EFFECT OF CONFORMATION TRAITS ON LONGEVITY OF DAIRY COWS IN LATVIA

Lāsma Cielava, **Daina Jonkus**, **Līga Paura**
Latvia University of Agriculture
lasma.cielava@llu.lv

Abstract
Cow lifespan is one of most important economical traits in every dairy farm and is affected by different environmental factors. One of genetic factors that affects longevity is cow conformation traits, which varies within different breeds, farms and animals. The aim in this study was to determine how stature and linear conformation traits affect cow lifespan and lifetime milk productivity. In the study, data about 34806 crossbred Holstein Black and White and 38201 Red cow group breed cows, which ended at least one full lactation and was culled from 2002 – 2012 year were analyzed. Data about cow productivity and culling was obtained from Latvian Agricultural Data center. In the study, data about cow stature, udder depth, central ligament, teat length, and rear and front teat placement were analyzed. Conformation traits were distributed in 3 groups. The average lifespan of analyzed cows was 1869.9 days in which average 18550.8 kg energy corrected milk (ECM) was obtained. Holstein Black and White cows characterize with shorter lifespan (1833.7 days) than red breed group cows, but lifetime productivity is for 2339.1 kg ECM higher than for average red breed cow. Significantly longer ($p<0.05$) lifespan – 2031.6 days was in cow group with stature 100 – 135 cm, but in cow group with stature more than 146 cm there is significantly higher lifetime and life day productivity. There is a significant difference between lifetime milk productivity and rear and front teat placement. Significantly higher productivity was given by cows with teat placement inside of quarter (linear evaluation 6- 9 points).
Key words: conformation traits, longevity, milk productivity.

Introduction

The term 'longevity' is usually referred to lifespan which ends by natural causes in old age, but nowadays in our intensive farming systems cow lifespan is significantly shorter than its potential. There is a significant amount of costs that covers heifer rearing process, and there is a possibility to avoid them by increasing herd lifespan. Breeders in many countries have recognized the economic importance of longevity, have calculated genetic parameters of longevity and have included them in dairy cattle breeding programs. Cow longevity is mainly affected by different environmental factors – herd management, feeding conditions, housing conditions etc., but there are cow genetic factors that affect cow potential lifespan as well. One of genetically lifespan determined factors is cow conformation traits – mainly those affecting udder. The relationship between conformation traits and cow longevity were analyzed in different populations, authors have reported that some traits are significantly related to longevity (Short & Lawlor, 1992; Larroque & Ducrocq, 2001; Schneider *et al*., 2003; Sewalem *et al*., 2004). In Latvia, Holstein Black and White breed cattle constitute approximately half of all dairy cow population. Red breed cows are more resistant to different farm obstacles and they easier adjust to new conditions than Holstein Black and White breed cows. Holstein Black and White cows genetically are bigger than Latvian Brown breed or other red breed cows; the breeding goals in Latvian cow breeding program are: average stature – 145 cm for red breed group cows and 150 cm for Holstein Black and White cows. In Latvia, cow conformation traits are evaluated by linear evaluation method in a 9 point scale. For different udder traits, optimal evaluation value is determined 5 pints (for central ligament 6 points).

Different studies determined that udder conformation traits significantly affect somatic cell count in milk, and milk quality is one of factors that affects cow life length. (Dube *et al*., 2008; Dadpassand *et al*., 2013). In Ral and his collagues study, the higher somatic cell count was determined for cows with udder evaluation of 1 – 5 points (udder below hock), whereas Latvian Brown cow breed characterizes with low, pendulous udder and long teat (Ral *et al*., 1990). Holstein Black and White breed cows characterize with well-made udder, short teat, and strong central ligament; udder traits impair as cow gets older (Zavadilová, Němcová, & Stípková, 2011).

The main objective of this study was to determine how different conformation traits affect Holstein Black and White and Red cow breed cow longevity and lifetime productivity.

