Relationships between conformation traits and milk yield, lifetime production and number of lactations in Czech Holstein cows

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Abstract

The phenotypic relationships between type traits and functional traits were analysed in Czech Holstein dairy cows born between years 2002 and 2015, with minimum proportion of Holstein genes 88%. Two slightly different models were used to evaluate the effects of 1 measured trait (in cm), 20 linear type traits (9 classes each), 4 composite traits, and final score (both with scales 0 – 100 points) on milk production traits and longevity. Sample for analysis of effect on milk yield included observations from 247 790 cows within one to four lactations (570 671 rows in total), second sample for longevity study included data from 228 161 cows with sums of one to maximum six lactations. Cows were required to obtain type classification scores between 30th and 210th day of the first lactation in age between 650 and 1206 days. Milk yield (in kg) records below 5079 kg and above 16 622 kg were set to absent.

Longevity traits were defined as lifetime performance, i.e. total milk yield in kg for whole productive life, and as total number of lactations. Lifetime production was between 1004 kg and 95 480 kg. Maximum number of lactations was 6, cows with higher count or cows, which were not culled before the possibility of survival of 6 lactations, were not included. Analysis were performed for linear type traits altogether as well as separately for each of 20 type traits.

Squared scores of type traits were included to derive polynomial regression and best fitting curve. They were added into the Linear models, which included fixed effects of herd-year-season of birth and classifier-herd-year-season of scoring, age at first calving and age at scoring in days, day of lactation at scoring, effect of classifier and (not for longevity model) number of lactation, service period and parturition interval. Different shapes of regression lines were obtained. Some traits showed linear relationship, straight line with both negative or positive slope (with higher contribution for 1 point or for 9 points), some were curved with best values either for middle values (4 – 6 points) or marginal values (1 and 9 points).

Also, composite traits did not show a clear linear relationship, as would be expected. The highest impacts on milk yield were from type traits (in decreasing order) body condition score, udder width, udder depth, rear udder height and angularity. The strongest influence on lifetime production was found for body condition score, udder depth, body depth, rump angle and rear legs side view. Importance of udder width, body condition score, udder depth, bone quality and rear legs side view for number of lactations was confirmed.

Some traits, such as stature, angularity, rump angle and width and body condition score, showed a clearly intermediate optimum for longevity traits, while greatest milk yield was expected for one of the extreme scores.

Keywords: linear type traits, conformation, milk yield, lifetime performance, number of lactations.

Introduction

In many studies, relationships between conformation traits and variety of production and non-production traits were investigated. Both phenotypic and genetic correlations were reported and used as a basis for selection of cows while accounting for the fact that cattle conformation is associated with production efficiency (Sawa *et al*., 2013). Therefore, often linear scoring of type traits is carried out routinely for the total population of cows or at least for daughter groups of test bulls (Zavadilová 2011).

Linear type traits are recorded with a use of lineare score on different scales, most frequent is a use of nine-point scale. That allows the type trait to vary from one extreme to another. While correlations between the production or non-production traits and the type traits give a basic information about relationship (whether it is negative or positive, strong or weak), true association can vary throughout the whole scale. In reality it can mean (an often means), that a peak value of the production traits is situated around a middle score of the type traits, i.e. the relationship between conformation and production or non-production traits can vary in shape from linear to curved (hyperbolic or parabolic). This prove multiple research results, as reported by Cruickhank *et al*. (2002), Sewalem *et al*. (2004), Zavadilová *et al*. (2011) and Khan *et al*. (2016).

Longevity can be defined in different ways, as length of productive life expressed in days (Ducrocq *et al*., 1988), as total number of lactations, lifetime performance (LP) or production per lactation (Morek-Kopec, Zarnecki, 2011). Observed length of productive life is called true longevity and after adjustment for production it is termed functional longevity (Ducrocq *et al*., 1988). Functional longevity represents a cow's ability to avoid involuntary culling, therefore it depends mainly on a decision of the farmer regarding culling.

