Analysis of linear description of type traits in the varieties and studs of the Old Kladrub horse

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ABSTRACT: An evaluation of the linear description of type in 494 horses of the Old Kladrub breed for 32 traits was used to analyse the effect of variety, stud, sex, year of birth and age at description. A linear model with fixed effects was used. The highest coefficient of variation was calculated for the forelimb side-view (40.14%), chest girth (36.25%) and height at withers (30.97%). 28 out of 32 traits were in the range from 7 to 9 utilized scores. The descriptor used a very high number of scores of the scale. Significant differences between both varieties were found in 13 out of 32 traits. Significant differences were found in 12 out of 32 traits between the Kladruby stud farm and the private studs. There is no reasonable explanation of this fact. A significant variety × stud interaction was recorded in only 7 traits. Significant differences between stallions and mares were recorded in a large number of front and body traits (in 11 out of 18 traits) and in 2 rear traits. Despite of a remarkable number of significant differences between the years of birth (in 18 out of 32 traits) and age at description (in 13 out of 32 traits) both factors are not the important ones for the selection of horses according to the type traits. The description of type traits, performance recording and selection are carried out in the population of four-years-old horses born in the given year. The age at description does not play a role because all horses are now described each year at a standard age of four years. The linear description of type is an important tool for the breeding and conservation of genetic diversity within the breed.

Keywords: Old Kladrub horse; linear description of type traits; varieties; studs; sex; year of birth; age at description

The Old Kladrub horse, which was established by the end of the 18th and at the beginning of the 19th century, is the most important genetic resource in the Czech Republic. The today's breed is a warm-blooded one created on the basis of Old Spanish and Old Italian horses and has been bred continuously in the territory of the Czech Republic for more than four hundred years. The breed is a robust carriage (coach) horse, which was originally used for ceremonial purposes by the Habsburg emperors. The population was closed against gene immigration from related breeds of Old Spanish origin in 1992. The extraordinary type and the specific external traits of this breed should be saved for the next generations. It is evident that for such a specific coach horse with a specific type, the breeding objective must be focussed on the conformation traits.

The linear description of type traits is an essential tool of the breeding programme of the Old Kladrub horse for retaining specific conformation traits for the next generations. In addition, this system contributes to an increase in the phenotype and genetic variability of the animals within the breed and breeding groups (sire lines and dam families). Last but not least, the linear description will be an

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Table 1. Estimates of the basic population parameters

Number	Trait	Mean	SD	*CV* (%)	Minimum	Maximum	Utilized scores
	Front						
1	height at withers	5.98	1.85	30.97	1	9	9
2	head profile	5.44	1.44	26.51	3	9	7
3	neck length	5.16	1.16	22.46	2	7	6
4	neck tethering	5.99	0.97	16.26	3	9	7
5	neck topside	6.04	1.68	27.83	1	9	9
6	withers length	4.99	1.48	29.69	1	9	9
7	withers height	4.41	1.20	27.29	1	9	9
	Body						
8	topline length	5.57	1.28	23.02	3	9	7
9	topline vault	4.60	0.78	16.96	1	7	7
10	loin length	5.98	1.14	19,06	3	9	7
11	loin vault	4.43	1.05	23.71	1	9	9
12	shoulder length	4.52	0.78	17.25	3	7	5
13	shoulder slope	3.85	1.04	26.97	1	7	7
14	chest girth	6.40	2.32	36.25	1	9	9
15	chest length	6.14	1.04	16.88	3	9	7
16	chest width	5.15	1.24	24.10	3	9	7
17	chest depth	6.03	1.19	19.72	3	9	7
18	breast width	5.14	1.29	25.10	2	9	8
	Rear						
19	croup length	4.15	0.93	22.33	1	7	7
20	croup width	5.89	1.16	19.63	3	9	7
21	croup shape	4.47	1.06	23.60	1	7	7
22	croup profile	4.70	1.35	28.64	1	9	9
23	tail tethering	5.05	1.10	21.89	1	9	9
	Limbs						
24	forelimb front view	5.06	0.81	16.01	3	9	7
25	forelimb side-view	4.03	1.62	40.14	1	7	7
26	cannon bone circumference	6,18	1.49	24.17	1	9	9
27	foretoe side-view	4.56	0.90	19.66	1	7	7
28	forehoof side-view	4.89	0.95	19.46	1	9	9
29	forehoof width	5.05	1.02	20.21	3	7	5
30	forehoof size	4.98	0.66	13.25	3	7	5
31	hind limb side-view	4.40	0.91	20.67	1	7	7
32	hind limb back view	4.94	0.78	15.80	3	9	7

effective tool for the precise determination of the breeding objective.

