and the unique mineral content of the soil, a tough, resistant breed was developed, with a fine structure, but steady physiology.
The local, reddish colour variant grew popularity mostly around the hills of Limoges. That area is the „Limousin public administration unit" presently.
Cattle from that area were called Limousin from the XVIIIth century. The conformation of the population was quite homogenous already at that time: animals were horned, had large frame, and had a bit coarser bone than nowadays. Cattle of the breed were mainly used for draught for a long time, consequently, the main selection aim was body size and physical strength which led to a large framed, well-muscled phenotype. Bulls of the breed were crossed with local dairy cows, to produce calves with good fattening ability (Dohy, 1985; Szabó, 1998).
Limousin cattle have fine and strong bone structures which ensures an excellent slaughter value at every age (Dervillé, Patin, & Avon, 2009). The average adult weight of cows is 650 kg. Bulls weigh 1000 kg on average. They are characterized by small and short head and wide foreheads; wide, well-muscled loins and backs. Calvings are easy.
Quality of beef is excellent: it is fine fibered, low fat contented, although well-marbled. In the Trophy of Quality by Blind Taste Limousin was the first prize winner in 1991 and 1992. The average carcass ratio is 62-65%, with 75% meat content – due to the light bones and low fat content.
Table 1 describes the different marketing types of Limousin cattle in their country of origin (France Limousin Sélection, 2020).

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Table 1 Types of marketing beef cattle in the breed in France

Type of the beef cattle	Slaughter age (months)	Live weight (kg)	Carcass weight (kg)
Milk-fed calf / bobby calf	3–4	180–230	120-150
Aveyron calf beef	8-10	350–450	230 – 290
Fattening cattle younger than a year	11–12	510–520	320
Lyon calf	13-16	500-600	320-380
Young bull	16–17	615-650	380–400
Saint-Etienne heifer	12-15	315–400	200–260
Lyon heifer	18–24	425-500	270-320
Fattened heifer	26–36	more than 600	more than 350
Reform cow	more than 36	more than 600	more than 350

Body conformation of Limousin heifers and cows

Body weight and body measurements are important economic traits in beef cattle sector and can be used as selection factors. At young ages they give information on the maturity of the animals, and also can be used to calculate indexes for the assessment of proportions of different body parts, as well as to estimate beef production (Bene et al, 2007; Ulutas, Saatci, & Ozluturk, 2001; Nogalski, 2003; Litwinczuk and Szulc, 2005; Przysucha, Grodzky, Gobiewsky, Slósarz, & Piottrowsky, 2012). In case of Normande breed – selected for both milk and beef production – all pieces of information promoting estimation of beef producing ability, such as tail height, rump width, muscularity of back and round are evaluated and used in breeding work which draws the attention to the importance of taking body measurements (Vallée and Valais, 2019).

The heritability of body measurements is comparatively high (0.37–8.88) (Szabó, 1998; Arango, Cundiff, & VanVleck, 2002; Bene et al, 2007) resulting in an efficient selection.

Przysucha, Grodzky, Gobiewsky, Slósarz, & Piottrowsky (2012) reported the following body measurements (cm) for adult Limousin cows of different ages: chest circumference 199±12.8; body length 133±9.9; withers height 139±4.7; height at sacrum 135±4.6; hip width 54±4.3; width at pins 25±3.0; rump length 55±3.4 cm).

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On a French database (n=2751) Phocas et al (2006) reported 363±32.9 kg as yearling weight for Limousin heifers. The phenotypic variance was 904 kg. Age at puberty was 470.4±36.5 days (n=2254) and cows weighed 503.3±47.7 kg (n=1540) at first calving.
Karamfilov, Nikolov, & Malinova (2019) studied body conformation and development of Limousin cows born in Austria, France and Bulgaria. Generally, animals had deep and wide body, well-muscled chest and rump and relatively thin bones. Cattle imported from Austria were the largest. No significant differences were found between conformation parameters of cattle originating from France and Austria. Limousin calves were adequately mature at the age of 1 year: reached 93-95% of adult height, 90% of cross body length and 95% of chest circumference.
Ozkaya, Neja, Krezel, Czopek, & Oler (2015) reported body measurement (taken by traditional and video image analysis /VIA/ methods) and live weight results for adult Limousin cows (n=56) of various ages (*Table 2*).

