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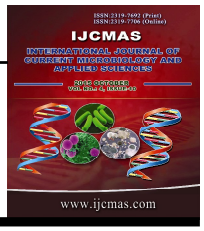

Original Research Article

Factors Affecting Linear Type Traits in Black-and-White Cows

Marinov I.[1]*, T. Penev[2] and Zh. Gergovska[1]

[1]Department of Animal Science, Faculty of Agriculture, Trakia University, 6014 Stara Zagora, Bulgaria
[2]Department of Applied Ecology and Animal Hygiene, Faculty of Agriculture, Trakia University, 6014 Stara Zagora, Bulgaria
**Corresponding author*

Keywords

Source of variation, Linear type traits, Parities, Stage of lactation, Black-and-wait cows

A B S T R A C T

In the study 514 black-and-white cows Holstein type from 14 farms of different regions in Bulgaria were included. The cows were from 1st to 3rd lactation. On all cows a scoring of 24 linear type traits on a scale from 1 to 9 was performed. A significant effect of the herd on almost all linear traits except the traits rear legs-side view, udder balance and rear teat position was found. The parity also had significant effect on a large number of conformation traits. A significant effect on the traits height, angularity, rump angle, rear legs-rear view, hock development, central ligament, teat position, body condition score (BCS) and locomotion was not established. The stage of lactation affects significantly only few linear traits – chest width, rear udder width, front and rear teat position and BCS. In the traits associated with the development of individual parts of the body a higher scores among cows with more parities were recorded - chest width, body depth, rump width, and in the legs and feet traits a trend to reducing the angle of hock joint and foot and lower values for rear legs-rear view were reported. In udder traits a trend for lower values of scores of the fore udder attachment, rear udder height and width, udder depth and udder balance was recorded, while in teats a slight tendency for longer and thicker teat among older cows was recorded. In cows scored in a later stage of lactation a narrower rear udder and closer teat placement was observed and also slightly higher values for BCS.

Introduction

In many countries, the selection in dairy cattle was mainly focused on milk production, and less attention to conformation traits was paid. The exclusive focus on selection for milk performance has a negative effect on conformation traits which affects the overall condition of the animals and can lead to negative consequences not only for productivity, but also for health, reproductive performance and respectively the duration of animals herdlife (Pryce *et al.*, 1998; Roxström *et al.*, 2001; Berry *et al.*, 2003; Krupa *et al.*, 2005; Bouška *et al.*, 2006; Heringstad *et al.*, 2003;

Veerkamp *et al.,* 2001). Economically profitable is that a cow, which besides, it has high productivity, maintains that productivity for a long period of time, calves regularly and has good health condition. The type evaluation and based thereon selection is a tool that supports the creation of animals in which premature culling for reasons not related to productivity can be avoided (Misztal *et al.,* 1992). Moreover, the conformation traits are assessed at an early stage in the cows life, at the first lactation, can more easily be scored and have a higher heritability than most reproductive, health and longevity traits which makes the selection more efficient (Berry *et al.,* 2004).

For correct evaluation of the breeding value of these traits also important are the model applied and respectively the factors included in it. The linear type traits are dependent on a number of heritable and environmental factors. Parity, age of cows during the scoring and the stage of lactation are among the physiological factors, which are important sources of variations in type traits, from the other factors such are the herd, the year of evaluation, the season and the classifier (Funk *et al.,* 1991; Harris *et al.,* 1992; Veerkamp *et al.,* 2002; Khan and Khan, 2015). The quantitative evaluation of such environmental factors is required for more accurate estimation of the linear traits for each population (Khan and Khan, 2015).

For a short period of time in Bulgaria an evaluation system for conformation traits of dairy cattle breeds was applied (Sartmadzhiev *et al.,* 1993; Krastanov, 1995). Subsequently, due to a number of organizational and other reasons, this practice was terminated, with the idea to be continued by the newly created then breed associations according to the new recommendations of ICAR. Farmers themselves are also interested in the application of the system and the opportunities to use the resulting evaluations for the breeding plans in herds.