In 1995, a new linear description of the conformation trait system was developed for the Old Kladrub horse (Jakubec et al., 1996) using knowledge from cattle breeding – the benefit of linear description after years of use was confirmed by Bouška et al. (2006a,b). The integral part of this system was also the description of colour and marks and body conformation failures. The new system was verified in 1995 in the grey and black variety of the National Stud Farm in Kladruby nad Labem. The analysis included also further factors such as sex, age and sire lines. The results of the analysis were published

by Jakubec et al. (1998, 1999 and 2000) and Schlote et al. (2002). Since 1996, the linear description of type traits has been extended to studs of private farmers. The objective of the paper was to analyse the linear description of conformation traits with regard to the variety (grey and black), studs of the National Stud Farm in Kladruby nad Labem and studs of private farmers, sex, year of birth, age at classification and interactions between varieties and studs.

MATERIAL AND METHODS

A qualified classifier described 494 horses from 1995 to 2000. The classifier used a scale of 1 to 9 levels for 32 conformation traits with increments of one point, where the parameters represented the extremes in the biological variation (Jakubec et al., 1996).

For the estimation of basic population parameters all traits were analysed by the least-squares analysis using the GLM procedure (SAS, 2005) according to Rasch and Mašata (2006). The following model was used:

$$Y_{ijklmn} = \mu + VAR_i + STUD_j + SEX_k + YEARB_l + AGEC_m + (VAR \times STUD)_{ij} + e_{ijklmn}$$

where:

Y_{ijklmn} = observation of a linear type trait
μ = overall mean
VAR_i = fixed effect of the i-th variety
$STUDj$ = fixed effect of the j-th stud
SEX_k = fixed effect of the k-th sex
$YEARB_l$ = fixed effect of the l-th year of birth
$AGEC_m$ = fixed effect of the m-th age at classification
$(VAR \times STUD)_{ij}$ = fixed effect of the ij-th variety × stud interaction
e_{ijklmn} = random residual error

The differences between the least-squares means were tested at the significance level (error probability) of $^{*}P < 0.05$, $^{**}P < 0.01$ and $^{***}P < 0.001$, see Tables 3, 4, 5, 6.

RESULTS AND DISCUSSION

The scale of the linear assessment describes the whole range of possible phenotypic expressions of the trait considered across the population. Therefore, the estimates of the parameters (overall mean, standard deviation, coefficient of variation, minimum and maximum of scores, number of utilized scores) characterize the specific properties and variation of the Old Kladrub breed in its current state (Table 1).

The means and standard deviations have only an informative value. The means lie between 3.85 and 6.40 scores. The standard deviations are in the range from 0.66 to 2.32 scores. The means are not a measure of the quality of traits and the standard deviations, as a measure of variation, depend on the mean. Therefore they will not be discussed in detail. The coefficients of variation are a more important measure of variation. In general a higher phenotypic variation of traits indicates a higher genetic variation which guarantees a sufficient selection response.

The traits can be dividend into 4 groups according to the magnitude of their coefficients of variation:

13.25–19.99% (12 traits)
20–24.99% (10 traits)
25–29.99% (7 traits)
30–40.14% (3 traits)

The highest coefficient of variation was calculated for the forelimb side-view (40.14%), chest girth (36.25%) and height at withers (30.97%). The latter two traits were measured and the measures were transformed to scores. The traits with values between 25% and 29.99% had a relatively high coefficient of variation (withers length, croup profile, neck topside, withers height, shoulder slope, head profile and breast width).

The described 28 out of the 32 traits were in the range from 7 to 9 utilized scores. All traits were within the minimum of 1–3 scores and maximum of 7–9 scores. The classifier used a very high number of scores of the scale.

In Tables 2 and 3 means of the type trait scores of the grey and black variety are shown for the studs at Kladruby and Slatiňany of the National Stud of Kladruby nad Labem on the one hand and the private breeders on the other hand. Significant differences between both varieties were found in 13 out of 32 traits. These differences result from the distinct development of both varieties after 1918. Since 1945 the black variety has been bred on the stud farm in Slatiňany and the grey variety has been kept on the stud farm in Kladruby. Until now both varieties have been bred separately. In the seventies of the last century the Old Kladrub horses expanded to state and private farms. These populations have been exclusively the property of private farmers since 1990. At this time more than a