Table 2 Body measurements of Limousin cows (n=56) by traditional and VIA method (Ozkaya, Neja, Krezel, Czopek, & Oler, 2015)

Parameter	Traditional measurement	VIA
Body weight, kg	616.7±21.3	–
Withers height, cm	127.9±1.3	128.9±1.3
Body length, cm	164.3±2.1	165.6±1.8
Chest girth, cm	69.1±0.9	70.5±0.9
Hip height, cm	132.9±1.3	133.8±1.3
Body area, cm^2	–	17223±1371

In comparison of the traditional and VIA body measurement results, the accuracy was 98% for withers height, 97% for hip height, 94% for chest depth and 90.6% for body length. Using regression analysis, R^2=61.5% was found when analysing regression between body surface and live weight. The regression equation including all VIA measurement traits had 88.7% reliability when estimating body weight. Despite the fact that the equipment and software for image processing have become cheaper, VIA method has not become widespread in the practice of taking cattle body measurements. Ashmawi, Alharbi, Almaghrabi, & Alhothal (2019) proposed a model that estimates human body measurements from human real-time pictures using the Haar Cascade classifier and support vector machines.
Bene et al (2007) studied body measures of cows belonging to nine beef cattle breeds kept in Hungary (n=110). According to their results, Limousin cows were longer and wider (e.g. rump length and pin width) compared to other breeds. They have calculated strong positive correlations between live weight and body measures (r=0.4–0.83).
Data of Limousin cows are presented in *Table 3*.

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Table 3 Body measurements of Limousine cows (n=9; Bene et al, 2007)

Trait	Mean	SD
Age, year	5.53	1.08
Live weight, kg	591	75.51
Height at withers, cm	138.0	2.65
Tail height, cm	143.3	3.32
Body length, cm	148.3	9.04
Rump length, cm	47.4	8.08
Withers width, cm	51.4	2.60
Pin width, cm	23.0	1.73
Head length, cm	50.4	3.28
Head width, cm	18.7	1.12

The aim of the present study was the evaluation of main body measurements and maturity of yearling Limousin heifers in Western regions of Hungary.

MATERIAL AND METHODS

Origin of data

A couple of years ago, the Association of Hungarian Limousin Cattle Breeders modified its breeding program, according to which, body measurements of yearling Limousin heifers were taken in the Western regions of Hungary (6 nucleus farms: Veszprém County: 1, 3, 6; Zala County: 4; Tolna County: 5; Bács-Kiskun County: 2) with individuals of 39-70; n=313 altogether.

Distribution of grasslands (Nagy and Tasi, 2017), suckler cow population, pasture area estimated based on the pasture support applications (Nagy and Tasi, 2017) imply that Transdanubian grasslands differ from TransTiszanian region, which is also supported by results of multiple potential natural vegetation model (Somodi et al, 2017). Being in the Transdanubian area, the six farms involved in the present evaluation are comparable with each other.

Body measurements were taken by skilled technicians with standardized equipment under appropriate conditions (plain concrete floor, fixing animals in corridor). The methods of measurement are described in *Table 4*.

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Table 4 Methods for taking body measurements

Body measurement	Measuring points	Equipment
Withers height	horizontal distance between the ground and the withers	measuring stick
Tail height	horizontal distance between the ground and the hip bone	measuring stick
Length of back	distance between the withers and the loin	tape measure
Width of shoulders	width at the widest point of the withers	measuring stick
Width at hip bone	distance between the two points of hip	measuring stick
Pin width	distance between the two ischium	measuring stick

Reference cow weight and body measurements were 600 kg (LBTE) and reference values for withers height (138 cm), tail height, (143 cm), pin width, (23 cm) 138; 143; and 23 cm, respectively (Bene et al, 2007).
Age and live weight of Limousin heifers are summarized in *Table 5*.

Table 5 Age and live weight of Limousin heifers in some Western Hungarian farms

Traits	No. of Herds	N	Mean values	Std. Deviation
Age, days (AG)	1	47	406,8	10,58
	2	70	423,9	27,04
	3	62	431,7	38,56
	4	43	481,4	28,26
	5	52	392,9	58,40
	6	39	452,6	32,41
	Total	313	429,2	44,81
Live weight, LW (kg)	1	47	329,8	43,33
	2	70	502,8	50,86
	3	62	404,4	45,90
	4	43	412,4	51,39
	5	52	378,4	57,43
	6	39	451,4	32,06
	Total	313	417,8	74,19

Statistical analysis
Statistical analysis was made by SPSS 24.0. Normal distribution of data was confirmed by Shaphiro-Wilks test. The GLM model was focused on the intercept, the effect of herds (n=1 to 6) and covariant factors (age or live weight). The null hypothesis of Levene's test was that the error variance of the dependent variable is equal across groups. The null hypothesis of the Lack of fit test was that data fit well to the model.

