

## INVESTIGATION OF EXTERIOR TRAITS DEPENDENCE ON THE GENOTYPE OF LITHUANIAN BLACK AND WHITE COWS ACCORDING TO THE DEGREE OF HOLSTEIN GENES

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**Abstract.** The conformation traits of cows are heritable and linked with functionality and longevity. The dominant dairy breed in Europe is the Holstein. The objectives of this study were to evaluate exterior traits dependence on genotype of Lithuanian Black and White cows according to the degree of Holstein genes. For analysis, the conformation traits data of 53160 cows (in average of 2.7±0.01 lactation) were evaluated, for the degree of Holstein genes estimation records of cows with complete pedigree information of 3 ancestor generations from the national database were used. The data were grouped by exterior evaluation scores. Although Lithuanian Black and White breed nowadays is intensively improved by Holstein breed, the average degree of Holstein genes has been determined to be 63.1±0.09%. The results of this study showed dependence of cows' exterior traits on genotype according to the degree of Holstein genes. The biggest positive influence of Holstein breed is produced on the height and udder depth of Lithuanian Black and White cows ( $P < 0.001$ ). The average content of Holstein genes of cows evaluated by optimal score based on body traits varied from 60.8 ± 0.36% (rump width) to 71.6±0.19% (height), on extremities traits from 61.1 ± 0.12% (rear leg set angle) to 67.4 ± 0.30% (rear leg form), and on udder traits from 61.6± 0.73% (teat length) to 72.8±1.22% (udder depth) ( $P < 0.001$ ). The data of Lithuanian Black and white cows included in the present study suggest that cows with high proportion of Holstein genes are taller, with deeper and higher attached udders.

**Keywords:** exterior traits, degree of Holstein genes, Lithuanian Black and White cattle

**Introduction.** Farm animals have been undergoing human-managed selection ever since their original domestication. Initially, selection was probably limited to docility and manageability, but in the last 60 years breeding programs have focused on the genetic improvement of production traits (Oltenacu and Broom, 2010). Although selection for yield traits has received primary emphasis in the selection goals of dairy cattle, substantial emphasis has been placed on other traits, particularly in North America. Many of these non-yield traits are related to the outward appearance of cows, such as overall conformation or 'type', udder-type traits, body size (including height, chest width and body depth), and angularity (Oltenacu and Broom, 2010).

A primary reason for collecting information on type is to aid breeders in selecting profitable, functional cows in order that early culling for causes unrelated to yield can be avoided (Strapak et al., 2005). Selection emphasis on type traits associated with increased herd life may be beneficial to decrease involuntary culling and increase profitability (Czister et al., 2010; Geourgescu, et al., 1998; Larroque et al., 2001; Lavrinovič et al., 2009; Rogers, 1989). Conformation traits are recorded in many dairy cattle breeds (Boelling et al., 1998; de Haas et al., 2007; Foster et al. 1988; Harris et al., 1992; Koenen et al., 1998).

In recent years, a considerable number of scientific studies have been carried out and it has been determined that the dairy cow productivity and culling reasons are

very closely related to the genotype of animals (Chirinos et al., 2007; Martinez et al., 2004; Meszaros et al., 2008; Pachova et al., 2005; Petersson et al., 2005; Tsuruta et al., 2004) and conformation traits of cows (Auld et al., 1996; Dadpasand et al., 2008; Forsbäck et al., 2010; Sanders et al., 2009; Shearer et al. 1996; Urech et al., 1999;).

Today, the Holstein breed of cows is known in Lithuania as the world's highest-production dairy animals (Jukna, Pauliukas, 2001). This breed has been used in Black-and-White cattle breeding improvement programs.

The objectives of this study were to evaluate the dependence of the exterior traits on the genotype of Lithuanian Black and White cows according to the degree of Holstein genes.

### Material and methods

The average % of Holstein genes in cows genotype has been estimated according to records of cows with complete (3 ancestors generations) pedigree information from the database of State Agricultural Information and Rural Business Centre. For the analysis of conformation traits the data of 53160 Lithuanian Black and White cows in average of 2.7±0.01 lactation were used.

The conformation assessment system, which has been applied in Lithuania, follows the recommendations of international organizations ICAR and INTERBULL and The State Animal Breeding Supervision Service founded under the Ministry of Agriculture of the Republic of

Lithuania, Order No. 1A-15, 2011 05 26.