Materials and Methods

In the study, data about 73 007 dairy cows culled in time period from 2002 to 2012 and finished at least one full lactation were included. The data were obtained from Latvian Agricultural data center, which operates the national recording scheme. Cows were distributed in 2 different groups depending on breed – Holstein Black and White cows (purebred and crossbred, N = 38201) and Red breed group cows (N = 34806). In Red breed group, Latvian Brown (local breed), Latvian Brown crossbred cows with 60 to 95% LB ancestry, and Danish Red, Angeln,

Table 1

Summary statistics for conformation traits and its optimal values

Type trait	n		Min (1)	Optimal	Max (9)
Stature	73007	141.6 ± 0.02	×	×	×
Udder depth	73006	6.9 ± 0.01	Below hock	5	Shallow
Central ligament	73005	4.9 ± 0.01	Weak	6	Strong
Teat length	73003	6.0 ± 0.01	Short	5	Long
Front teat placement	73006	4.7 ± 0.01	Outside of quarter	5	Inside of quarter
Rear teat position	73005	5.6 ± 0.01	Outside of quarter	5	Inside of quarter

Table 2

Distribution of cows depending on linear evaluation score of conformation traits

Type trait	1 group	2 group	3 group
Udder depth	1 – 4	5	6 – 9
Central ligament	1 – 5	6	7 – 9
Teat length	1 – 4	5	6 – 9
Front teat placement	1 – 4	5	6 – 9
Rear teat position	1 – 4	5	6 – 9
Stature	100 – 135 cm	136 – 145 cm	>146 cm

Aishere, Swedish Red and White, Swiss, Holstein Red and White cows were included.

Means, standard errors, min and max values for conformation traits of dataset and conformation traits optimal values are shown in Table 1.

There is large variation between traits score, in each group linear score varies from 1 to 9 points independent from traits optimal value. The optimal value for practically all udder conformation traits is 5 points except udder ligament; there optimal value is 6 points.

To evaluate and compare cow productivity in the study, we used energy corrected milk (ECM), which was calculated by formula:

$$ECM = milk\ yield \times \times \frac{(0.383 \times fat\ content,\%) + (0.242 \times protein\ content,\%) + 0.7832}{3.14} \quad (1)$$

To evaluate cow lifespan and lifetime productivity, cows were distributed in 3 different groups depending on analyzed type trait. The second group always was the optimal value of type trait (Table 2).

For the statistical analyses of influence of conformation traits groups to the lifespan and lifetime milk productivity, analysis of variance (ANOVA) was performed. Bonferroni's pairwise comparisons test was used to analyse the differences between factors groups. Differences were considered statistically significant when $p<0.05$. Significant differences ($p<0.05$) in the tables were marked with different superscripted letters of alphabet (A, B, C, etc.). The mathematical processing was performed using the SPSS for Windows, version 15.

Results and Discussion

Cow longevity and lifetime productivity depend not only on different environmental factors, but also it is affected by cow breed. The Black and White breed cows have shorter lifespan than Red breed group cows, but the level of productivity not only in life, but as well in one life day is larger for Holstein Black and White cows. The average productivity for all in the study included dairy cows was 18550.8 kg energy corrected milk (ECM) in 1869.9 life days (5.12 years) (Table 3).

The lifespan of Red breed cows was 1903.0 days long, but for Holstein Black and White cows it was 70 days shorter. The difference between lifetime productivity of Red breed cows and Holstein breed cows was more than 2300 kg ECM. The same tendency occurred within life day productivity. There is a large variation between cow lifetime productivity traits, because cows are located in different farms and farms have different cows feeding and housing conditions, and different levels of productivity.

Table 3

Average longevity and milk productivity of cows

Traits		Min	Max	V, %
Total (N = 73007)				
Lifespan, days	1869.9 ± 2.06	786	4058	29
Lifetime productivity, kg	18550.8 ± 42.24	1488	98524	61
Life day productivity, kg	9.3 ± 0.01	0.6	29.9	40
Red cow breed (N = 34806)				
Lifespan, days	1903.0 ± 2.89	768	4050	29
Lifetime productivity, kg	17435.6 ± 54.1	1488	90132	60
Life day productivity, kg	8.5 ± 0.01	0.6	23.5	39
Holstein Black and White (N = 38201)				
Lifespan, days	1833.7 ± 2.93	845	4058	29
Lifetime productivity, kg	19774.7 ± 65.09	1560	98524	61
Life day productivity, kg	10.1 ± 0.02	1.0	29.9	40

The lifetime productivity range is from 1488 to 90132 kg ECM for Red cow breed and from 1560 to 98524 kg ECM for Holstein Black and White breed.