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The F tests were based on the linearly independent pairwise comparisons among the estimated marginal means. In adjustment for multiple comparisons, Bonferroni method was used, at level 0.05. Diagrams (excel) were used to illustrate tendencies.

RESULTS AND DISCUSSION

Mean live weight of heifers (417.8 kg) was 69.6% of the reference cow weight. Regarding age of heifers (429 days), this implies an adequate development.
Table 6 introduces the effects revealed by GLM model for different body measurement parameters.

Table 6 Results of the univariate analysis of variance (GLM) for traits of Limousin heifers in same Western Hungarian farms (n=313)

Dependent parameters	Levene's test	Test of between-subjects effects				Lack of fit test	R^2 %
		Intercept	Herd	Age[1]	Live weight[1]		
Live weight, LW (kg)	n.s.	P≤0.001	P≤0.001	P≤0.001	-	n.s.	66
Withers height, WH, cm	P≤0.001	P≤0.001	P≤0.001	-	P≤0.001	n.s.	67
Tail height, TH (cm)	P≤0.001	P≤0.001	P≤0.001	-	P≤0.001	n.s.	65
Length of back, LB (cm) I.	P≤0.001	P≤0.001	P≤0.05	-	P≤0.001	P≤0.05	47
Length of back, LB (cm) II	P≤0.001	P≤0.001	P≤0.001	P≤0.001	-	n.s.	30
Width of shoulders, WS (cm)	P≤0.001	P≤0.001	P≤0.001	-	P≤0.001	n.s.	38
Width at hip bone, WHB (cm)	P≤0.001	P≤0.001	P≤0.001	-	P≤0.001	n.s.	42
Pin width, WP (cm)	P≤0.001	P≤0.001	P≤0.001	-	P≤0.001	n.s.	40

[1]=covariant effect,***=P<0.001, **=P<0.01, *=P<0.05

Regarding Levene test, null-hypothesis was accepted only in the case of live weight, for the other parameters, error variances between groups differed significantly (P<0.05). Significant effect of herd, and covariance effects of age (429.2 days), or weight (417.8 kg) were proven for all body measurements. Data fitted well to the models in all cases except length of back (covariant: live weight). For back length, a further evaluation was carried out, in which age was present as a covariant factor. In this case, data fitted correctly. R^2% values were changeable by parameters (30-67%). Comparatively high values (R^2%≥65) were observed for weight, withers height and tail height. Mean values obtained by the models are plotted on *Figures 1-8* by herds. *Figure 1* visualizes live weight values. The grand mean was 411.9. kg. Pairwise comparison revealed statistically significant

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(P<0.001) between herds, except for pairs of farms 3-4, and 3-5. Large differences in weight (163 kg) were observed between farms 1 and 2. Farm 2 had the highest mean for live weight of heifers, while farm 1 had the lowest. It is obvious that among contemporary heifers, larger ones reach sexual maturity earlier and calve earlier.

The mean daily gain of the 313 heifers was 0.97 kg. Values for farms 1-6 were 0.81; 1.19; 0.93; 0.85; 0.98; 0.99 kg, respectively. These imply that different herds were adapting to their possibilities and reared heifers with growth rates adjusted to their breeding goals.