The objective of this study was to determine the effect of main factors such as herd, parity and lactation stage on the linear traits in black-and-white cows reared in Bulgaria.

Material and Methods

The study included 514 black-and-white cows Holstein type, respectively on 1st lactation – 224, on 2nd – 194 and 3rd – 96. Cows were of 14 dairy farms from different regions of Bulgaria - Plovdiv, Stara Zagora, Sliven, Gabrovo and Lovech districts. All farms were under selection control of productivity.

On all cows a scoring on 24 linear type traits on a scale from 1 to 9 was carried out, in accordance with the Instruction for evaluation by type (Hamoen, 2008; ICAR, 2012). The scoring was carried out by the authors in the period 2013–2014, as the cows were between 30 to 210 days in milk. To obtain a better approximation the stage of lactation was presented in classes, respectively: 1-from 30 to 90 days; 2-from 91 to 150 days; 3- from151 to 210 days.

A fixed effects model was used to investigate factors associated with individual type traits using the following model:

$$\mathbf{Y_{ijkl} = \mu + H_i + L_j + SL_k + e_{ijkl}}$$

Where: Y_{ijkl} is linear type trait for cow; μ is population mean; H_i is fixed effect of herd (14 levels); L_j is fixed effect of parity (number of lactation, 3 levels); SL_k is fixed effect of stage of lactation (3 classes); e_{ijkl} is random residual effect.

The analysis of variance (ANOVA) was applied, using the relevant module of STATISTICA6.

Results and Discussion

On table 1 the descriptive statistics of 24 linear type traits included in the study was presented. With the lowest average value was the score of trait BCS – 3.31, and with the highest were traits chest width and rear udder height – 6.83. The greatest variation determined by the standard deviation (SD) was in the trait locomotion – 2.13 and smallest in teat thickness- 0.76. In the trait stature the average height was 143.18 cm (score 5.08) considering that cows were from first to third lactation, this means that in all 14 farms animals with not too much variation of height were reared. All linear traits related to the general development of the body and its parts had scores near and slightly above average (score 5) – stature, chest width, body depth and rump width. The top line also had score 5.22, but in rump angle a slide tendency for sloped rump was reported (6.11). All of the traits associated with legs and feet, including locomotion had values close to the average score 5. An exception is the trait foot angle, in which a slight tendency for a smaller angle was found (4.25). In udder traits, most were around and above the average score – 5. Slightly below the average were scores for udder balance – 4.61, teat length – 4.61 and greater deviation had the teat thickness - 4.41. BCS average score was 3.31, but considering that the majority of cows included in the study were at the beginning and middle of lactation, this was normal.

Table.1 Mean and standard deviation for the studied linear type traits

Linear type trait	x ± SE	SD	Scale	
			1……9	
Stature, cm	143.18 ± 0.23	5.33	up to 132 cm	over 154 cm
Stature	5.08 ± 0.08	1.76	Short	Tall
Chest width	6.83 ± 0.07	1.50	Narrow	Wide
Body depth	5.93 ± 0.05	1.21	Shallow	Deep
Angularity	6.53 ± 0.07	1.47	Coarse	Angular
Top line	5.22 ± 0.05	1.06	Very weak	Upwards
Rump angle	6.11 ± 0.08	1.73	High pins	Sloped
Rump width	5.85 ± 0.04	0.99	Narrow	Wide
Rear legs rear view	5.56 ± 0.07	1.68	Hock in	Parallel
Rear legs set	5.56 ± 0.07	1.58	Straight	Sickled
Hock development	5.17 ± 0.07	1.61	Filled	Dry
Bone structure	4.98 ± 0.06	1.30	Coarse	Fine and thin
Foot angle	4.25 ± 0.05	1.10	Low	Steep
Fore udder attachment	5.33 ± 0.08	1.74	Loose	Strong
Rear udder height	6.83 ± 0.70	1.66	Low	High
Rear udder width	6.36 ± 0.07	1.53	Narrow	Wide
Central ligament	5.64 ± 0.07	1.48	Broken	Strong
Udder depth	3.79 ± 0.08	1.76	Deep	Shallow
Udder balance	4.61 ± 0.04	0.99	Deep rear udder	Deep front
Front teat position	5.23 ± 0.05	1.15	Wide	Close
Rear teat position	6.58 ± 0.08	1.80	Wide	Close
Teat length	4.65 ± 0.05	1.15	Short	Long
Teat thickness	4.41 ± 0.03	0.76	Thin	Thick
Body condition score	3.31 ± 0.04	0.87	Poor	Grossly fat
Locomotion	4.98 ± 0.11	2.13	Severe abduction	No abduction