The stature is one of the conformation traits that shows cows' postnatal growth and is affected by cow's genetic potential. The longer lifespan (2031.6 days) had cows with stature 100 – 135 cm, and it was significantly ($p<0.05$) higher than in cows groups with stature 136 cm and higher (Table 4).

The lifetime productivity was obtained in cow group with stature 136 – 175 cm (18624.5 – 18826.1 kg ECM), but in one life day milk productivity significantly increased with cow stature. In different studies cow stature is a factor which significantly affects cow productivity (Short *et al*., 1992; DeGroot *et al*., 2002; Němcová *et al*., 2011). Udder conformation traits: udder depth and central ligament are associated with udder health problems, including different traumas as udder is unprotected and high somatic cell count in milk (Samoré *et al*., 2010). In our study, it was obtained for cows with drooping udder average lifespan (2041.8 days) and it is significantly longer than for cows with udder located close to the body (1865.7 days). The lifetime milk productivity was significantly lower for cows whose udder was evaluated with 1 – 5 points, but significantly higher lifetime milk productivity was for cows with udder located close to body (18612.0 kg in lifetime and 9.3 kg ECM in one life day). Central ligament is a trait that is responsible for the udder composition and teat

Table 4

Longevity and lifetime productivity depending on stature, udder depth and central ligament

Group**	N	Lifespan, days	Lifetime productivity, kg	Life day productivity, kg
Stature, cm				
100 – 135 cm	10163	2031.6 ± 6.04^{A}	17751.5 ± 108.16^{A}	8.1 ± 0.03^{A}
136 – 145 cm	45534	1869.6 ± 2.59^{B}	18624.5 ± 53.58^{B}	9.3 ± 0.02^{B}
146 – 175 cm	17310	1775.9 ± 3.88^{C}	18826.1 ± 88.41^{B}	9.9 ± 0.03^{C}
Udder depth				
1 – 4	584	2041.8 ± 25.61^{A}	16815.2 ± 440.77^{A}	7.6 ± 0.13^{A}
5	2256	1956.5 ± 12.60^{B}	17096.6 ± 228.98^{A}	8.1 ± 0.07^{B}
6 – 9	70167	1865.7 ± 2.09^{C}	18612.0 ± 43.16^{B}	9.3 ± 0.01^{C}
Central ligament				
1 – 5	61180	1873.7 ± 2.25^{A}	18592.9 ± 46.17^{A}	9.3 ± 0.01^{A}
6	9773	1861.2 ± 5.67^{A}	18567.0 ± 116.47^{A}	9.3 ± 0.03^{A}
7 – 9	2054	1799.8 ± 11.39^{B}	17223.6 ± 234.26^{B}	8.9 ± 0.08^{B}

**Cows divided by groups, depending on linear evaluation score of different type traits.

Table 5

Average longevity and lifetime productivity depending on different udder conformation traits

Group**	N	Lifespan, days	Lifetime productivity, kg	Life day productivity, kg
Teat length				
1 – 4	7078	1908.4 ± 7.00^{A}	17560.8 ± 132.28^{A}	8.6 ± 0.04^{A}
5	17348	1899.7 ± 4.36^{A}	18198.6 ± 85.12^{B}	9.0 ± 0.02^{B}
6 – 9	48581	1853.7 ± 2.45^{B}	18820.1 ± 52.24^{C}	9.5 ± 0.01^{C}
Front teat placement				
1 – 4	11589	1869.6 ± 5.46^{A}	16894.5 ± 100.16^{A}	8.5 ± 0.03^{A}
5	17118	1890.0 ± 9.32^{B}	18338.1 ± 85.99^{B}	9.1 ± 0.03^{B}
6 – 9	44300	1862.3 ± 2.59^{A}	19066.4 ± 55.07^{C}	9.6 ± 0.02^{C}
Rear teat position				
1 – 4	20792	1878.6 ± 3.88^{A}	18318.0 ± 72.70^{A}	9.1 ± 0.03^{A}
5	49378	1865.3 ± 2.50^{B}	18559.4 ± 51.53^{B}	9.3 ± 2.50^{B}
6 – 9	2837	1888.3 ± 10.35^{AB}	20107.7 ± 228.17^{C}	10.0 ± 0.07^{C}