Table 2. Least squares means (LSM) and standard errors (SE) for the varieties

Number	Trait *n*	Varieties				Level of significance
		grey		black		
		255		239		
		LSM	SE	LSM	SE	
	Front					
1	height at withers	6.03	0.19	6.22	0.20	0.2733
2	head profile	5.45	0.15	5.85	0.16	0.0031**
3	neck length	5.52	0.12	5.46	0.13	0.5950
4	neck tethering	6.14	0.10	6.52	0.11	<0.00001***
5	neck topside	6.46	0.11	6.73	0.17	0.0901
6	withers length	5.08	0.15	4.76	0.16	0.0221*
7	withers height	4.40	0.12	4.14	0.13	0.0220*
	Body					
8	topline length	5.41	0.13	5.55	0.14	0.2413
9	topline vault	4.62	0.08	4.52	0.09	0.2141
10	loin length	5.88	0.11	5.86	0.12	0.9013
11	loin vault	4.41	0.11	4.58	0.11	0.0934
12	shoulder length	4.57	0.08	4.60	0.09	0.7719
13	shoulder slope	3.86	0.10	4.01	0.11	0.1319
14	chest girth	6.92	0.23	6.53	0.25	0.0821
15	chest length	5.85	0.10	6.03	0.11	0.0635
16	chest width	5.57	0.13	5.31	0.14	0.0293*
17	chest depth	6.00	0.12	5.74	0.13	0.0208*
18	breast width	5.53	0.13	5.26	0.14	0.0245*
	Rear					
19	croup length	4.13	0.09	4.36	0.10	0.0093**
20	croup width	5.90	0.12	5.61	0.13	0.0084**
21	croup shape	4.53	0.11	4.62	0.12	0.3698
22	croup profile	5.10	0.14	5.03	0.15	0.5741
23	tail tethering	5.44	0.11	5.16	0.12	0.0064**
	Limbs					
24	forelimb front view	5.35	0.08	5.00	0.09	<0.00001***
25	forelimb side-view	4.34	0.16	4.12	0.18	0.1654
26	canon bone circumference	6,23	0.15	6.27	0.16	0.8120
27	foretoe side-view	4.68	0.09	4.45	0.10	0.0054**
28	forehoof side-view	5.08	0.10	4.96	0.10	0.1913
29	forehoof width	5.08	0.10	4.99	0.11	0.3656
30	forehoof size	5.04	0.07	4.88	0.07	0.0151*
31	hind limb side-view	4.36	0.09	4.32	0.10	0.6332
32	hind limb back view	5.02	0.08	5.00	0.09	0.8311

half of the breed population (grey and black horses) is in private hands.

In 2005 a new uniform breeding objective for both varieties was formulated with the aim to breed sire lines and dam families in both colours. The linear type classification will be an important resource for the realization of this aim. On the other hand, this arrangement will be an effective breed-

Table 3. Least squares means (LSM) and standard errors (SE) for the studs and variety × stud interaction

Number	Trait *n*	Stud farms				Significance	Signif. of interaction var. × stud
		Kladruby		private			
		201		293			
		LSM	SE	LSM	SE		
	Front						
1	height at withers	6.53	0.22	6.72	0.18	<0.0001***	0.4973
2	head profile	5.88	0.17	5.42	0.14	0.0019**	0.9994
3	neck length	5.67	0.13	5.30	0.11	0.0020**	0.4525
4	neck tethering	6.47	0.11	6.20	0.09	0.0072**	0.7290
5	neck topside	6.91	0.12	6.28	0.20	0.0002***	0.7205
6	withers length	4.84	0.17	4.99	0.14	0.3076	0.2922
7	withers height	4.25	0.14	4.28	0.12	0.7914	0.9636
	Body						
8	topline length	5.42	0.15	5.54	0.12	0.3562	0.3944
9	topline vault	4.56	0.09	4.58	0.08	0.7477	0.1765
10	loin length	5.93	0.13	5.82	0.11	0.3437	0.8349
11	loin vault	4.55	0.12	4.44	0.10	0.2941	0.6921
12	shoulder length	4.63	0.09	4.54	0.08	0.2822	0.0314*
13	shoulder slope	3.90	0.12	3.96	0.10	0.5593	0.0810
14	chest girth	7.25	0.27	6.20	0.23	<0.0001***	0.0290*
15	chest length	5.82	0.12	6.05	0.10	0.0296*	0.5523
16	chest width	5.54	0.14	5.34	0.12	0.1187	0.0746
17	chest depth	5.77	0.14	5.98	0.12	0.0850	0.0670
18	breast width	5.52	0.15	5.27	0.12	0.0541	0.0201*
	Rear						
19	croup length	4.32	0.11	4.18	0.09	0.1274	0.4551
20	croup width	5.85	0.13	5.65	0.11	0.0938	0.0803
21	croup shape	4.65	0.12	4.50	0.10	0.1600	0.0400*
22	croup profile	5.28	0.13	4.85	0.13	0.0021**	0.3746
23	tail tethering	5.39	0.13	5.21	0.11	0.1204	0.1301
	Limbs						
24	forelimb front view	5.26	0.09	5.09	0.08	0.0445*	0.0095**
25	forelimb side-view	4.26	0.19	4.20	0.16	0.7237	0.5314
26	canon bone circumference	6.60	0.17	5.90	0.14	<0.0001***	0.0001***
27	foretoe side-view	4.48	0.10	4.65	0.09	0.0544	0.4482
28	forehoof side-view	4.97	0.11	5.07	0.09	0.3507	0.1251
29	forehoof width	4.88	0.12	5.18	0.10	0.0047**	0.5211
30	forehoof size	4.91	0.08	5.01	0.06	0.1185	0.0023**
31	hind limb side-view	4.38	0.11	4.30	0.09	0.3589	0.6699
32	hind limb back view	5.11	0.09	4.91	0.08	0.0118*	0.8825