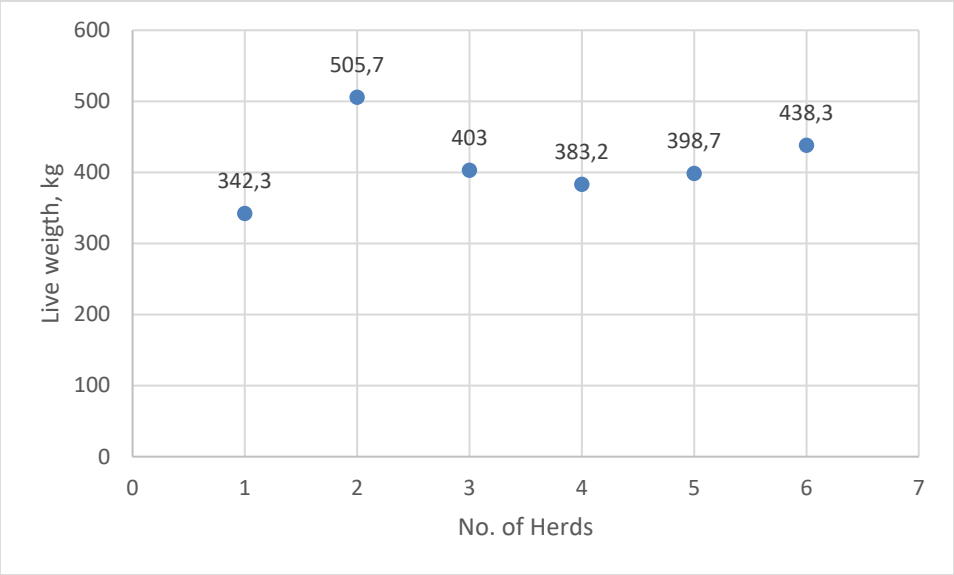

Figure 1 Estimated marginal means of live weight in herds

Withers height of heifers is shown in *Figure 2*. The grand mean for all heifers (n=313) was 120.4 cm. The mean values of farms 2, 3 and 5 were below the grand mean; while the rest three farms (1; 4; 6) were above it. However, in the pairwise comparison farms 1-4; 1-6; and 2-5 did not differ, differences were significant in all other combinations (P<0.001).

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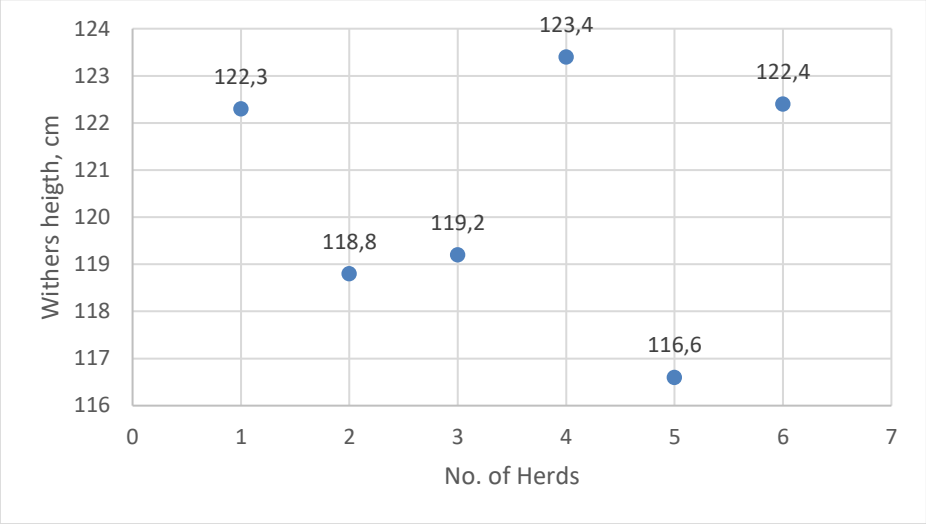

Figure 2 Estimated marginal means of withers height in herds

Figure 3 introduces heifers' tail height values in the examined herds (grand mean: 129.8 cm). It is well marked that tendency is similar to what was experienced in withers height, which – regarding the close positive correlation between these traits – is not surprising. Remarkably**,** comparatively large height sizes (withers: 122.3 cm; tail: 131.9 cm) were measured in herd 1, where heifers had the lowest live weight (342.2 kg). This implies that heifers with large live weights are not taller (e.g. farm 2: live weight 505.7 kg, tail height 118.8 cm). Under similar conditions, the same weight can be achieved either by thick set or large framed animals. In pairwise comparison differences in tail height were not significant in the case of farms 1-4; 1-6; 2-3; 2-5; and 4-6.