Because longevity is highly positively correlated with profitability (Weigel *et al*., 1995; Norman *et al*., 1996), reducing involuntary culling leads to improved herd profitability, e.g. reduced cost of replacement, higher intensity of dam selection, and an increased proportion of mature cows with higher production (Morek-Kopec, Zarnecki, 2011). The assessment of exact length of life or connected performance would require waiting, which for the purposes of breeding is not acceptable. Therefore, earlier estimations are being used, which involve different methods. The official genetic evaluation for longevity in the Czech Republic is carried out using survival analysis, as reported by Ducrocq and Sölkner (1998). To increase the accuracy of genetic evaluation it is possible via including correlated traits, that can be assessed during the first lactation (Weigel *et al*., 1998). Type traits have been investigated for their suitability, regarding routine recording in most breeding programs and international conversion of sire-predicted transmitting abilities for some type traits (Brotherstone *et al*. 1997; Berry *et al*. 2004).

The objective of this study was to evaluate the relationships between conformation traits and milk yield and longevity traits in Czech Holstein cows in the level of measured (phenotypic) levels.

Material and methods

Data

Two datasets and two model equations were created in order to assess the relationships, first for milk yield and second for longevity traits. Data were obtained from the Holstein Cattle Breeders Association of the Czech Republic.

The two slightly different models were used to evaluate the effects of 1 measured trait (height at sacrum in cm (HS)), 20 linear type traits (9 classes each), 4 composite traits, and final score (FS) (both evaluated in interval 50 – 100 points) on milk yield (MY) and longevity. MY was provided in kg of milk per normalized (305-day) lactation. Longevity traits were defined as lifetime performance (LP), i.e. total milk yield in kg for the whole productive life (maximum 6 lactations), and as total number of lactations (NL).

The linear type traits were: stature (ST), chest width (CW), body depth (BD), angularity (AN), rump angle (RA), rump width (RW), rear leg set – rear view (RLR), rear leg set – side view (RLS), foot angle (FA), fore udder attachment (FUA), front teat placement (FRP), teat length (TL), udder depth (UD), rear udder attachment (RUA), medial suspensory ligament (MSL), rear teat placement (RTP), rear udder width (RUW), bone quality (BQ), locomotion (LOC), body condition score (BCS). Following composite traits, computed as a function of scores of the appropriate sets of linear type traits, were: dairy strength (DS) (from the year 2004 as a combination of dairy form and body capacity), body composition (BC), udder (U) and feet and legs (FL). Final score was computed from other composite traits. All the traits were recorded on all cows in datasets, that is for 247 790 records in first dataset and 570 671 in the second. The distributions of linear traits were not transformed, because the scores showed normal or near-normal distribution, which enabled statistical analyses. The basic description statistics of scores of analysed traits as well as production traits are presented in Table 1.

Table 1. Means, standard deviations and minimum and maximum values of height at the sacrum, linear type traits, composite traits, milk yield and longevity traits.

	Dataset 1[1]					Dataset 2[2]				
Trait	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
HS[*]	570,671	145.32	3.47	110	168	228,161	145.17	3.53	110	168
ST	570,671	5.68	1.20	1	9	228,161	5.70	1.22	1	9
CW	570,671	5.60	1.17	1	9	228,161	5.60	1.21	1	9
BD	570,671	5.58	1.24	1	9	228,161	5.59	1.27	1	9
AN	570,671	5.45	1.11	1	9	228,161	5.45	1.13	1	9
RA	570,671	4.74	1.09	1	9	228,161	4.75	1.11	1	9
RW	570,671	5.58	1.23	1	9	228,161	5.61	1.24	1	9
RLR	570,671	5.46	1.39	1	9	228,161	5.41	1.42	1	9
RLS	570,671	4.80	1.11	1	9	228,161	4.85	1.15	1	9
FA	570,671	5.07	1.04	1	9	228,161	5.06	1.05	1	9
FUA	570,671	5.20	1.36	1	9	228,161	5.15	1.40	1	9
FRP	570,671	5.03	1.11	1	9	228,161	5.04	1.14	1	9
TL	570,671	4.63	1.10	1	9	228,161	4.63	1.12	1	9
UD	570,671	5.83	1.28	1	9	228,161	5.79	1.34	1	9
RUA	570,671	5.52	1.25	1	9	228,161	5.48	1.29	1	9
MSL	570,671	5.69	1.37	1	9	228,161	5.64	1.42	1	9
RTP	570,671	5.80	1.28	1	9	228,161	5.78	1.32	1	9
RUW	565,193	5.54	1.32	1	9	225,446	5.48	1.37	1	9
BQ	570,671	5.78	1.31	1	9	228,161	5.76	1.34	1	9
LOC	546,362	5.10	1.48	1	9	216,463	5.10	1.51	1	9
BCS	534,687	4.93	1.02	1	9	209,233	4.90	1.06	1	9