Traits, all scored on a 9 – point scale, were for height, stoutness, body depth, chest width, dairy type, rump width, rump angle, rear leg set angle, rear leg form, heel joint, hoof height, hoof tarsus angle, udder attachment, udder height, udder cleft, udder depth, teat thickness, and

teat length (from 1 to 9 point scale). Optimal scores of cows conformation traits (Saikevičius and Juozaitiene; 2004; European council directives 77/504, 86/130, 87/328, 94/515 and recommendations of international organization ICAR) are presented in the Table 1.

Table 1. Optimal scores of cows conformation traits

Optimal scores of body assessment traits		Optimal scores of extremities assessment traits		Optimal scores of udder assessment traits	
Height	9	Rear leg set angle	5	Udder attachment	9
Stoutness	8	Rear leg form	6	Udder height	9
Body depth	8	Heel joint	8	Udder cleft	9
Chest width	7	Hoof height	8	Udder depth	9
Dairy type	8	Hoof tarsus angle	7	Teat placement	6
Rump width	7			Teat thickness	5
Rump angle	5			Teat length	6

Statistical characteristics in the sample (n) – arithmetic mean (M), standard error (SE), and indicator of statistical significance (P) – were calculated using R 2.1.0” package (<http://www.r-project.org/>).

### Results and discussion

Analyzing our data set, we estimated that the average proportion of Holstein genes in Lithuanian Black and White cows population is 63.1 ±0.09 % (degree of Holstein genes amounts to 50 % in 21 % of Lithuanian Black and White cows, from 50 to 75 % in 44 %, and 75 % and more in 35 % of Lithuanian Black and White cows).

Conformation was one of the first nonproduction traits scored and included in the selection indices of dairy cattle

populations around the world (Powell, 2006; Shook, 2006; White, 1974).

Type traits are recorded relatively early in life, most often in the first lactation, and are more heritable than longevity (Boettcher et al., 1997; Kadarmideen et al., 2003; Strapak et al., 2010; VanRaden and Wiggans, 1995) which makes selection relatively more efficient.

In cattle, body conformation traits such as height and body depth affect feed intake and thus milk production (Hiendleder et al., 2003).

Table 2. The average % of Holstein genes of cows evaluated by body assessment traits

Score	Height		Stoutness		Body depth		Chest width		Dairy type		Rump width		Rump angle	
	n	M±SE	n	M±SE	n	M±SE	n	M±SE	n	M±SE	n	M±SE	n	M±SE
1	1507	51.2±0.50	1556	49.9±0.56			2	43.8±0.00	17	45.4±7.64			93	53.9±2.34
2	1499	51.3±0.54	935	54.7±0.66	14	65.9±4.12	29	79.0±3.43	85	63.0±2.31	21	70.8±4.93	457	64.8±0.88
3	3868	53.1±0.33	1600	55.1±0.53	149	61.1±1.44	326	68.7±1.41	581	60.8±0.90	263	63.0±1.16	1834	64.7±0.45
4	4826	57.0±0.30	2803	56.9±0.41	1413	61.7±0.63	1991	64.7±0.55	2256	61.5±0.49	4549	62.9±0.32	8853	64.9±0.22
5	6537	59.3±0.24	3858	60.5±0.34	8177	61.2±0.25	10255	61.7±0.22	6183	61.4±0.30	25394	64.3±0.13	<b>31301</b>	<b>61.5±0.12</b>
6	7434	61.4±0.24	6171	63.3±0.27	19975	62.7±0.15	17016	61.0±0.16	10724	61.3±0.21	19022	62.1±0.15	8043	65.2±0.23
7	8794	64.6±0.21	6029	63.3±0.27	19179	64.8±0.15	<b>16431</b>	<b>64.0±0.16</b>	15217	61.6±0.17	<b>3480</b>	<b>60.8±0.36</b>	2216	69.6±0.41
8	8307	68.2±0.22	<b>6225</b>	<b>62.1±0.28</b>	<b>3714</b>	<b>62.8±0.35</b>	6769	67.6±0.24	<b>13699</b>	<b>64.7±0.17</b>	379	57.6±0.13	337	67.0±1.11
9	<b>10388</b>	<b>71.6±0.19</b>	23983	66.2±0.13	539	56.8±0.94	341	66.8±0.86	4398	71.8±0.27	52	60.00±1.80	26	80.9±3.58

Note: the optimal exterior trait assessment score is bold.