Zink *et al.* (2014) presented descriptive values for Czech Holstein primiparous, as most linear traits were with averages around score 5. The authors reported slightly higher values than ours for the trait stature- 6.14, even more considering that the data was only for primiparous. Just as in our results they reported slightly lower values for teat length - 4.68, but much higher average values for BCS - 4.96. Tapkiand and Ziya Guzey (2013) showed slightly lower values for stature in Holstein cows in Turkey compared to ours (4.09), while in most of linear traits the average score was about 5. The data were for primiparous, so it was normal lower values especially for traits related to growth and development to be reported. With lower scores were several traits and with more expressed deviation ware rump angle (3.97) and foot angle (4.06). Close to our averages for linear traits in Serbian black-and-white cows with different share of Holstein-Friesian genes showed and Pantelić *et al.* (2010).

Because of the fact that classifiers were the same for all farms and scoring of linear traits was made twice for each farm in the period from 2013 to 2014, in most cases in the same year for the individual farm, the effect of the year and the classifier were not included as factors in the valuation model. From the analysis for influence of the controlled factors with the highest significance ($P < 0.001$) in almost all linear traits was the herd (Table 2). A significant effect of the herd only in traits rear legs-side view, udder balance and rear teat position was not reported.

The significant differences between herds indicated that rearing conditions and nutrition in the individual farms were quite different. Considering that most of the farms included in the study raised their replacement animals, this affects the overall development of the cows as young.

Statistically significant effect on the herd for almost all linear traits in cows of the Brown breed in Bulgaria was found and from Angelova (2006). The herd had no significant effect only to rear udder height and teat position. Khan and Khan (2015) also reported significant effect of the herd to almost all linear traits with the exception of the fore udder attachment and rear teat position. In Italy similar results showed and other authors, as Mantovani *et al.* (2010) in the breed Piedmont and Mazza *et al.* (2013) in the breed Valdostana.

The parity affected significantly large number of traits. It had highly significant effect ($P<0.01$) to traits – chest width, body depth, rump width, rear legs-side view, bone structure, foot angle, fore udder attachment, rear udder height, udder depth and balance, teat length and thickness. The effect of the parity had lower significance in traits top line ($P<0.01$), rear udder width and rear legs-rear view ($P<0.05$). A significant effect of parity was not established on the traits – stature, angularity, rump angle, hock development, central ligament, teat position, BCS and locomotion. Angelova (2006) also found no effect of parity on the same traits with the exception of teat position. On all other linear traits in the Brown breed parity had significant effect. Petkov and Stoyanova (2006) studied the effect of parity on udder traits in black-and-white cows in Bulgaria. They established significant effect on traits fore udder attachment, udder depth, teat length, udder balance and rear legs-rear view. Khan and Khan (2015) found that the effect of parity is significant ($P<0.001$) for stature, chest width, body depth, rear udder height, udder depth, teat length and udder width.