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	Dataset 1[1]					Dataset 2[2]				
Trait	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
DS	426,167	80.57	2.39	63	90	155,957	80.52	2.44	64	90
BC	570,671	80.99	3.07	66	91	228,161	80.94	3.17	66	91
FL	570,671	80.78	3.04	66	91	228,161	80.60	3.18	66	91
U	570,671	79.62	3.60	65	90	228,161	79.37	3.73	66	90
FS	570,671	80.27	2.32	68	88	228,161	80.10	2.43	68	88
MY	570,671	9,749	2,044	5,079	16,622					
LP						228,161	22,174	14,265	1,004	95,480
NL						228,161	2.5	1.3	1.0	6.0

[1] Dataset for analyses of milk yield
[2] Dataset for analyses of longevity traits (lifetime production in thousands kg of milk, number of lactations)
* Height at sacrum in cm (HS), stature (ST), chest width (CW), body depth (BD), angularity (AN), rump angle (RA), rump width (RW), rear leg set – rear view (RLR), rear leg set – side view (RLS), foot angle (FA), fore udder attachment (FUA), front teat placement (FRP), teat length (TL), udder depth (UD), rear udder attachment (RUA), medial suspensory ligament (MSL), rear teat placement (RTP), rear udder width (RUW), bone quality (BQ), locomotion (LOC), body condition score (BCS), dairy strength (DS), body composition (BC), feet and legs (FL), udder (U), final score (FS).

The records consisted of Czech Holstein cows born between years 2002 and 2015, with minimum proportion of Holstein genes 88%. Animals were required to obtain type classification scores between 30th and 210th day of the first lactation in total age between 650 and 1206 days. Maximum number of lactations used for the milk yield analyses was 4. Milk yield (MY) records below 5079 kg and above 16 622 kg were set to absent. Lifetime production was between 1004 kg and 95 480 kg. Maximum number of lactations in the second dataset was 6, cows with higher count or cows, which were not culled before the possibility of survival of 6 lactations, were not included.

Model

For studying the influence of linear type traits, a single-trait model incorporating only fixed effects was used:

$$\boldsymbol{y}_{ij} = \sum \boldsymbol{x}_i + \boldsymbol{e}_{ij}$$

Where $\boldsymbol{y}_{ij}$ is a vector containing phenotypic observations; $\boldsymbol{x}_i$ is a vector of i[th] fixed effect and $\boldsymbol{e}_{ij}$ is the random error. There were two slightly different models used for different trait analyses. In both models the linear type traits were used as fixed effects in both linear and quadratic form (landq); other effects were: combined class effect of the herd, year and season (HYS) at calving; number of days at calving (landq); combined class effect of the HYS at classifying; class effect of a classifier; age in days at classifying (landq) and number of days from calving to classifying (landq). In the first model for MY, three additional effects were used: service period (landq); calving interval (landq) and class effect of number of lactations.

The residuals were used in calculating quadratic phenotypic regressions of MY, LP and NL on each type trait individually as well as altogether. To generate the regression coefficients and subsequently the predictions, the BLUPf90 program of Misztal *et al.* (2002) was used. The estimated predictions were calculated with a use of the quadratic equation and subtracted from population mean, i.e. the mean of the dataset used (separated means for first and second dataset).

Additionally, the CORR procedure of SAS (2013) was used to estimate Pearson's simple phenotypic correlations between individual conformation traits and the production and longevity traits.

Results and discussion

The relationship between milk production and longevity traits was analysed three times: as simple phenotypic correlations, in interaction with other type traits and without interactions.

Correlations obtained between the type traits and MY, LP and NL are shown in Table 2. The strongest correlation between RUW and MY was as the strongest similarly observed by Khan *et al* (2016) – 0,5, Misztal *et al.* (1992) – 0,22, Cruickshank *et al.* (2002) – 0,44, Wasana *et al.* (2015) – 0,39 and Zink *et al.* (2014) – 0,32.