As presented in Table 2, the average proportion of Holstein genes of cows evaluated by height ranged from 51.2±0.50 % (score 1, n = 1507) to 71.6±0.19 % (score 9, n = 10388), by stoutness from 49.9±0.56 % (score 1, n = 1556) to 66.2±0.13 % (score 9, n = 23983), and by body depth from 61.1±1.44 % (score 3, n = 149) to 65.9±4.12 % (score 2, n = 539) (P<0.001).

Małgorzata Morek-Kopeć et al. (2012) investigated the highest impacts on functional longevity were for body depth, chest width, and dairy type.

In our study, the average degree of Holstein genes of cows evaluated by chest width varied from 43.8±0.00 % (score 1, n=2) to 79.0±3.43 % (score 2, n=29) (P<0.4) and by dairy type assessment from 45.4±7.64 % (score 1, n=17) to 71.8±0.27 % (score 9, n=4398) (P<0.001).

The average proportion of Holstein genes of cows evaluated by rump width varied from 57.6±0.13 % (score 8, n=379) to 70.8±4.93 % (score 2, n=21) (P<0.01).

Pe' rez-Cabal and Alenda (2002) found a significant linear and quadratic relationship between rump breeding values and days of productive life, suggesting that animals with an intermediate rump angle (from 4 to 6 on a 1-to-9 scale) had a lower culling rate than animals at the extremes (high and low pin bones). The relative risk of involuntary culling is lowest at intermediate rump angles

(Caraviello et al., 2004; Sewalem et al., 2004).

In our investigation, the average degree of Holstein genes of cows assessed by rump angle ranged from 53.9±2.34 % (score 1, n=93) to 80.9±3.58 % (score 9, n=26) (P<0.001).

Zavadiłova et al. (2011) found an intermediate optimum was evident for rear legs rear view and rear legs set, whereas cows with sickle-shaped legs had lower longevity than cows with straighter legs.

We investigated the average proportion of Holstein genes of cows evaluated by rear leg set angle. It varied from 54.3±2.85 % (score 9, n=66) to 77.7±3.50 % (score 1, n=37) (P<0.001) (Table 3).

Dadpasand et al. (2008) estimated traits such as udder depth, rear legs side view and foot angle and showed an intermediate optimum with respect to longevity and extreme scores of these traits which increased the risk of involuntary culling. Every year in Lithuania an average of 4 % of the cows (of all culled cows) are culled for feet and 13–14 % (of all culled cows) and udder diseases (Annual report of milk recording No. 74 and No. 75).

In our investigation, the average degree of Holstein genes of cows evaluated by the shape of rear legs ranged from 55.6±1.90 % (score 1, n=154) to 67.4±0.30 % (score 6, n=4610) (P<0.001).

Table 3. The average % of Holstein genes of cows evaluated by extremities assessment traits

Score	Rear leg set angle		Rear leg form		Heel joint		Hoof height		Hoof tarsus angle	
	n	M±SE	n	M±SE	n	M±SE	n	M±SE	n	M±SE
1	37	77.7±3.50	154	55.6±1.90	173	70.8±1.08	192	65.8±1.38	126	63.8±2.22
2	228	65.1±1.43	493	59.8±0.98	375	65.5±1.11	1207	66.5±0.65	393	58.1±1.21
3	1344	67.7±0.59	3565	63.8±0.33	1518	65.8±0.58	3708	66.1±0.37	2704	59.5±0.46
4	6906	61.3±0.27	23134	62.7±0.13	5460	64.1±0.30	7780	65.1±0.25	15703	62.6±0.17
5	<b>27775</b>	<b>61.1±0.12</b>	18850	62.1±0.16	9429	63.3±0.22	22819	63.2±0.14	27386	62.8±0.13
6	13108	67.2±0.18	<b>4610</b>	<b>67.4±0.30</b>	8828	61.6±0.23	14370	61.6±0.17	4256	68.1±0.31
7	3233	66.1±0.36	1898	66.9±0.47	14705	60.8±0.17	2530	58.6±0.42	<b>2236</b>	<b>66.9±0.40</b>
8	463	61.6±0.89	331	65.6±1.00	<b>10195</b>	<b>65.0±0.20</b>	<b>524</b>	<b>64.6±0.94</b>	330	67.1±1.07
9	66	54.3±2.85	125	66.7±1.39	2477	69.9±0.38	30	67.0±2.74	26	53.6±6.04

Note: the optimal exterior trait assessment score is bold.

