ANALYSIS OF LINEAR TYPE TRAITS IN HOLSTEIN COWS IMPORTED TO THE CZECH REPUBLIC

V. Jakubec, I. Majzlík, M. Staňková, V. Novotný

Czech University of Agriculture, Faculty of Agronomy, Prague, Czech Republic

In the years 1990–1995 8,445 mainly highly pregnant Holstein heifers were imported to the Czech Republic from France, Germany, the Netherlands and Denmark. Following 16 linear type traits of 2,227 cows of this breed were assessed: angularity, stature, strength, body depth, rump angle, rump width, legs side view, legs rear view, foot angle, fore udder attachment, rear height udder attachment, rear width udder attachment, udder support, udder depth, teat placement and teat length. In a mixed linear model following factors were analysed: herd, year of assessment, lactation number, lactation phase and sire line. The herd was highly significant for all traits. The differences between herds included not only the environmental differences, but also genetic differences due to the origin of breeds. The factors lactation number and lactation phase were highly significant and significant in 15 traits. For both factors the rump angle was non-significant. In the Czech Republic the linear assessment of Holstein cows is now carried out according to a standard method at first lactation from 30 to 180 days after parturition. The analysis showed that the methodological principles of the linear assessment are quite right and no innovation is necessary. Highly significant and significant differences were reported for stature, strength, body depth, rump angle, rump width, legs side view, rear height udder attachment, rear width udder attachment, udder support, udder depth and teat placement. The differences in the rest of 5 factors were non-significant. The sire line was also significant for 11 traits (angularity, strength, rump angle, rump width, legs side view, legs rear view, fore udder attachment, rear width udder attachment, udder support, teat placement and teat length. The differences of effects within the other 5 factors were non-significant. The linear type traits as secundary traits are very important for a more efficient estimation of animal breeding values and for the optimization of mating schemes.

dairy cows; linear type traits; analysis; environmental factors; sire lines

INTRODUCTION

In the Black Spotted cattle the genetic level and milk production have been improved in the Czech Republic after 1989. This was conditioned above all by numerous imports of high quality heifers, semen and embryos of the Holstein breed in the first half of the 1990s.

Urban et al. (1997) reported that 8,495 heifers, mostly highly pregnant ones, of the Black Spotted breed were imported. The most heifers were imported from France (3,901) and Germany (3,581). A lower number of heifers was imported from the Netherlands (386). The average performance of these heifers was at the first lactation 6,215 kg of milk with the fat content 4.18% and protein content 3.26%.

To assess the contribution of imported heifers to improve the conformation traits of the Black Spotted cattle, it is desirable and interesting, except for milk production, to carry out an analysis of the linear type classification in the imported cows. In addition to that, an analysis of internal and external environmental factors are in the centre of concern together with genetic factors which affect linear type traits. This is one of the last opportunities to realize such an analysis. The linear type classification is now standardized according to new guidelines and the data obtained in such a way could not be used for such an analysis. The contemporary linear type classification in the cow populations is carried out at the first lactation and in an exactly defined period.

Attention has been paid abroad to factors which affect the linear type traits. For example Thompson and Freeman (1983) studied the effect of classifier, age of cows at classification, lactation phase and sire line on the linear type traits in the Holstein breed. They found that the lactation phase had the greatest effect on the classified traits (differences for all traits were highly significant and significant). Foster et al. (1988) came to similar conclusions. In addition, these authors reported that age at parturition has only a non-significant effect on the linear type classification.

Thompson and Freeman (1983) found that the age of dairy cows is an important source of variability for all linear type traits except the legs side view and foot angle. The optimal period for the linear type classification of the Black Spotted cattle are three months after parturition (Bouška et al., 1988). This conclusion has been confirmed by Vacek and Vetýška (1990) that linear type classification can be done from 60 to 180 days after parturition. Pilát (1992) found an optimum of linear type classification within the fourth to the seventh month of lactation. Thompson and Freeman (1983) found also a significant effect of sire on all linear type traits.