The results for correlations between type traits themselves were comparable to the ones obtained in aforementioned studies Cruickhank *et al.* (2002), Sewalem *et al.* (2004), Zavadilová *et al.* (2011) and Khan *et al.* (2016). Some differences were observed in comparison with Tapki *et al.* (2013), where the correlations were varying in both negative and positive direction, e.g. the difference for CW - AN was in the present study -0.44; FUA – UD was in the present study 0.36 against -0.41 from the Tapki *et al.* (2013). Regarding the correlations between composite traits and the production traits the study agreed with analyses from Sewalem *et al.* (2004), however in comparison with Zavadilová *et al.* (2012) the estimation effect of DS is lower.

Second type of analyses was made with the use of the model, where all the type traits were used altogether and their effect on the analysed production trait or longevity trait was derived after consideration the interactions between the type traits respectively. Results are shown in Table 3. The coefficients of reliability (R^2), i.e. the proportion of explained variability by models with the use of all effects and linear type traits altogether were 60% for MY and 36% for both LP and NL. Major part was explained by effect HYS at classifying; linear type traits explained 2.3% in decreasing order: RUW, AN, BCS, UD and BD. Type traits with the lowest R^2 were (in ascending order): RTP, FUA, RA, FRP and TL. This order of linear type traits is reflected also in the absolute value of estimated predictions of deviations for each production trait (Table 3.). According to the score, i.e. class of the cow in each linear type trait, the estimated values of kg milk or expected length of life (the expected deviation of the cow from population mean) were calculated.

In the last approach, effect of type traits on the milk yield and longevity traits was analyzed without interactions with other type traits. That means, model equations included all the fixed effects as second approach, except for other type traits. All the linear type traits, composite traits and final score were used with linear and quadratic form, separately from others. Different shapes of regression lines were obtained. Some traits showed linear relationship, straight line with both negative or positive slope (with higher contribution for 1 point or for 9 points), some were curved with best values either for middle values (4 – 6 points) or marginal values (1 and 9 points). Also, composite traits did not show a clear linear relationship, as would be expected (see Figure 1).

Table 2. Estimate of phenotypic correlations (r) among milk yield in kg (MY), lifetime production in kg of milk (LP), lifespan in number of lactations (NL), conformation traits and other conformation traits. Maximum and minimum correlations for each column are in bold.

Shortage	Trait	MY	LP	NL
	Linear type traits			
HS	Height at sacrum in cm	0.087	-0.015	**-0.056**
ST	Stature	0.071	0.029	0.001
CW	Chest width	0.042	0.032	0.017
BD	Body depth	0.089	0.046	0.009
AN	Angularity	0.087	0.023	-0.014
RA	Rump angle	-0.014	0.007	0.015
RW	Rump width	0.051	0.008	-0.012
RLR	Rear leg set - rear view	0.106	0.057	0.013
RLS	Rear leg set - side view	-0.040	-0.023	-0.004
FA	Foot angle	0.045	0.025	0.004
FUA	Fore udder attachment	0.017	0.053	0.044
FRP	Front teat placement	0.003	-0.004	-0.006
TL	Teat length	0.038	0.037	0.022
UD	Udder depth	**-0.049**	0.014	0.032
RUA	Rear udder attachment	0.093	0.083	0.045
MSL	Medial suspensory ligament	0.052	0.087	0.066
RTP	Rear teat placement	-0.009	**-0.027**	-0.023
RUW	Rear udder width	**0.189**	0.099	0.021
BQ	Bone quality	0.057	0.022	-0.005
LOC	Locomotion	0.036	0.056	0.042
BCS	Body condition score	-0.042	0.029	0.048
	Composition traits			
DS	Dairy strength	0.133	0.052	-0.006
BC	Body composition	0.077	0.031	0.000
FL	Feet and legs	0.105	0.062	0.016
U	Udder	0.089	0.110	**0.071**
FS	Final Score	0.141	**0.113**	0.053
	Mean	0.060	0.038	0.013

Table 3. Estimate of predictions of the effect of the linear type traits on milk yield (MY), lifetime production in 1,000 kg (LP) and number of lactations (NL) as deviations from the population mean. Maximum values for each trait in bold.