The stage of lactation had significant effect on only few linear traits – chest width ($P<0.01$), rear udder width, front and rear teat position and BCS ($P<0.05$).

Angelova (2006) also found statistically significant effect of the lactation stage in a small number of linear traits – chest width, angularity, udder depth, teat position and central ligament. Similar results pointed and Krastanov (1995), but he established a significant effect of the stage of lactation and on the traits rear udder width and height. Petkov and Stoyanova (2006) studied the impact of the stage of lactation on udder traits and established a significant effect only on fore udder attachment and central ligament. Khan and Khan (2015) found significant effect of the stage of lactation in Sachival cows on a larger number of linear traits: stature, body depth, angularity, rump width, rear legs-side view, rear udder height and width, udder depth, teat length, chest width and central ligament.

As recognized the herd, parity and the stage of lactation had significant effect on the different number of linear traits as well as in different breeds and in different countries. This confirms the need for specific studies of this effect, and the inclusion of these factors in the models for the evaluation of breeding value.

Table.2 Results from ANOVA for type traits

	Herd		Parity		Stage of lactation	
Linear type trait	MS	**F P**	MS	**F P**	MS	**F P**
Degree of freedom	**13**		**2**		**2**	
Stature, cm	190.0	7.90***	18	0.80 -	12.0	0.50
Stature	20.14	7.63***	2.07	0.78 -	1.37	0.52 -
Chest width	26.54	17.67***	16.20	10.79***	7.48	4.98 **
Body depth	5.56	4.43***	23.75	18.90***	0.70	0.56 -
Angularity	35.64	3.19***	19.72	1.77	8.45	0.76
Top line	5.57	5.71 ***	6.34	6.51 **	1.34	1.37
Rump angle	16.84	6.51***	1.70	0.66	7.20	2.79
Rump width	3.62	4.29***	16.18	19.18***	1.99	2.36
Rear legs rear view	14.09	5.69***	8.05	3.25*	5.46	2.20
Rear legs set	3.35	1.42-	34.34	14.58***	4.84	2.06
Hock development	7.93	3.25***	4.83	1.98	2.41	0.99
Bone structure	9.87	6.97***	12.55	8.86***	1.77	1.25
Foot angle	3.53	3.21***	11.38	10.33***	0.10	0.09
Fore udder attachment	28.94	12.68***	24.77	10.85***	0.94	0.43
Rear udder height	18.72	8.58***	19.96	9.15***	3.56	1.63
Rear udder width	35.84	26.30***	4.80	3.52*	5.52	4.05 *
Central ligament	8.12	3.94***	0.37	0.18	3.20	1.56-
Udder depth	20.90	10.46***	133.27	66.70***	1.31	0.66
Udder balance	1.58	1.70	7.63	8.25***	0.92	0.99
Front teat position	3.63	2.22***	0.22	0.18	3.81	3.04*
Rear teat position	3.76	1.17	3.97	1.24	10.72	3.35*
Teat length	3.79	3.28***	24.03	20.83***	0.71	0.61
Teat thickness	1.66	3.18***	6.64	12.70***	0.61	1.16
Body condition score	3.62	5.34***	1.22	1.79	2.08	3.07 *
Locomotion	42.34	12.67***	1.92	0.57	4.27	1.28

* - significant in P <0.05; ** - significant in P <0.01; *** - significant in P <0.001; ns - no significant effect

On table 3 the LS-means for the effect of parity on linear traits are presented. In the trait stature significant effect was not reported, and also difference in height of cows on first, second and third parity, although the normal expectation of higher animals with bigger number of parities (Table 3). The reason was probably the difference in rearing conditions of herds, which was reported for the herd effect. In the traits associated with the development of individual parts of the body the expected better development in cows with more parities was reported – chest width, body depth, rump width. In the traits related to legs and feet a trend to reduced angle of the hock (slightly sickled) was observed, also reduced foot angle among cows with more parities. In the rear legs-rear view, a slight tendency for closer placed hocks was reported. All these changes were a consequence of weakening and amortization of the joints with advancing of the age. Khan and Khan (2015) found that cows with more parities had higher scores for stature, chest width, body depth, angularity, rear legs-rear view, central ligament, teat length and rear udder width.