The objective of the conformation assessment through linear type traits is the precise breeding value estimation and the design of mating schemes (Seiber et al., 1988). Novotný (1999) also calls attention to the importance of linear type classification for the design of mating schemes by computer. In connection with this fact he points out correction mating schemes WMS (World-Wide Mating Service) – pedigreemate which is now applied in the Czech Spotted cattle in the Czech Republic. Despite the fact that this scheme does not work directly with production traits but prevailingly with linear type traits, the programme algorithm consists in the preference of such a conformation of the sire and dam which supports a long-time improvement of quantitative and qualitative milk production. Except of linear type traits the programme takes into account to breeder's wish these parameters: size of inbreeding coefficient, recessive defects, easy birth, protein content and milking ability.

From the mentioned factors, which affect the linear type traits and which are used for the breeding value estimation of sires and dams and the optimization of mating schemes results their importance for the running analysis.

The objective of the study is the analysis of factors affecting the linear type traits.

MATERIAL AND METHODS

The linear type classification of 16 traits in 2,227 Holstein cows imported predominantly from France and Germany and also to a lesser extent from the Netherlands and Denmark, in the years1994 to 1998, was done by one classifier in twelve herds of different size.

The data were obtained from the data base of the MTS Limited Liability Company, Jičín. The classification for 14 traits (angularity, stature, strength, body depth, rump angle, rump width, legs side view, foot angle, fore udder attachment, rear height udder attachment, udder support, udder depth, teat placement, teat length) was carried out according to the valid methodology since the 1st September 1993. Two additional traits were classified: rear width udder attachment and legs rear view.

All the traits were analysed by the least squares method using the GLM methodology (SAS, 1999). The linear model included the following fixed factors: herd, year of classification, lactation number, lactation phase and sire line:

$$y_{ijklmn} = \mu + a_i + b_j + c_k + d_l + f_m + e_{ijklmn}$$

where: y_{ijklmn} – observed linear type trait
μ – overall mean

a_i – effect of the i-th herd (i = 1, ..., 12)
b_j – effect of the j-th year of assessment (j = 1, ..., 5)
c_k – effect of the k-th lactation number (k = 1, ..., 8)
d_l – effect of the l-th lactation phase (l = 1, ..., 6)
f_m – effect of the m-th sire line (m = 1, ..., 35)
e_{ijklmn} – random residual error

It is necessary to add to the effect of lactation number that eight effects were analysed in total, i.e. seven lactations and the effect of heifers which did not calve. Lactation phases are classified in this way: S – parturition to 14 days, E – 15 to 90 days, M – 91 to 210 days, L – 211 to 305 days, D – over 305 days, N – lactation phase not found.

RESULTS AND DISCUSSION

Basic statistical characteristics of the set are presented in Table I. With respect to the fact that the score classification serves to the trait assessment, not to its qualitative expression, this score classification is a starting point for the evaluation of this population in time or for a comparison with other

I. Means, standard deviations (SD), variation coefficients (CV) of scores of linear type traits

Trait	Mean	SD	CV (%)
1. Angularity	5.68	1.28	22.55
2. Stature	6.64	1.24	18.69
3. Strength	5.45	0.98	17.98
4. Body depth	6.31	0.89	14.16
5. Rump width	5.06	0.97	19.24
6. Rump angle	5.69	1.02	17.82
7. Legs side view	5.29	1.09	20.79
8. Legs rear view	4.81	1.31	27.35
9. Foot angle	5.01	1.27	25.39
10. Fore udder attachment	5.24	1.53	29.24
11. Rear height udder attachment	5.99	0.96	16.04
12. Rear width udder attachment	5.37	1.15	21.34
13. Udder support	5.09	1.41	27.72
14. Udder depth	5.62	1.22	21.79
15. Teat placement	4.59	1.06	23.21
16. Teat length	4.69	0.89	18.87