**Cows divided by groups, depending on linear evaluation score of different type traits.

placement and angle towards ground. If the central ligament is optimally evaluated with 6 points, it means that teats are parallelly placed. The lifespan was longer for cows with average central ligament evaluation 1 – 6 points, but if ligament is too strong (evaluation 7 – 9 points), cow lifespan was shorter by 72 days. The

Table 6

Longevity and milk productivity of cows within different breeds depending on different conformation traits

Group**	Breed	N	Lifespan, days	Lifetime productivity, kg	Life day productivity, kg
Stature					
100 – 135 cm	HM*	1268	1989.5 ± 17.58^{A}	18230.3 ± 327.89^{A}	8.5 ± 0.10^{A}
136 – 145 cm	HM*	20474	1854.5 ± 3.88^{B}	19953.2 ± 85.48^{B}	10.0 ± 0.03^{B}
146 – 175 cm	HM*	13064	1786.0 ± 4.53^{C}	19644.9 ± 105.3^{B}	10.3 ± 0.03^{B}
100 – 135 cm	RB*	8895	2037.6 ± 6.43^{A}	17683.3 ± 114.39^{A}	8.1 ± 0.03^{A}
136 – 145 cm	RB*	25060	1882.0 ± 3.48^{B}	17538.9 ± 67.05^{A}	8.7 ± 0.03^{B}
146 – 175 cm	RB*	4246	1783.5 ± 4.35^{C}	16306.7 ± 151.46^{B}	10.3 ± 0.03^{C}
Udder depth					
1 – 4	HM*	153	1978.8 ± 48.29^{A}	16824.2 ± 873.92^{A}	7.8 ± 0.28^{A}
5	HM*	762	1940.3 ± 21.62^{A}	18450.4 ± 435.72^{B}	8.8 ± 0.14^{B}
6 – 9	HM*	33891	1830.6 ± 2.96^{B}	19818.0 ± 65.99^{C}	10.1 ± 0.02^{C}
1 – 4	RB*	431	2064.0 ± 30.13^{A}	16811.9 ± 10.20^{AB}	7.5 ± 0.15^{A}
5	RB*	1494	1964.8 ± 15.52^{B}	16406.1 ± 263.22^{A}	7.8 ± 0.08^{A}
6 – 9	RB*	36276	1898.5 ± 2.95^{C}	17485.4 ± 55.64^{B}	8.6 ± 0.02^{B}
Central ligament					
1 – 5	HM*	29054	1836.2 ± 3.20^{A}	19831.8 ± 71.37^{A}	10.1 ± 0.02^{A}
6	HM*	4746	1834.1 ± 8.10^{A}	19830.4 ± 177.28^{A}	10.1 ± 0.06^{A}
7 – 9	HM*	1006	1758.4 ± 15.99^{B}	17876.1 ± 346.84^{B}	9.5 ± 0.01^{B}
1 – 5	RB*	32126	1907.6 ± 3.16^{A}	17472.5 ± 59.02^{A}	8.5 ± 0.01
6	RB*	5027	1886.8 ± 7.93^{B}	17374.5 ± 150.59^{A}	8.6 ± 0.04
7 – 9	RB*	1048	1839.5 ± 16.11^{B}	16597.2 ± 315.05^{B}	8.4 ± 0.10

*HM – Holstein Black and White, RB – Red breed group cows
**Cows divided by groups, depending on linear evaluation score of different type traits.

same tendency was observed in lifetime productivity and one life day productivity. The significant effect of central ligament and udder depth on cow lifespan and lifetime productivity occurred in studies that covered different cow breeds (Moore *et al*., 1998).