Miteva *et al.* (2012) found a significant trend for set too close at the hocks in rear legs-rear view among cows with more parities (from the first to third). This was related to various reasons, such as increasing the capacity of the udder, gestations, type of floor, and others (Manske, 2002).

Table.3 LS-means for influence of parity on linear type traits

Linear type trait	I^{-st} lactation	II^{-nd} lactation	III^{-rd} lactation
	LSM ± SE	LSM ± SE	LSM ± SE
Stature, cm	143.29± 0.355	143.29 ±0.366	143.99±0.522
Stature	5.14± 0.120	5.10 ±0.123	5.36±0.173
Chest width	**6.57± 0.089**	**6.97 ±0.092**	**7.27±0.131**
Body depth	**5.63± 0.082**	**6.15±0.085**	**6.47±0.119**
Angularity	6.34± 0.242	6.79±0.250	7.10±0.357
Top line	**5.08± 0.072**	**5.24±0.074**	**5.54±0.105**
Rump angle	6.11± 0.117	6.04±0.120	6.27±0.172
Rump width	**5.59± 0.067**	**6.01±0.069**	**6.28±0.098**
Rear legs rear view	**5.80± 0.114**	**5.61±0.118**	**5.28±0.168**
Rear legs set	**5.15± 0.111**	**5.75±0.115**	**6.17±0.164**
Hock development	5.19± 0.113	5.23±0.117	4.85±0.167
Bone structure	**4.82± 0.086**	**5.11±0.089**	**5.46±0.127**
Foot angle	**4.50± 0.076**	**4.12±0.079**	**3.93±0.112**
Fore udder attachment	**5.69± 0.110**	**5.22±0.113**	**4.82±0.161**
Rear udder height	**7.19± 0.107**	**6.66±0.111**	**6.47±0.158**
Rear udder width	**6.24± 0.085**	**6.55±0.087**	**6.52±0.125**
Central ligament	5.68± 0.104	5.65±0.107	5.57±0.153
Udder depth	**4.52± 0.103**	**3.36±0.106**	**2.51±0.151**
Udder balance	**4.76± 0.070**	**4.58±0.072**	**4.26±0.103**
Front teat position	5.27± 0.081	5.26±0.084	5.18±0.120
Rear teat position	6.55± 0.129	6.72±0.134	6.37±0.191
Teat length	**4.68± 0.086**	**4.79±0.095**	**4.81±0.099**
Teat thickness	**4.28± 0.052**	**4.48±0.054**	**4.74±0.078**
Body condition score	3.41± 0.060	3.27±0.062	3.24±0.088
Locomotion	5.15± 0.187	4.96±0.186	4.87±0.242

In udder traits a trend for more undesired deviations in cows with bigger number of parities was reported. The fore udder attachment had became loose, the rear udder was wider but lower attached. The depth of the udder increases, the bottom goes down closer to the hock, and became steeper. In teat a slight tendency for longer and thicker teat for older cows was reported.

Kuczaj (2003) showed that the parity affects significantly almost all udder traits as the lowest values were for the primiparous. The lowest increase in relation to parity the author reported in trait central ligament. With the increasing of parities number, the distance from the bottom of the udder to the ground (for fore and rear udder) decreases, as the reducing was 14.48 and 15.53cm or 26.8 to 29.05% from first towards third lactation. The author found that in older cows after third lactation the length of the teat has increased compared to those on first with 0.55 and 0.44 cm or 9.61 and 9.32% for front and rear teats. The teat thickness was also increased significantly from first towards third lactation, respectively, for front and rear for 11.11% and 16.08%. The distance between teats also was increased with consecutive parity. Similar results for udder traits in black-and-white cows pointed and Petkov and Stoyanova (2006). They reported that the fore udder scores were reducing, the udder depth was increased, and the slope of the udder bottom was increased too.