Type trait		Linear score (in points)								
		1	2	3	4	5	6	7	8	9
ST*	MY	6.93	16.48	28.64	43.43	60.83	80.85	103.49	128.75	**156.63**
	LP	481.69	851.32	1108.88	1254.37	**1287.80**	1209.16	1018.45	715.68	300.84
	NL	0.04	0.06	0.07	**0.08**	0.06	0.04	0.01	-0.04	-0.10
CW	MY	**-20.64**	-38.03	-52.18	-63.09	-70.76	-75.18	-76.36	-74.31	-69.01
	LP	342.84	621.06	834.65	983.62	1067.97	**1087.69**	1042.78	933.26	759.10
	NL	0.04	0.08	0.10	0.12	0.14	**0.14**	0.14	0.13	0.12
BD	MY	96.62	180.71	252.27	311.31	357.82	391.80	413.26	422.18	**418.59**
	LP	1145.16	2025.25	2640.29	2990.27	**3075.19**	2895.05	2449.86	1739.60	764.29
	NL	0.08	0.15	0.19	**0.20**	0.20	0.17	0.12	0.05	-0.05
AN	MY	43.56	86.66	129.31	171.49	213.22	254.49	295.30	335.65	**375.55**
	LP	425.32	749.38	972.16	1093.67	**1113.92**	1032.89	850.60	567.04	182.20
	NL	0.02	0.03	**0.04**	0.04	0.03	0.01	-0.02	-0.05	-0.10
RA	MY	-12.70	-23.83	-33.39	-41.38	-47.79	-52.63	-55.90	-57.60	-57.72
	LP	895.60	1630.24	2203.93	2616.66	2868.42	**2959.23**	2889.08	2657.98	2265.91
	NL	0.10	0.18	0.24	0.29	0.31	**0.32**	0.32	0.29	0.25
RW	MY	62.17	117.26	165.27	206.21	240.07	266.85	286.55	299.18	**304.73**
	LP	209.81	352.47	427.98	**436.35**	377.56	251.63	58.55	-201.68	-529.06
	NL	**0.00**	0.00	0.00	-0.01	-0.02	-0.04	-0.06	-0.09	-0.12
RLR	MY	76.48	141.45	194.92	236.88	267.34	286.30	**293.75**	289.70	274.15
	LP	192.02	352.98	482.88	581.72	649.51	686.23	**691.90**	666.50	610.05
	NL	0.01	0.02	0.03	0.03	**0.03**	0.03	0.03	0.03	0.02
RLS	MY	**-0.51**	-8.06	-22.66	-44.30	-72.98	-108.71	-151.48	-201.30	-258.16
	LP	657.50	1122.47	1394.92	**1474.85**	1362.24	1057.12	559.46	-130.72	-1013.42
	NL	0.07	0.12	0.15	**0.17**	0.16	0.14	0.10	0.04	-0.03
FA	MY	102.39	186.58	252.58	300.37	329.96	**341.36**	334.55	309.55	266.34
	LP	406.33	735.67	988.00	1163.33	1261.66	**1282.98**	1227.31	1094.63	884.95
	NL	0.02	0.04	0.05	0.06	**0.06**	0.06	0.05	0.04	0.03
FUA	MY	**-40.24**	-74.56	-102.95	-125.42	-141.97	-152.60	-157.30	-156.08	-148.94
	LP	344.90	639.58	884.03	1078.26	1222.27	1316.05	**1359.61**	1352.95	1296.06
	NL	0.04	0.08	0.11	0.13	0.15	0.16	**0.16**	0.15	0.14
FRP	MY	102.69	184.96	246.80	288.22	309.21	**309.78**	289.92	249.64	188.93
	LP	373.96	646.48	817.55	**887.18**	855.35	722.08	487.36	151.20	-286.41
	NL	0.01	0.02	**0.03**	0.02	0.01	0.00	-0.02	-0.05	-0.08
TL	MY	84.11	152.94	206.51	244.81	267.84	**275.61**	268.10	245.33	207.29
	LP	950.51	1695.83	2235.96	2570.90	**2700.66**	2625.22	2344.60	1858.79	1167.79
	NL	0.07	0.13	0.17	0.19	**0.20**	0.19	0.17	0.13	0.08
UD	MY	**-2.77**	-30.35	-82.72	-159.90	-261.88	-388.66	-540.25	-716.63	-917.82
	LP	1502.36	2700.76	3595.22	4185.71	**4472.26**	4454.85	4133.49	3508.17	2578.90
	NL	0.15	0.27	0.37	0.44	0.49	0.52	**0.52**	0.49	0.45