The teat length and placement are traits which need to be corrected by breeders, because of new milking technologies that change every few years. Cows whose conformation traits do not comply with milking technology are culled from herds and more technology appropriate cows are kept for breeding purposes. (Mrode, Swanson, & Winters, 1998; Ptak *et al*., 2009) The Teat length negatively influences milking characteristics and potentially udder health and, as a result, influences the cows' longevity (Table 5).

The significantly longer productive life (1899.7 - 1908.4 days) occurred in a cow group with average teat length evaluation 1 – 5 points, but in those groups there were significantly lower lifetime milk production and life day milk production. Front and rear teat placement mainly affects milking process (Samoré *et al*., 2010). Significantly longer lifespan occurred within a cow group with optimal front teat placement, but productivity wise cows in this group characterized with second lowest lifetime milk productivity and life day milk productivity (18338.1 and 9.1 kg ECM). Significantly longer lifespan and higher life and life day milk productivity was for cows with rear teat evaluation 6 – 9 points. There are differences between longevity traits not only between type trait groups, but also between different breeds (Table 6).

Holstein Black and White cows characterize with shorter lifespan, but lifetime productivity and productivity in one life day shows that they are more productive than Red breed group cows. Latvia Holstein Black and White cows are usually bigger than Red breed group cows. In analyzed populations, the number of Holstein Black and White cows with stature more than 146 cm is around 25% larger than the number of Red breed cows.

The longer lifespan in Holstein Black and White cow group was for cows with stature at least 135 cm (1989.5 days), but in this group the lowest lifetime and life day productivities are detected. Average stature 136 – 145 cm ensure lifespan of 1854.5 days with

Table 7

Udder teat type trait effect on different breed cow lifespan and milk productivity

Group**	Breed	N	Lifespan, days	Lifetime productivity, kg	Life day productivity, kg
Teat length					
1 – 4	HM*	3216	1866.4 ± 10.08^{A}	18511.0 ± 203.64^{A}	9.2 ± 0.06^{A}
5	HM*	7838	1851.4 ± 6.31^{A}	19624.9 ± 135.39^{B}	9.9 ± 0.04^{B}
6 – 9	HM*	23752	1823.4 ± 3.49^{B}	19994.5 ± 79.57^{C}	10.2 ± 0.06^{C}
1 – 4	RB*	3862	1943.5 ± 9.67^{A}	16769.6 ± 172.25^{A}	8.0 ± 0.05^{A}
5	RB*	9510	1939.6 ± 5.99^{A}	17023.0 ± 106.48^{B}	8.2 ± 0.03^{AB}
6 – 9	RB*	24829	1882.6 ± 3.49^{B}	17696.5 ± 67.45^{C}	8.7 ± 0.02^{B}
Front teat placement					
1 – 4	HM*	4628	1788.9 ± 8.22^{A}	18128.5 ± 166.44^{A}	9.5 ± 0.06^{A}
5	HM*	7372	1835.6 ± 6.44^{B}	19449.4 ± 138.98^{B}	9.9 ± 0.04^{AB}
6 – 9	HM*	22806	1942.1 ± 3.58^{C}	20214.0 ± 81.70^{C}	10.3 ± 0.03^{B}
1 – 4	RB*	6961	1923.2 ± 7.20^{A}	16074.2 ± 123.76^{A}	7.7 ± 0.01^{A}
5	RB*	9746	1931.2 ± 5.79^{A}	17497.5 ± 107.68^{B}	8.5 ± 0.03^{AB}
6 – 9	RB*	21494	1883.6 ± 3.74^{B}	17848.7 ± 72.35^{C}	8.9 ± 0.02^{B}
Rear teat position					
1 – 4	HM*	9819	1832.9 ± 5.49	19574.2 ± 120.00^{A}	10.0 ± 0.04
5	HM*	23316	1832.8 ± 3.59	19755.8 ± 79.85^{A}	10.1 ± 0.02
6 – 9	HM*	1671	1850.8 ± 13.17	21212.9 ± 313.62^{B}	10.7 ± 0.10
1 – 4	RB*	10973	1919.5 ± 5.43^{A}	17193.2 ± 99.50^{A}	8.3 ± 0.03
5	RB*	26062	1844.3 ± 65.84^{B}	17489.1 ± 65.84^{A}	8.6 ± 0.02
6 – 9	RB*	1166	1941.8 ± 16.54^{A}	18523.8 ± 320.27^{B}	8.9 ± 0.10