Table.4 LS-means for the effect of stage of lactation on linear type traits

Linear type trait	Stage of lactation		
	from 30 to 90	From 91 to150	from 151 to 210
	LSM ± SE	LSM ± SE	LSM ± SE
Stature, cm	143.56± 0,39	143.81± 0.43	143.21 ±0.45
Stature	5.17 ±0.13	5.31 ±0.14	5.10 ±0.15
Chest width	**6.72 ±0.09**	**6.92 ±0.11**	**7.19 ±0.11**
Body depth	6.01 ±0.09	6.10 ±0.10	6.14 ±0.10
Angularity	6.53 ±0.27	6.69 ±0.29	7.02 ±0.31
Top line	5.39 ±0.06	5.20 ±0.09	5.28 ±0.09
Rump angle	6.29 ±0.13	6.27 ±0.14	5.87 ±0.15
Rump width	5.93 ±0.07	5.85 ±0.08	6.10 ±0.08
Rear legs rear view	5.73 ±0.13	5.63 ±0.14	5.33 ±0.15
Rear legs set	5.50 ±0.12	5.68 ±0.14	5.88 ±0.14
Hock development	4.95 ±0.13	5.21 ±0.14	5.12 ±0.14
Bone structure	5.22 ±0.10	5.00 ±0.10	5.17 ±0.11
Foot angle	4.18 ±0.08	4.15 ±0.09	4.21 ±0.10
Fore udder attachment	5.30 ±0.12	5.29 ±0.13	5.15 ±0.14
Rear udder height	6.80 ±0.12	6.92 ±0.13	6.59 ±0.14
Rear udder width	**6.69 ±0.94**	**6.39 ±0.12**	**5.94 ±0.12**
Central ligament	5.80 ±0.12	5.57± 0.13	5.52± 0.13
Udder depth	3.42 ±0.11	3.58 ±0.12	3.39± 0.13
Udder balance	4.50 ±0.08	4.63 ±0.08	4.47 ±0.09
Front teat position	**5.20 ±0.09**	**5.08 ±0.10**	**5.42 ±0.10**
Rear teat position	**6.40 ±0.14**	**6.36 ±0.16**	**6.88 ±0.16**
Teat length	4.68 ±0.86	4.80 ±0.09	4.81 ±0.99
Teat thickness	4.58 ±0.06	4.46 ±0.06	4.47 ±0.07
Body condition score	**3.27 ±0.06**	**3.29 ±0.07**	**3.45 ±0.07**
Locomotion	5.22 ±0.19	4.91 ±0.21	4.84 ±0.21

Atasever and Erdem (2013) showed that under normal conditions, the structure of the udder tolerate unfavorable changes with ageing (increasing the number of parities) due to the degeneration of connective tissue in the udder attachments. Nevertheless, the authors do not established a significant difference in the different consecutive parities for udder traits (fore udder attachment, rear udder height and teat length).

The stage of lactation, in which the linear traits were scored, had significant effect only on several traits. Very slight tendency for a greater chest width among cows scored in a later stage of lactation - after the 150th day was established. This in all probability was related and to the older age of the animals. In the trait rear udder width the reverse trend was reported - in cows scored in later lactation stage a smaller udder width was reported. With reducing the milk yield after the middle of lactation, respectively, and the total capacity of the udder decreases.

At the end of lactation with reducing the quantity of milk and udder capacity the teat position was affected. Both in front and rear teat closer placing was reported in cows scored in a later stage of lactation, although the differences were small. In cows, scored in a later stage of lactation a slightly higher values for BCS was reported, which is a consequence of the increased level of obesity after the middle of lactation.