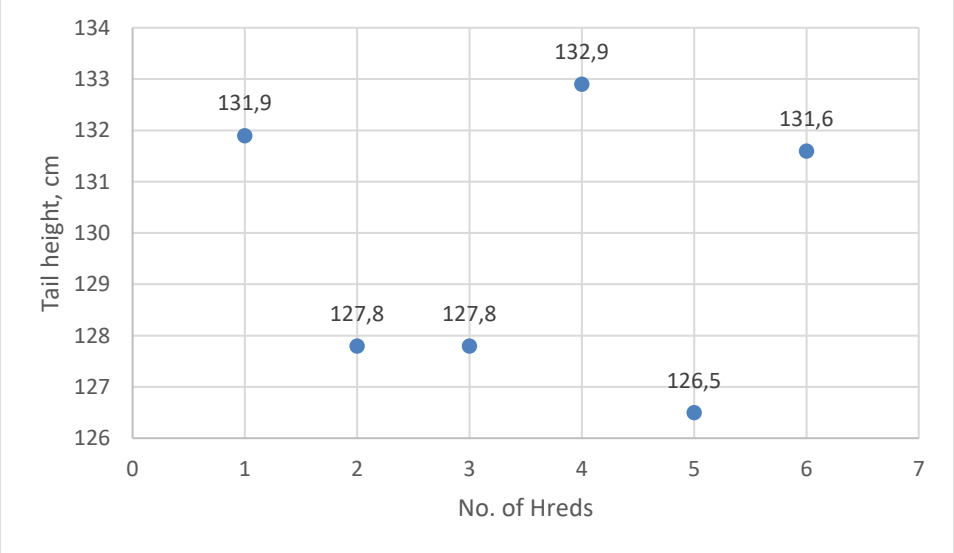

Figure 3 Estimated marginal means of tail hight in herds

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Back length (*Figure 4*) has been an important parameter recently since breeders more and more tend to prefer cattle with longer bodies. In this trait, live weight as a covariant was involved in the evaluation involved (grand mean: 71.2 cm). Heifers were observed to be the shortest on farm 2 (70.4 cm) and the longest on farms 3 and 4 (72.3 cm).
When age as a covariant was included in the model (*Figure 5*), a different tendency was revealed than on Figure 4. Grand mean was 70.9 cm. In this case, estimated back length (74.9 cm) was the largest on farm 2 with the largest heifers, and the lowest on farm 1 (67.4 cm). No significant differences were found between farms 1-5, 3-4, 3-5, 3-6, 4-3, 4-5, and 4-6.

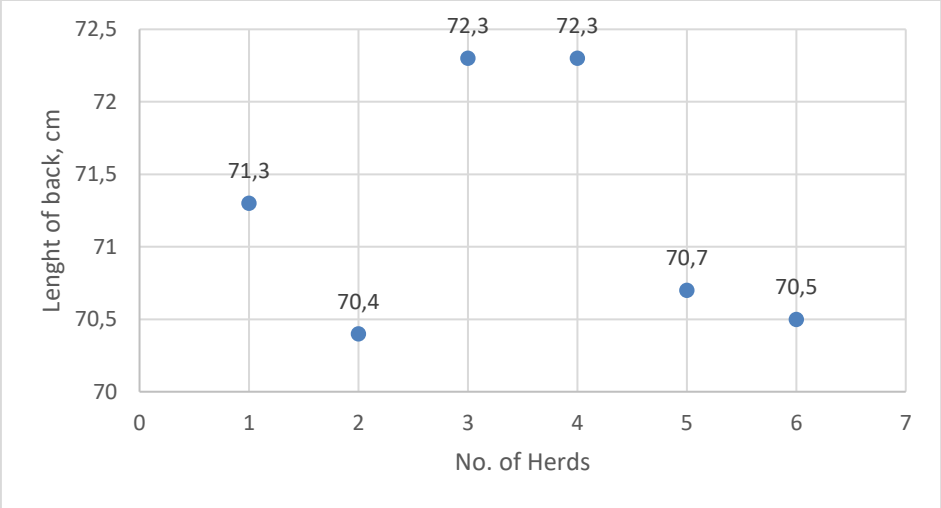

Figure 4 Estimated marginal means of length of back I in herds
[1]=covariant effect: live weight, kg