*HM – Holstein Black and White, RB – red breed group cows
**Cows divided by groups, depending from linear evaluation score of different type traits.

significantly higher lifetime and life day productivity (19953.2 and 10.0 kg ECM). In Red cow breed group highest life day productivity occurred in the group with stature more than 146 cm, but in this cow group there is the shortest lifespan and lifetime productivity. Udder depth grow with the cows age and depend on cows productivity. The lifespan of Holstein Black and White and Red cow breed cows is longer when udder depth in first lactation is evaluated with 1 – 4 points (udder is deep), but in this group there is significantly lower lifetime and life day productivity. There are not significant differences between longevity traits within central ligaments groups with optimal evaluation point score and within cow group with ligament evaluation 1 – 5 points (udder central ligament is weak and little expressed), in those groups occurred longest lifespans and largest lifetime and life day productivities. The results of different studies show that udder depth and central ligament are factors that have statistically significant correlation with lifespan and cow lifetime productivity (DeGroot *et al*., 2002; Caraviello, Weigel, & Gianola, 2004; Němcová *et al*., 2007).

Red cow breed cows usually are characterized with longer teat in our study −7838 (22%) Holstein Black and White cow and 9510 (23%) and Red breed cow teats were evaluated with optimal 5 points (Table 7).

Average lifespan is significantly shorter in cow groups with teat length evaluation 6 – 9 points (teats are longer than in average population), but in those groups larger lifetime and life day productivity occurred. Front teat placement results differ between two breed groups. In Holstein Black and White cow group, longer lifespan with more productivity in one life day and in lifetime occurred in a cow group with front teat placement 6 – 9 points (teats located closer, into the quarter), but in Red cow breed group lifespan longer was in the group with front teat evaluation 1 – 4 points (teats are versed to outside, located outside quarter), but in this group, significantly lower lifetime and life day productivity occurred. Rear teat placement significantly affects cow lifetime productivity, the largest amount of ECM was obtained in the cow group with evaluation score 6 – 9 points.

Conclusions

1. Average lifespan of Holstein Black and White cows were 1903.0 days with average lifetime productivity 17435.6 kg ECM, but in Red breed group average lifespan was 1835.7 days with 19774.7 kg ECM.
2. Holstein cow lifespan was significantly affected by all analyzed udder type traits and cow stature ($p<0.05$). The longest lifespan in almost all type traits (except front and rear teat placement) was in cow groups with linear evaluation score less than optimal.
3. Lifetime and one life day productivity were significantly ($p<0.05$) affected by all analyzed traits and it was higher for cows with type trait linear evaluation scores above optimal.
4. Udder central ligament linear evaluation score showed less impact on cow lifespan and lifetime productivity traits within Holstein Black and White and Holstein Red and White breed groups.