populations (genotypes). With respect to the selection standard deviations and particularly variation coefficients of scores of various linear type traits are of greater importance. Though these parameters are a criterion of the phenotype variability, we can expect that the higher phenotype variability is also connected with a higher genetic variability. Therefore a greater response to selection can be expected in traits with higher variation coefficients. The difference between the trait with the lowest variation coefficient (body depth – 14.16%) and the trait with the highest variation coefficient (fore udder attachment – 29.24 %) was 15.08 %. If this interval is divided into three parts, the following classification of the traits is obtained: class I 14.2–19.1%, II 19.2–24.1% and III 24.2–29.3%. Therefore class I includes six traits (37.5%), class II also includes six traits (37.5%) and class III (25%), i.e. foot angle, legs side view, udder support and front udder attachment. The lowest response to selection (again ascendingly according to the variation coefficient) can be expected in body depth, rear height udder attachment, rump angle, strength, stature and teat length. More detailed information on the genetic variability can be drawn from the heritability coefficients of linear type traits.

Table II gives statistical significances of the analysed factors for different traits. The factor herd was highly significant for all traits. Differences between herds included not only the environmental differences in the widest sense of word, i.e. the herd and the type of housing, but also genetic differences that were caused by differences in the origin of these animals which were imported from different countries. With respect to the unsuitable structure of data, an analysis according to the country of origin was not possible. Therefore it will be necessary to pay proper attention to these factors in another data set analyses.

The factors lactation number and lactation phase showed highly significant and significant differences in 15 traits. The differences were insignificant for rump angle for both factors. Both factors were included in the model in addition for the analysis of the effect of cow's age (lactation number) and lactation phase to express linearly classified traits (conformation traits) and to minimize the residual (error) variance. Nowadays such analyses are not possible, since the lactation number and lactation phase are standardized in the new methodology.

Differences in the year of classification were highly significant and significant for stature, strength, udder support, udder depth, teat placement and rear width udder attachment. The differences for the other five traits were insignificant. It means that in the breeding value prediction of sires and cows it is necessary to adjust scores of these traits in which the factor year of classification was significant at least. This condition can be fulfilled for linear type traits, if adjustments for the effect herd, year and season are done.

II. Statistical significances of analysed traits for different traits

Trait	Trait				
	herd	year of classification	lactation number	lactation phase	sire line
1. Angularity	**		**	**	**
2. Stature	**	**	**	**	**
3. Strength	**	*	**	**	
4. Body depth	**	**	**	**	
5. Rump width	**	**	*	*	**
6. Rump angle	**	**			**
7. Legs side view	**	**	*	**	**
8. Legs rear view	**		**	**	**
9. Foot angle	**		**	**	
10. Fore udder attachment	**		**	**	**
11. Rear height udder attachment	**	**	**	**	
12. Rear width udder attachment	**	**	**	**	*
13. Udder support	**	**	*	**	**
14. Udder depth	**	**	**	**	
15. Teat placement	**	**	**	**	**
16. Teat length	**		**	*	**

* $P < 0.05$, ** $P < 0.01$

Means of scores in different lactations (Table III) are interesting. From the total number of 2,227 animals which were linearly classified, 219 animals were heifers, i.e. 9.8%, 1,785 cows at the first lactation, i.e. 80.1%, 148 cows at the second lactation, i.e. 6.6% and 57 cows at the third lactation, i.e. 2.6%. This represents 2,209 cows in total, i.e. 99.2 %. The remaining percentage of cows from the fourth to the seventh lactation (18 cows – 0.8%) is negligible, and therefore the statistical parameters for the effects of cows from the fourth to the seventh lactation are not presented in Table III.

With respect to the fact that the classification is done in the cows at the first lactation according to the methodology, the average score expression from the first to the third lactation was compared in Table III. A highly significant difference was found between the minimum score expression at the first lactation and maximum score expression at the second lactation. It is evident from this that the dairy type is manifested better at the second and