Petkov and Stoyanova (2006) reported that with advancing of the lactation values of the score for fore udder were reduced, because of reducing the area of attachment of the fore udder due to decrease in milk productivity. The central ligament became more pronounced in cows at a later stage of the lactation - after the 60th day.

Khan and Khan (2015) also reported consistent reduction in values for the linear traits from early to later stages of lactation for the traits chest width, rear udder height and width and teat length. In the later stages of lactation cows had a deeper body, wider rump, a shallower udder and a narrower rear udder.

Mazza *et al.* (2013) found that with advancing of the lactation stages the value of the scores for fore udder attachment, rear udder height and width and teat position were reducing ($P<0.001$) and for teat length and rump width a slightly lower levels of significance were established ($P<0.01$). For these traits the decline of values is more substantial for the period after the 180th day of lactation. The authors also found an increase ($P <0.01$) for the rump angle and width in the later stages of lactation.

In conclusion, the strongest effect on almost all linear traits had the factor herd. The conditions of feeding and rearing of the animals had strong influence on their development. Next by influence was the factor parity, which significantly affected a large number of traits, associated with both the growth and development of animals and with increase in productivity and its influence on udder traits. The stage of lactation had less effect on linear traits, and it was mainly reported on udder traits. The study and the results obtained, represent a good basis for further constructing of linear models for evaluation of breeding value on conformation traits in black-and-white cows in Bulgaria.

Reference

Angelova, T. 2006. Study for opportunities to optimize the selection of Brown cattle in Bulgaria. Ph.D. Thesis, Institute of Agriculture, Stara Zagora, Bulgaria, 133.

Atasever, S., Erdem, H. 2013. Relationships between somatic cell count and udder type scores in Holstein cows. *Int. J. Agric. Biol.*, 15: 153–156;

Berry, D. P., Buckley, F., Dillon, P., Evans, R.D., Veerkamp, R.F. 2004. Genetic relationships among linear type traits, milk yield, body weight, fertility and somatic cell count in primiparous dairy cows. *Irish J. Agricult. Food Res.*, 43(2): 161–176.

Berry, D.P., Buckley, F., Dillon, P., Evans, R.D., Rath, M., Veerkamp, R.F. 2003. Genetic relationships among body condition score, body weight, milk yield and fertility in dairy cows. *J. Dairy Sci.*, 86: 2193–2204.

Bouška, J., Vacek, M., Štipkova, M., Němcova, E., Pytloun, P. 2006. The relationship between conformations of dams and daughters in Czech Holsteins. *Czech J. Anim. Sci.*, 51: 236–240.

Funk, D.C., Hansen, L.B., Funk, D.A. 1991. Adjustment of linear type scores from Holstein classification for age and stage of lactation. *J. Dairy Sci.*, 74: 64S–650.

Hamoen, A. 2008. Progress of type harmonization. Results General Assembly. Killarney, Ireland, Octobre 2008.

Harris, B.L., Freeman, A.E., Meizger, E. 1992. Genetic and phenotypic parameters for type and production in guernsey dairy cows. *J. Dairy Sci.*, 75: 1147–1153.

Heringstad, B., Chang, Y.M., Gianola D., Klemetsdal, G. 2003. Genetic analysis of longitudinal trajectory of clinical mastitis in first-lactation Norwegian Cattle. *J. Dairy Sci.*, 86: 2676–2683.

ICAR (International Committee for Animal Recording), 2012. Recording guidelines. Conformation Recording of Dairy cattle.

Khan, M.A., Khan, M.S. 2015. Non-genetic factors affecting linear type traits in Sahiwal cows. *J. Anim. Plant Sci.*, 25(1): 29–36.

Krastanov, J. 1995. Study for opportunities for increasing the efficiency of selection in the main dairy cattle breeds in Bulgaria, Ph.D. Thesis, Institute of Agriculture, Stara Zagora, Bulgaria, 154 Pp.