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Type trait		Linear score (in points)								
		1	2	3	4	5	6	7	8	9
RUA	MY	99.70	191.09	274.15	348.89	415.31	473.41	523.18	564.64	**597.78**
	LP	382.80	730.92	1044.36	1323.11	1567.18	1776.57	1951.27	2091.29	**2196.63**
	NL	0.02	0.04	0.05	0.06	0.07	0.07	**0.08**	0.07	0.07
MSL	MY	11.57	23.95	37.14	51.14	65.95	81.57	98.00	115.24	**133.29**
	LP	638.00	1201.74	1691.23	2106.47	2447.45	2714.18	2906.65	3024.87	**3068.84**
	NL	0.06	0.10	0.15	0.18	0.21	0.23	0.24	**0.24**	0.24
RTP	MY	25.68	43.82	54.41	**57.47**	52.99	40.97	21.41	-5.69	-40.32
	LP	341.61	577.35	707.23	**731.24**	649.39	461.68	168.10	-231.34	-736.65
	NL	0.03	0.05	0.07	**0.07**	0.07	0.05	0.03	0.00	-0.04
RUW	MY	13.27	52.44	117.51	208.47	325.34	468.09	636.75	831.30	**1051.75**
	LP	684.40	1325.70	1923.92	2479.05	2991.08	3460.03	3885.88	4268.65	**4608.33**
	NL	0.04	0.07	0.09	0.11	0.12	0.13	**0.14**	0.13	0.12
BQ	MY	63.46	113.48	150.06	173.21	**182.91**	179.17	162.00	131.38	87.33
	LP	1129.04	2074.74	2837.09	3416.09	3811.75	4024.07	**4053.03**	3898.66	3560.93
	NL	0.09	0.17	0.24	0.29	0.32	0.34	**0.35**	0.34	0.32
LOC	MY	28.70	51.37	68.02	78.63	**83.22**	81.78	74.31	60.81	41.29
	LP	349.83	644.34	883.50	1067.34	1195.84	1269.01	**1286.85**	1249.35	1156.52
	NL	0.03	0.05	0.07	0.09	0.10	0.11	**0.11**	0.11	0.11
BCS	MY	122.64	189.20	**199.68**	154.08	52.39	-105.38	-319.23	-589.16	-915.18
	LP	1330.63	2422.08	3274.33	3887.40	4261.27	**4395.95**	4291.45	3947.75	3364.86
	NL	0.09	0.17	0.24	0.31	0.37	0.43	0.48	0.52	**0.56**

* Stature (ST), chest width (CW), body depth (BD), angularity (AN), rump angle (RA), rump width (RW), rear leg set – rear view (RLR), rear leg set – side view (RLS), foot angle (FA), fore udder attachment (FUA), front teat placement (FRP), teat length (TL), udder depth (UD), rear udder attachment (RUA), medial suspensory ligament (MSL), rear teat placement (RTP), rear udder width (RUW), bone quality (BQ), locomotion (LOC), body condition score (BCS).

The highest impacts on milk yield were from type traits (in decreasing order) body condition score, udder width, udder depth, rear udder height and angularity. The strongest influence on lifetime production was found for body condition score, udder depth, body depth, rump angle and rear legs side view. Importance of udder width, body condition score, udder depth, bone quality and rear legs side view for number of lactations was confirmed. Some traits, such as stature, angularity, rump angle and width and body condition score, showed a clearly intermediate optimum for longevity traits, while greatest milk yield was expected for one of the extreme scores. Those results were generally consistent with those from Zavadilová *et al.* (2011). Only effect of bone quality on milk yield and especially lifetime production was concluded as more important opposite to aforementioned study, however agreed with results from Sewalem *et al.* (2004).