ing step for the conservation of genetic diversity within the breed.

In the black variety the head profile was more expressed and the neck tethering was higher. Both traits correspond more to the breeding objective. This was due to the consistent selection and the closing of this population to immigration of genes from other breeds in 1992. The withers length and

Table 4. Least squares means (LSM) and standard errors (SE) for the sex

Number	Trait	Sex				Level of significance
		stallion		mare		
	n	63	12.75 (%)	431	87.25 (%)	
		LSM	SE	LSM	SE	
	Front					
1	height at withers	6.30	0.27	5.95	0.14	0.1817
2	head profile	5.91	0.21	5.39	0.11	0.0113*
3	neck length	5.64	0.17	5.34	0.09	0.0638
4	neck tethering	6.66	0.14	6.00	0.07	< 0.0001***
5	neck topside	7.05	0.25	6.14	0.13	0.0001***
6	withers length	4.66	0.22	5.17	0.11	0.0160*
7	withers height	3.95	0.18	4.59	0.09	0.0002***
	Body					
8	topline length	5.28	0.19	5.68	0.10	0.0275*
9	topline vault	4.63	0.12	4.51	0.06	0.2488
10	loin length	5.52	0.16	6.23	0.08	< 0.0001***
11	loin vault	4.71	0.15	4.28	0.08	0.00420**
12	shoulder length	4.56	0.11	4.61	0.06	0.6010
13	shoulder slope	4.09	0.15	3.77	0.08	0.0290*
14	chest girth	6.58	0.34	6.87	0.18	0.3779
15	chest length	5.64	0.15	6.25	0.08	< 0.0001***
16	chest width	5.36	0.18	5.52	0.09	0.3711
17	chest depth	5.47	0.18	6.28	0.09	< 0.0001***
18	breast width	5.30	0.19	5.49	0.10	0.3138
	Rear					
19	croup length	4.22	0.14	4.28	0.07	0.6100
20	croup width	5.38	0.17	6.12	0.09	< 0.0001***
21	croup shape	4.62	0.16	4.53	0.08	0.5217
22	croup profile	5.28	0.20	4.85	0.10	0.0228
23	tail tethering	5.53	0.16	5.07	0.08	0.0028**
	Limbs					
24	forelimb front view	5.14	0.12	5.21	0.06	0.5577
25	forelimb side-view	4.29	0.24	4.16	0.12	0.5730
26	canon bone circumference	6.24	0.22	6.26	0.11	0.9085
27	foretoe side-view	4.58	0.13	4.55	0.07	0.8352
28	forehoof side-view	5.01	0.14	5.03	0.07	0.9191
29	forehoof width	5.11	0.15	4.96	0.08	0.3020
30	forehoof size	5.00	0.10	4.92	0.05	0.3736
31	hind limb side-view	4.34	0.13	4.34	0.07	0.9587
32	hind limb back view	5.06	0.12	4.97	0.06	0.4326

height, chest width, depth and breast width are significantly more expressed in the grey variety.

In the height at withers, neck length and topside and other body traits no significant differences between both varieties were found.