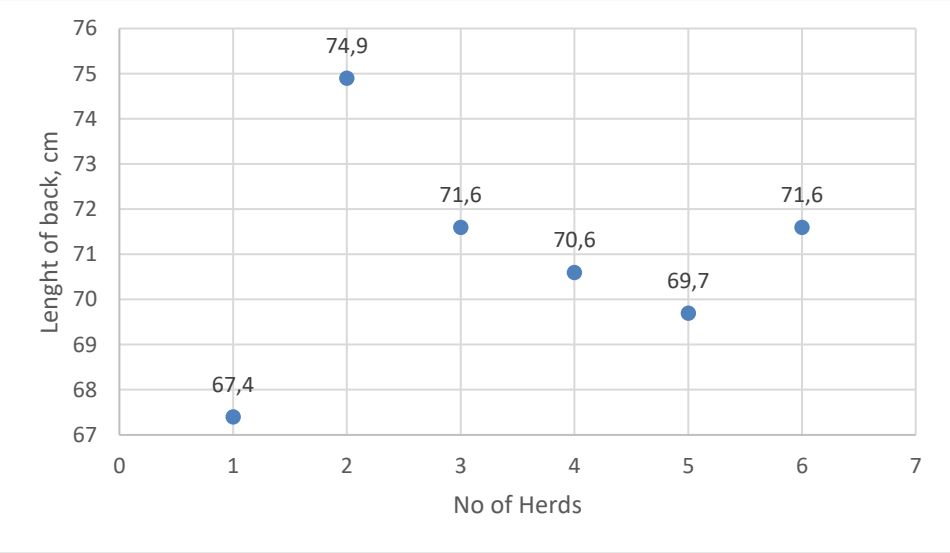

Figure 5 Estimated marginal means of length of back II in herds
[1]=covariant effect: age, days

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Figures 4 and 5 confirm that the involvement of age or live weight in the GLM evaluation gives different results.

The width of the shoulders (*Figure 6,* grand mean: 31.3 cm) is important for correct muscularity. Heifers on farm 2 that were the heaviest in weight had the narrowest shoulder (30.6 cm) while those on farm 4 the widest (33.4 cm). Farm 4 had higher shoulder width values than all other farms (P≤0.001).

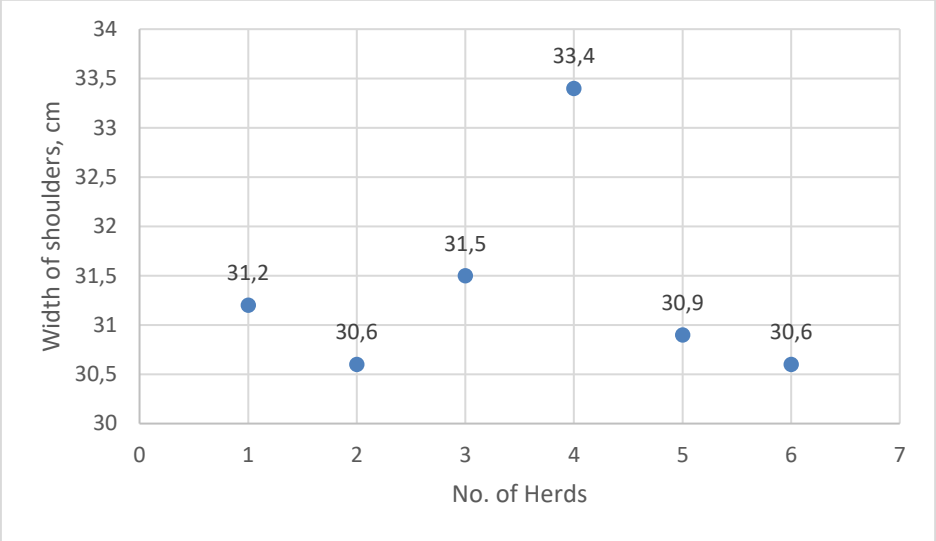

Figure 6 Estimated marginal means of width of shoulders in herds

Width at the hip bone has an influence both on calving ease and muscularity (*Figure 7,* grand mean: 39.6 cm). This trait is easy to evaluate by type classification scoring. The lowest values for this parameter were observed on farm 2, with a mean value of 37.9 cm which is significantly (P<0.001) lower than values of farms 3, 4, 5, and 6. Means of all other farms were statistically similar.