Krupa, E., Wolfova, M., Peškovičova, D., Huba, J., Krupova, Z. 2005. Economic values of traits for Slovakian Pied cattle under different marketing strategies. *Czech J. Anim. Sci.*, 50: 483–492.

Kuczaj, M. 2003. Analysis of changes in udder size of high-yielding cows in subsequent lactations with regard to mastitis. *Elect. J. Polish Agricult. Univ.*, 6(1). http://www.ejpau.media.pl/volume6/issue1/animal/art-02.html

Manske, T. 2002. Hoof lesions and lameness in Swedish dairy cattle. Prevalence, risk factors, effects claw trimming, and consequences for productivity. University of Agricultural Sciences. Skara, Sweden, Thesis for PhD.

Mantovani, R., Cassandro, M., Contiero, B., Albera, A., Bittante, G. 2010. Genetic evaluation of type traits in hypertrophic Piemontese cows. *J. Anim. Sci.*, 88: 3504–3512.

Mazza, S., Sartori, C., Berry, D., Mantovani, R. 2013. Factors affecting linear type traits of Valdostana cattle. *Agriculturae Conspectus Scientificus*, 78(3): 207–211.

Misztal, I., Lawlor, T.J., Short, T.H., Van Raden, P.M. 1992. Multiple-trait estimation of variance-components of yield and type traits using an animal-model. *J. Dairy Sci.*, 75: 544–551.

Miteva, Tch., Penev, T., Gergovska, Zh., Mitev, J., Vasilev, N., Dimova, V.

2012. Changes in the hindleg conformation and their relation to lameness, production system and lactation number in dairy cows. *Agricult. Sci. Technol.,* 4(4): 382–387;

Pantelić, V., Samolovać, l., Aleksić, S., Trivunović, S., Petrović, M.M., Ostojić-Andrić, D., Novaković, Ž. 2010. Heritability of type traits in first calving Black and White cows. *Tierzucht,* 53(5): 545–554,

Petkov, P., Stoyanova, R. 2006. Study of some linear type traits in relation with cow age and period of lactation. *Anim. Sci.,* XLIII(1): 22–25.

Pryce, J.E., Esslemont, R.J., Thompson, R., Veerkamp, R.F., Kossaibati, M.A., Simm, G. 1998. Estimation of genetic parameters using health, fertility and production data from a management recording system for dairy cattle. *Anim. Sci.,* 66: 577–584.

Roxström, A., Strandberg, E., Berglund, B., Emanuelson, U., Philipsson, J. 2001. Genetic and environmental correlations among female fertility traits and milk production in different parities of Swedish red and white dairy cattle. *Acta Agricultura Scandinavica,* 51: 7–14.

Sartmadzhiev, H., Videv, V., Krastanov, J., Fenerova, Y. 1993. Selection guidelines. Stara Zagora, Bulgaria, 40 Pp.

Tapkiand, I., Ziya Guzey, Y. 2013. Genetic and phenotypic correlations between linear type traits and milk production yields of Turkish Holstein dairy cows. *Greener J. Agricult. Sci.,* 3(11): 755–761,

Veerkamp, R.F., Gerritsen, C.L.M., Koenen, E.P.C., Hamoen, A., De Jong, G. 2002. Evaluation of classifiers that score linear type traits and body condition score using common sires. *J. Dairy Sci.,* 85: 976–983.

Veerkamp, R.F., Koenen, E.P.C., De Jong, G. 2001. Genetic correlations among body condition score, yield, and fertility in first-parity cows estimated by random regression models. *J. Dairy Sci.,* 84: 2327–2335.

Zink, V., Zavadilova, L., Lassen, J., Stipkova, M., Vacek, M., Stolc, L. 2014. Analyses of genetic relationships between linear type traits, fat-to-protein ratio, milk production traits, and somatic cell count in first-parity Czech Holstein cows. *Czech J. Anim. Sci.,* 59: 539–547.