Robust constitution and dry, not swollen heel joint are desirable for dairy type cows. Heel joint scored 1 to 4 is undesirable, the average score being 5 (Saikevičius and Juozaitiene; 2004).

According to the results of our research, the average proportion of Holstein genes of cows by heel joint assessment ranged from 60.8±0.17 % (score 7, n=14705) to 70.8±1.08 % (score 1, n=173) and by hoof height assessment from 58.6±0.42 % (score 7, n=2530) to 65.8±1.38 % (score 9, n=30) (P<0.001).

Zavadiłova et al., (2011) found that foot and leg traits showed substantially lower effect on longevity, and the effect of foot angle was minimal.

In our investigation, the average % of Holstein genes of cows evaluated by hoof tarsus angle varied from 53.6±6.04 (score 9, n=26) to 68.1±0.31% (score 6, n=4256) (P<0.001).

Hoof tarsus angle disorders affect the welfare of the animal and have economic implications due to costs of treatment, earlier culling, and production losses (Koenig et al., 2005; Schöpke et al., 2013; Swalve et al., 2008; Van der Linde et al., 2010; Van der Waaij et al., 2005).

Dadpasand et al. (2008) found the strongest relationship between the length of productive life and type traits for fore udder attachment, udder depth, udder cleft.

In our research (Table 4), the average degree of Holstein genes by udder attachment assessment varied from 61.8±1.09 (score 1, n=314) to 68.0±0.94 % (score 9, n=264) (P<0.001).

In accordance to Rupp et al. (1999), Tilki et al. (2005), the fore udder attachment and udder depth are among the most important conformation traits with regard to udder health.

Table 4. The average % of Holstein genes of cows evaluated by udder assessment traits

Score	Udder attachment		Udder height		Udder cleft		Udder depth		Teat placement		Teat thickness	
	n	M±SE	n	M±SE	n	M±SE	n	M±SE	n	M±SE	n	M±SE
1	314	61.8±1.09	421	53.5±1.10	202	64.9±1.31	358	56.9±1.12	204	59.8±1.28	359	76.2±6.10
2	1075	61.8±0.65	526	59.3±0.85	452	63.2±0.96	797	54.8±0.82	652	58.7±0.85	36347	63.6±1.49
3	3104	61.8±0.40	1802	56.9±0.51	1856	60.3±0.48	2552	57.9±0.44	1891	64.3±0.45	15931	58.5±0.84
4	4967	62.1±0.33	4356	64.4±0.33	2881	61.6±0.44	6268	58.5±0.26	11104	61.6±0.21	459	56.0±4.32
5	11548	62.8±0.20	6790	65.8±0.27	5431	61.6±0.30	15888	60.6±0.16	28857	62.5±0.12	<b>52</b>	<b>62.3±3.56</b>
6	18086	63.4±0.15	7376	63.3±0.26	6989	62.5±0.26	11705	65.0±0.20	<b>7607</b>	<b>65.8±0.25</b>	-	-
7	11805	63.3±0.19	12720	58.5±0.18	10869	61.13±0.20	11539	68.1±0.19	2151	69.3±0.44	-	-
8	1997	66.5±0.44	12908	63.0±0.18	15729	62.1±0.16	3828	65.9±0.32	553	68.9±0.91	12	49.2±0.00
9	<b>264</b>	<b>68.0±0.94</b>	<b>6261</b>	<b>71.6±0.22</b>	<b>8751</b>	<b>67.0±0.20</b>	<b>225</b>	<b>72.8±1.22</b>	141	60.0±2.13		

Note: the optimal exterior trait assessment score is bold.

The average proportion of Holstein genes by cows udder height assessment varied from 53.5±1.10 % (score 1, n=421) to 71.6±0.22 % (score 9, n=6261) (P<0.001).

Strapak et al. (2005) and Vacek et al. (2006) suggest a well attached fore udder, high attached rear udder, strong cleft, close front teat placement and moderately long teats as important traits for a long productive cow's life.

In our investigation, the average degree of Holstein genes evaluated by cows udder cleft ranged from 60.3±0.48 % (score 3, n=1856) to 67.0±0.20 % (score 9, n=8751) (P<0.001).