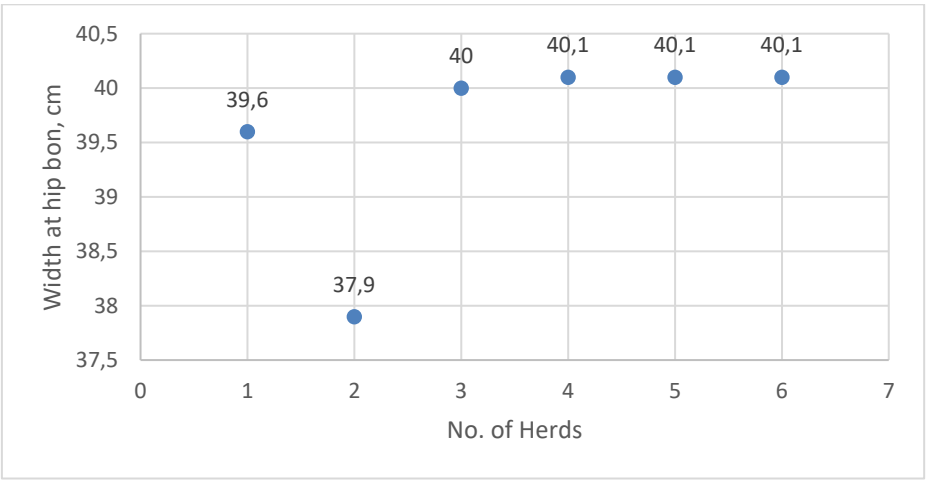

Figure 7 Estimated marginal means of width at hip bone in herds

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The results for pin width are summarized in *Figure 8*. Grand mean was 15.4 cm. Five farms (farm 1-5) had similar values, while pin width of heifers on farm 6 was lower than all others (15.7 cm; P≤0.001. Pin width is important for calving ease, however, in the case of heifers with over condition it can be difficult to be scored in type classification.

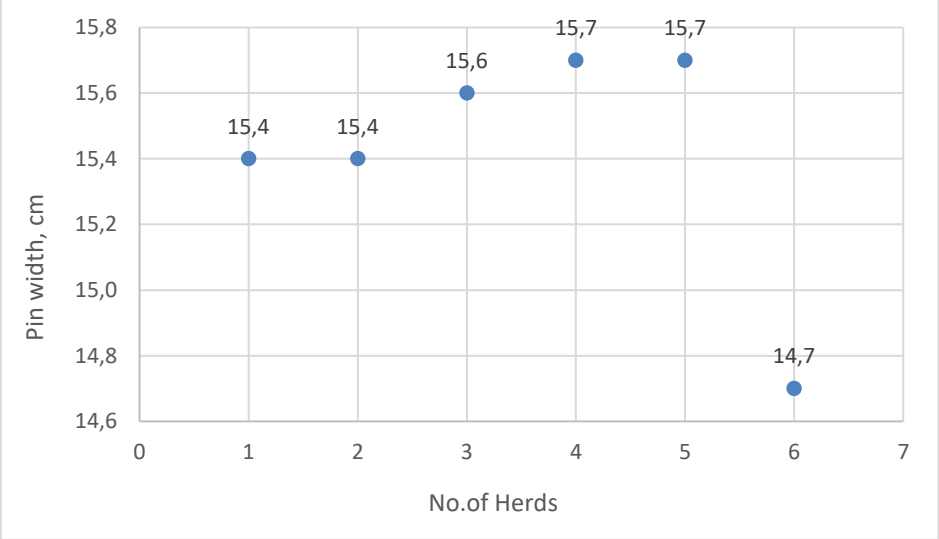

Figure 8 Estimated marginal means of pin width in herds

No data were found on body measurements of Limousin heifers, so mature cows' data were taken as references (Bene et al, 2007). *Figure 9* shows differences (%) of the examined herds compared to the reference values for withers height, tail height and pin width. In the case of withers height and tail height, heifers on different farms reached 84-89% and 88-93% of mature size respectively, implying an appropriate development. Pin width had 64-68% of the reference value for mature cows; it is expected to grow later with age.