The croup is longer in the black variety. The scores of the croup width, tail tethering, forelimb front view and foretoe side-view are highly significantly and significantly higher of the forehoof size in the grey variety. No significant differences were

Table 5. Significance of the differences between the year of birth and age at classification

Number	Trait n = 494	Overall mean	Year of birth	Age at classification
	Front			
1	height at withers	5.98	0.3072	0.4301
2	head profile	5.44	0.7873	0.0580
3	neck length	5.16	0.0455*	0.0508
4	neck tethering	5.99	0.0127*	0.0734
5	neck topside	6.04	< 0.0001***	0.1536
6	withers length	4.99	0.0019**	0.1964
7	withers height	4.41	0.5334	0.0267*
	Body			
8	topline length	5.57	0.1943	0.1226
9	topline vault	4.60	0.0511	0.2824
10	loin length	5.98	< 0.0001***	< 0.0001***
11	loin vault	4.43	< 0.0001***	0.0225*
12	shoulder length	4.52	< 0.0001***	0.0003**
13	shoulder slope	3.85	0.3873	0.8843
14	chest girth	6.40	0.7219	0.2755
15	chest length	6.14	0.0516	0.3779
16	chest width	5.15	0.0712	< 0.0001***
17	chest depth	6.03	0.0008**	0.0003***
18	breast width	5.14	0.0362*	0.0002***
	Rear			
19	croup length	4.15	0.6100	0.0050**
20	croup width	5.89	0.0008***	0.0001***
21	croup shape	4.47	0.0048**	0.5603
22	croup profile	4.70	0.0011**	0.0016**
23	tail tethering	5.05	< 0.0001***	0.1013
	Limbs			
24	forelimb front view	5.06	0.5170	0.0569
25	forelimb side-view	4.03	0.3086	0.1346
26	canon bone circumference	6,18	0.4603	0.0748
27	foretoe side-view	4.56	< 0.0001***	0.0048**
28	forehoof side-view	4.89	< 0.0001***	0.0083**
29	forehoof width	5.05	0.0431*	0.5311
30	forehoof size	4.98	< 0.0001***	0.0214*
31	hind limb side-view	4.40	< 0.0001***	0.0898
32	hind limb back view	4.94	0.4301	0.2228

found in the croup shape and profile and the rest of the limb traits between both varieties.

Horses of both varieties with the desirable traits will be selected and used for corrective mating to attain the breed uniformity in these linear type traits which show a significant difference in the grey and black variety.

The conformation of the grey variety corresponds more to the breeding goal, above all in the wider and deeper chest, larger width of breast and croup, higher tail tethering, broad forelimb front view and weaker foretoes (side view). This is due to several factors such as the consequent selection for these traits, immigration of genes of

the sire line Favory of the Lipizzan breed and of the breed Lusitano due to the imported stallion Rudolfo.

The inclusion of private studs in the breeding programme is a further important contribution to the conservation of genetic diversity within the breed. Between the Kladruby studs and the private ones highly significant differences were found in five out of seven front traits (height at withers, head profile, neck length, tethering and topside), chest girth, croup profile, cannon bone circumference, forehoof width and significant differences between chest length, forelimb front view and hind limb back view. The consequence of this fact is a positive response of the horses on the National Stud Farm in the convex head profile, longer neck, convex neck topside, longer chest girth, vaulted croup profile, broader forelimbs and hind limbs poise. This is also due to the consequent breeding and immigration of favourable genes from breeds of Old Spanish origin (Lipizzan, Lusitano, Friesian).

The horses on the private stud farms show a higher height at withers, longer chest and broader forehoof. Highly significant and significant variety × stud interactions were recorded in only 7 traits.

Significant differences between stallions and mares were recorded in a large number of front and body traits (in 11 out of 18 traits) and in 2 rear traits (Table 4). In stallions the head profile, neck tethering, topside, loin vault, shoulder slope and tail tethering were highly significant and significantly more expressed. The mares showed highly significantly and significantly higher scores in the withers length and height, loin and chest length, chest depth and croup width. No significant differences were found between stallions and mares in limb traits.

The differences between stallions and mares were firstly the result of the sexual dimorphism. The more favourable expression of stallion traits could be influenced by the more intensive selection.

In Table 5 only the significance of the year of birth and the age at classification is recorded. Significant differences between the years of birth were found in 18 out of 32 traits. Significant differences between the ages at classification were found in 13 out of 32 traits. A large number of significant differences for the mentioned traits indicate a large variation of the effects within the factors. The year of birth and the age at classification are not important factors for the selection of horses with respect to the linear type traits. The classification, performance recording and selection are carried out in the population of four-years-old horses born in the given year. The age at classification does not play a role because all horses are now classified at a standard age of four years each year.

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