Udders of dairy-type cows accommodate a lot of milk, so they must be sufficiently deep and have a strong udder cleft. The results obtained by Strapak et al. (2005) show that dairy cows with less hallow udder but well attached, wide and long rear udder and moderate teat length reach a higher longevity in herds.

The average proportion of Holstein genes by cows udder depth assessment varied from 54.8±0.82 % (score 2, n=797) to 72.8±1.22 % (score 9, n=225) (P<0.001).

It is convenient when teats of milk cows are cylindrical, uniformly located, not deviating too much from side to side or forward. It is undesirable if the space between the teats is very large, teats are located in the bottom quarter edge or if the space is very small and teats are close to each other. Teats which are turned outward or extremely inward also make milking very difficult.

Our data records showed that the average degree of Holstein genes by cows teat placement assessment ranged from 58.7±0.85 % (score 2; n=652) to 69.3±0.44 % (score 7, n=2151) (P<0.001).

Too short or too long teats often do not enable correct placing of teat cups and teat cup liner causing the interruption of vacuum pressure and penetration of air into milking system, contaminating the milk by micro

organisms from the environment (Pantelic et al., 2010)

Teat length and thickness is important in milking cows. It is convenient when teat length of heifers is 5.0–5.5 cm and of cows 5.5–6.0 cm and thickness is 2.4–2.5 cm in heifers and 2.7–2.8 cm in (Bardakcioglu H.E. et al., 2011).

The average proportion of Holstein genes of cows by teat thickness assessment varied from 49.2±0.00 % (score 8, n=12) to 76.2±6.10 % (score 1, n=359) (P<0.001).

As presented in (Fig.1), the average % of Holstein genes of cows evaluated by teat length ranged from 42.6±2.95 % (score 9, n=274) to 73.7±2.77 % (score 3, n=1372) (P<0.001)

Visual evaluation and recognition of milk characteristics of cows are preliminary indicators of milk production, and partially also of longevity and reproductive ability of cattle, which is also very important in terms of economic efficiency of milk production. Detailed knowledge of the cow's exterior features may provide valuable information about the genetic life potential of cows (Pantelic et al., 2007).

In a considerable number of scientific researches it has been determined that cows with optimal conformation traits are more productive and liable to increased longevity (Chirinos et al., 2007; Forsbäck et al., 2010; Meszaros, 2008; Sanders et al., 2009).

The data of Lithuanian Black and White cows included in the present study suggest that cows with high proportion of Holstein genes are taller and have deeper and higher attached udders.

Similar changes have occurred in other Holstein-Friesian populations. In the Dutch Holstein-Friesian dairy population, from 1981 to 2007, the average height of heifers increased by 14 cm (Oltenucu and Broom, 2010).

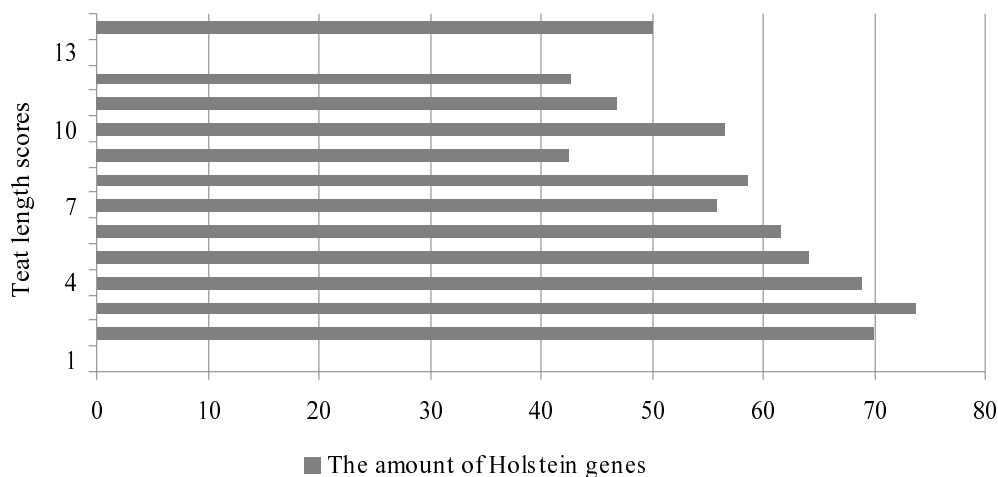


Fig.1 The average % of Holstein genes of cows evaluated by teat length

The results of our study showed dependence of cows exterior traits on genotype according to the degree of Holstein genes. The biggest positive influence of Holstein breed has been produced on height and udder depth of Lithuanian Black and White cows ( $P < 0.001$ ). The average content of Holstein genes of cows (Fig.2)