References

1. Caraviello, D.Z., Weigel, K.A., & Gianola, D. (2004). Analysis of the relationship between conformation traits and functional survival in US Holstein cattle using a Weibull proportional hazards model. *Journal Dairy Science*, 87, 2677-2686. DOI: 10.3168/jds.S0022-0302(04)73394-9.
2. Dadpasand, M., Zamiri, M.J., Akhlaghi, A., & Atashi, H. (2013). Genetic relationship of conformation traits with average somatic cell score at 150 and 305 days in milk in Holstein cows of Iran. I*ranian Journal of Veterinary Research, Shiraz University*, 95(12), 7340-7345. DOI: 10.3168/jds.2011-5002.
3. DeGroot, B.J., Keown, J.F., Van Vleck, L.D., Marotz, E.L. (2002). Genetic parameters and responses of linear type, yield traits, and somatic cell scores to divergent selection for predicted transmitting ability for type in Holsteins. *Journal of Dairy Science*, 85, 1578-1585.
4. Dube, B., Dzama, K., & Banga, C.B. (2008). Genetic analysis of somatic cell score and udder conformation traits in South African Holstein cows. *South African Journal of Animal Science*, 38, 1-11. DOI: 10.4314/sajas.v38i1.4102.
5. Larroque, H., Ducrocq, V. (2001). Relationships between type and longevity in the Holstein breed. *Genetic Selection and Evolution*, 33, 39-59. DOI: 10.1186/1297-9686-33-1-39
6. Moore, R.K., Higgins, S., Kennedy, B.W., & Burnside, E.B. (1998). Relationships of teat conformation and udder height to milk flow rate and milk production in Holsteins. *Canadian Journal of Animal Science*, 61, 493-501. DOI: 10.4141/cjas81-059.
7. Mrode, R.A., Swanson, G.J.T., Winters, M.S. (1998). Genetic parameters and evaluations for somatic cell counts and its relationship with production and conformation traits in some dairy breeds in the United Kingdom. *Animal Science*, 66, 569-576. DOI: 10.3168/jds.2011-5002.
8. Němcová, E., Štípková, M., Zavadilová, L. (2011). Genetic parameters for linear conformation traits in Czech Holstein cattle. *Czech Journal of Animal Science*, 56, 157-162. DOI: 10.17221/8730-CJAS.

9. Němcová, E., Štípková, M., Zavadilová, L., Bouška, J., & Vacek, M. (2007). The relationship between somatic cell count, milk production and six linearly scored conformation traits in Holstein cows. *Czech Journal of Animal Science,* 52, 437-446. DOI: 10.3168/jds.2011-5002.
10. Ptak, E., Jagusiak, W., Żarnecki, A., & Otwinowska-Mindur, A. (2009). Relationship between somatic cell score and udder conformation traits in Polish Holstein-Friesian cows. *Annual Animal Science,* 9, 237-241. DOI: http://dx.doi.org/10.5713/ajas.13.0627.
11. Ral, G., Berglund, B., Philipsson, J., Emanuelson, U., Tengroth, G. (1990). Comprehensive experiments on traits affecting longevity in Swedish dairy cattle breeds. 3. Teat, udder and milkability traits effects of breed and age repeatabilities and correlations. *Swedish Journal of Agricultural Research,* 52, 89-95.
12. Samoré, A.B., Rizzi, R., Rossoni, A., & Bagnato, A. (2010). Genetic parameters for functional longevity, conformation traits, somatic cell scores, milk flow and production in the Italian Brown Swiss. *Italian Journal of Animal Science* 9, 145-151. DOI: 10.4081/ijas.2010.e28.
13. Schneider, M.P., Durr, J.W., Cue, R.I., & Monardes, H.G. (2003). Impact of conformation traits on functional herd life of Quebec Holsteins assessed by survival analysis. *Journal of Animal Science,* 86, 4083-4089. DOI: 10.3168/jds.S0022-0302(03)74021-1.
14. Sewalem, A., Kistemaker, G.J., Miglior, F., & Van Doormaal, B.J. (2004). Analysis of the relationship between conformation traits and functional survival in Canadian Holsteins using a Weibull proportional hazards model. *Journal of Dairy Science,* 87, 3938-3946. DOI: 10.3168/jds.S0022-0302(03)74021-1.
15. Short, T.H., & Lawlor, T.J. (1992). Genetic parameters of conformation traits, milk yield and herd life in Holsteins. *Journal of Dairy Science,* 75, 1987-1998. DOI: 10.3168/jds.S0022-0302(92)77958-2.
16. Zavadilová, L., Němcová, E., & Stípková, M. (2011). Effect of conformation traits on functional longevity of Czech Holstein cows estimated from a Cox proportional hazards model. *Journal of Dairy Science,* 94(8), 4090-4099. DOI: 10.3168/jds.2010-3684.