Most of the results from third approach corresponded to the second approach, although there were some differences. For example, effect of chest width considered in interaction with other type traits clearly shows maximum prediction of milk yield for the score 1 and lowest for 7 points. In contrast, the curve regardless interactions (third approach)

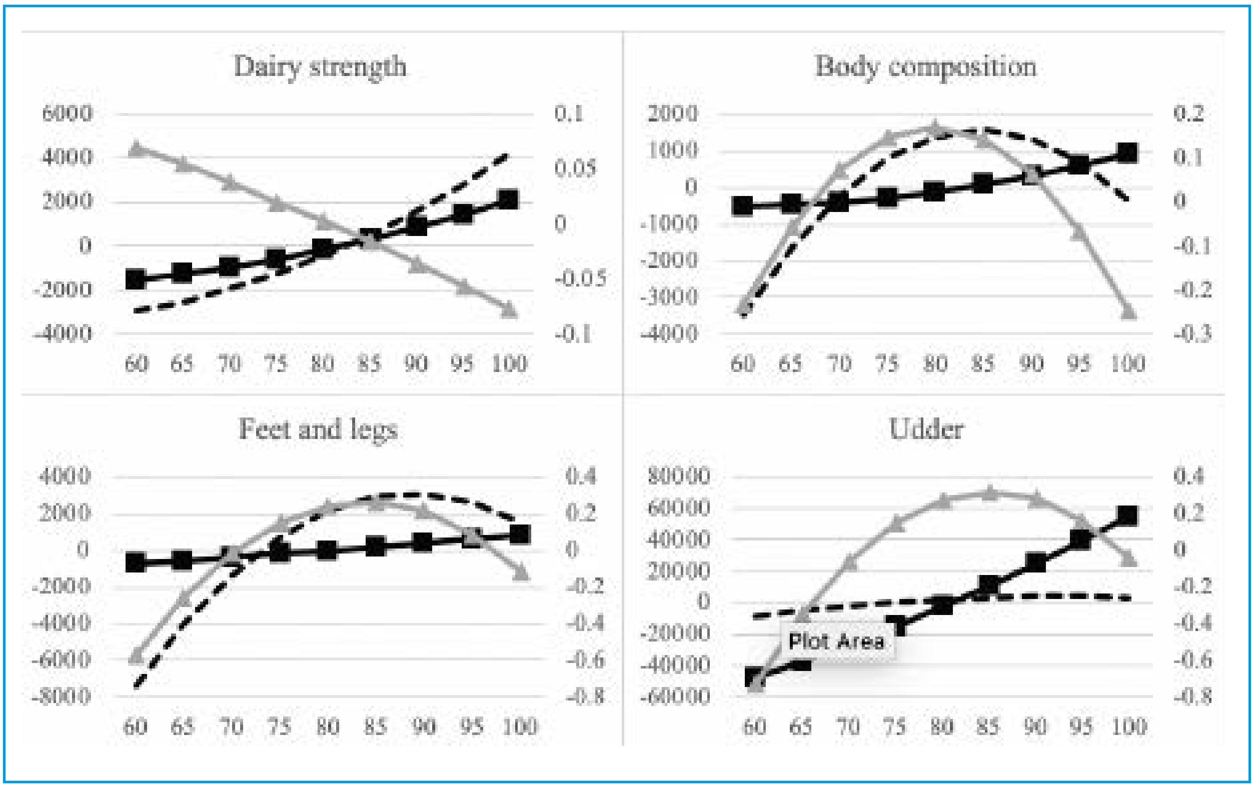

Figure 1. Quadratic relationships between composition traits and milk yield (■), lifetime production (.▲) and number of lactations (second y-axis).

shows the peak of maximum values around 7 and 8 points, i.e. complete opposite trend. That can be explained also with the statement in paper from Kern *et al.* (2014), where is presented high degree of interrelations and collinearity between the type traits, especially between udder and conformation traits.

Conclusions

Different models were used to describe relationships between type traits and milk yield, lifetime production and number of lactations in Czech Holstein population. Results were generally consistent with those from studies of other Holstein populations in other countries. Important influences of body condition score, udder traits and angularity on milk yield were confirmed. The strongest influence on lifetime production was found for body condition score, udder depth, body depth, rump angle and rear legs side view.

However significant effects of the type traits were concluded, reliability of prediction of milk yield based only on phenotypic measurements was 2.3%. Another conclusion stated the importance of interactions between linear type traits itself, as demonstrated on the effect of chest width on milk yield.

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