evaluated by optimal score based on body traits varied from  $60.8 \pm 0.36\%$  (rump width) to  $71.6 \pm 0.19\%$  (height), on extremities traits from  $61.1 \pm 0.12\%$  (rear leg set angle) to  $67.4 \pm 0.30\%$  (rear leg form), and udder traits from  $61.6 \pm 0.73\%$  (teat length) to  $72.8 \pm 1.22\%$  (udder depth) ( $P < 0.001$ ).

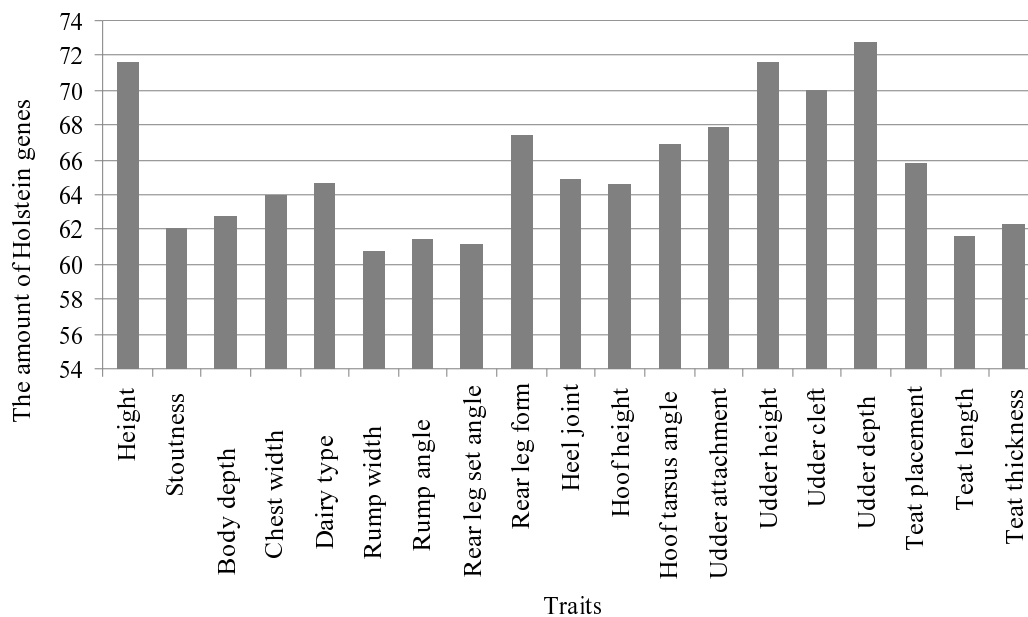


Fig.2 The average % of Holstein genes of cows evaluated by optimal exterior traits score

The Holstein is the dominant dairy breed in Europe (Oltenucu and Broom, 2010). Atkins G. et al. (2008) reported that cattle of Holstein breed perform high production and desirable conformation. The functional conformation necessary for a cow to express her productive and reproductive potential is the ability to maintain adequate body condition and the ability to move with sound locomotion (Atkins et al., 2008). Since conformation traits are heritable and are linked with

functionality, selection for conformational traits is an effective tool to predict genetic improvement in functionality.

### Conclusions

1. According to our investigation data set, the estimated average proportion of Holstein genes in Lithuanian Black and White cattle population was  $63.1 \pm 0.09\%$ .

2. The obtained results showed dependence of cows exterior traits on genotype according to the degree of Holstein genes. The biggest positive influence of Holstein breed has been produced on height and udder depth of Lithuanian Black and White cows ( $P < 0.001$ ). The average content of Holstein genes of cows evaluated by optimal score based on body traits varied from  $60.8 \pm 0.36\%$  (rump width) to  $71.6 \pm 0.19\%$  (height), on extremities traits from  $61.1 \pm 0.12\%$  (rear leg set angle) to  $67.4 \pm 0.30\%$  (rear leg form), and on udder traits from  $61.6 \pm 0.73\%$  (teat length) to  $72.8 \pm 1.22\%$  (udder depth) ( $P < 0.001$ ).

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