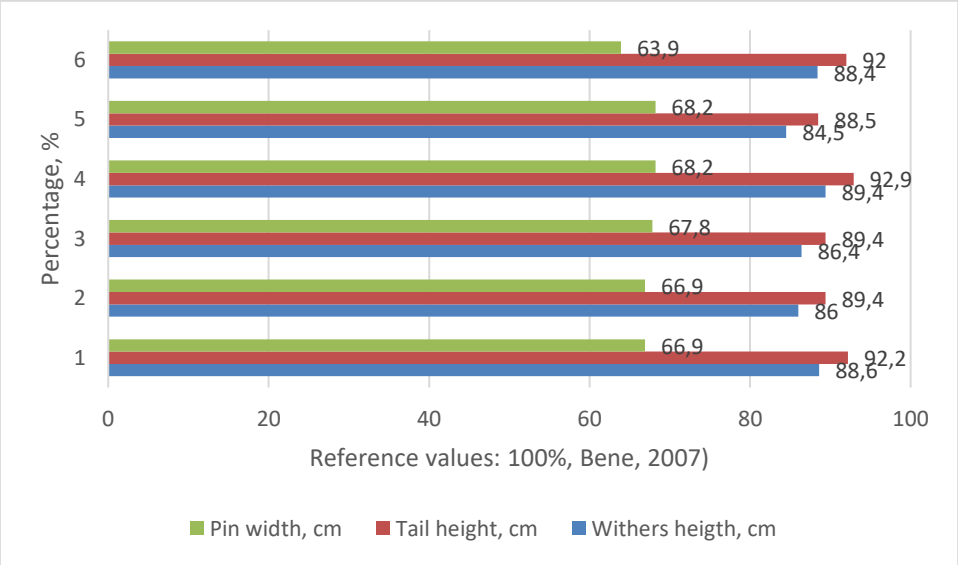

Figure 9 Body measurements compared to the reference values

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CONCLUSIONS

Analyzing the body measurements of n=313 Limousine heifers on six Transdanubian Hungarian farms, the following results are worth to be highlighted:

- Body measurement data of heifers in the same region can be evaluated by GLM which contains effect of herd and age or weight as covariant. All components involved in the models were proven to have significant effects.
- Heifers of all herds were adequately developed compared to reference values of mature cows, ensuring a strong basis for successful breeding work in the future.
- Data of farm 2 (n=70, large weight, lower values for withers and tail height, narrower shoulder) draws attention to the fact that large weight is not necessarily paired with a large frame.

LIMOUSIN ÜSZŐK TESTMÉRETEINEK ÉRTÉKELÉSE NÉHÁNY NYUGAT-MAGYARORSZÁGI GAZDASÁGBAN

ÖSSZEFOGLALÁS

A testméretek és az élősúly a húsmarhatenyésztésben gazdaságilag jelentős értékmérő tulajdonságok. Fiatal állatok esetén információt adnak az egyedek fejlettségéről. A szerzők 313, átlagosan 429,2 nap életkorú Limousine üsző testméreteit (marmagasság, farmagasság, vállszélesség, háthosszúság, csípőszélesség, ülőgumók közti távolság) és élőtömegét értékelték hat Tiszántúli tenyészetben. A testméretek felvétele képzett technikusok által, standardizált eszközökkel, a szakma szabályai szerinti körülmények közt történt. A statisztikai értékelést SPSS 24.0 programmal végezték. Az adatok a Shaphiro-Wilks teszt eredménye szerint normál eloszlásúak voltak minden tulajdonság esetében. A GLM modell a következőket tartalmazta: ordinátatengely-metszet, tenyészet hatása (n=1-6) és kovariáns hatások (életkor vagy testtömeg). Az eredmények arra utaltak, hogy az azonos régióban levő üszők testméretei jól értékelhetők GLM használatával, amelyben hatásként a tenyészet, kovariánsként pedig a kor vagy súly szerepel. A modellbe épített minden tényező hatása szignifikánsnak bizonyult (P<0,001). Az életkorukat figyelembe véve, minden tenyészet üszői megfelelő fejlettséggel rendelkeztek a kifejlett tehenekre jellemző értékekhez hasonlítva mind élőtömeg (69,6%), mind testméretek (84-93%) tekintetében, amely alapján jó alapnak bizonyulnak a jövőbeli sikeres tenyésztői munkához. A legnagyobb testtömegű üszőkkel rendelkező állomány (505,7 kg) esetében a többihez képest alacsonyabb marmagasság (118,8 cm) és farmagasság (127,8 cm) értékeket, illetve keskenyebb vállszélességet (30,6 cm) tapasztaltak, amely felhívja a figyelmet arra, hogy a nagy tömeg nem feltétlenül párosul nagy rámával.
Kulcsszavak: testméretek, Limousin fajta, üszők, GLM eljárás

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