III. Least squares means (LSM) of scores and their standard errors (SE) for the lactation number

Trait	Cow lactation number								
	heifers		1		2		3		diff.+
	LSM	SE	LSM	SE	LSM	SE	LSM	SE	
1. Angularity	5.38	0.21	5.62	0.16	6.11	0.19	5.98	0.24	0.49**
2. Stature	5.39	0.19	6.74	0.15	6.59	0.19	7.06	0.23	0.47*
3. Strength	5.38	0.15	5.27	0.12	5.61	0.15	6.02	0.19	0.75**
4. Body depth	6.24	0.14	6.19	0.11	6.77	0.14	7.13	0.17	0.94**
5. Rump width	5.33	0.15	5.11	0.12	5.26	0.15	5.41	0.18	0.30
6. Rump angle	5.61	0.16	5.62	0.12	5.85	0.15	5.97	0.19	0.35*
7. Legs side view	5.36	0.17	5.35	0.13	5.41	0.17	5.51	0.21	0.16
8. Legs rear view	3.74	0.21	4.69	0.16	4.55	0.21	4.28	0.25	0.41
9. Foot angle	4.21	0.19	4.58	0.15	4.26	0.19	3.85	0.24	0.73**
10. Fore udder attachment	4.76	0.24	4.81	0.19	4.63	0.23	4.34	0.29	0.47
11. Rear height udder attachment	5.31	0.15	6.08	0.12	6.25	0.15	5.52	0.18	0.56**
12. Rear width udder attachment	5.64	0.18	4.99	0.14	5.48	0.17	5.23	0.22	0.49**
13. Udder support	4.96	0.22	4.85	0.17	4.73	0.22	4.19	0.27	0.66**
14. Udder depth	4.89	0.19	5.77	0.15	4.72	0.19	4.05	0.23	1.72**
15. Teat placement	4.96	0.17	4.73	0.13	4.43	0.16	4.39	0.21	0.34
16. Teat length	5.21	0.14	4.71	0.11	4.91	0.14	5.23	0.17	0.52**

* $P < 0.05$, ** $P < 0.01$
+ difference between extremes

third lactation than at the first one. For the majority of the traits which develope with age in individuals, highly significant and significant differences were found between the extreme score classification at the first and third lactation (strength, body depth) and at the second and third lactation (stature), while minimum values were found at the first or second lactation, resp. and maximum values at the third lactation. This conclusion is logical because cows are still growing after the first lactation. The differences for rump width between the minimum expression at the first lactation and maximum expression at the third lactation were insignificant.

The next set of traits is: rump angle, legs side view, legs rear view and foot angle. In the case of rump angle more significant angle appeared from the first to third lactation. Legs side view and legs rear view from the first to the third lactation did not change basically. Differences in the score expression of foot angle were highly significant between the first and third lactation, the claw flattens with age.

The remaining traits are connected with the udder structure and placement. No differences were found in the fore udder attachment and teat placement between the first and third lactation which exhibited extreme values. Rear height udder attachment showed a higher score expression at the second lactation and the lowest one at the third lactation. The difference was again highly significant.

The score expression of rear width udder attachment and teat length was growing significantly from the first to the second lactation or to the third lactation, respectively. It is interesting that a highly significant difference was found in the udder support between the first and third lactation. There was an outstanding better placement of udder support at the first lactation than at the third lactation. Teat depth was increasing significantly from the first to the third lactation, i.e. highly significant decrease of score classification was reported. Differences between lactations were insignificant for teat placement.

With respect to the fact, that the data provided information for the analysis of the lactation phase, while the observation ranged from birth to 305 days of age, this factor was included in the more detailed classification (Table IV).

From this table was the phase S (0–14 days) deleted because of only nine observations (0.4%). Further the class N was deleted since it comprised cows with not known lactation phase. Therefore phases with these absolute and relative frequencies were included into the classification: phase E (15–90 days) – 1,307 cows, 58.7%, M (91–210 days) – 566 cows, 25.4%, L (211–305 days) – 169 cows, 7.6% and D (over 305 days) – 29 cows, 1.3%. From the total number 2,227 of classified cows 2,071 cows, i.e. 92,99% represented the mentioned phases.

In the case of angularity the best score expression was in phase E (15–90 days) and towards the phases L and D highly significant decrease in the scores appeared. The factor stature had the highest number of scores in phase M (91–210 days), the lowest in phase L (211–305 days). Regarding all phases, it can be said that the score classification fluctuated extremely. In the factor strength, body depth and rump width a significant growth of scores was evident with the advancing lactation phases. Though in the factor rump angle was a significant difference between the phase E and L in the score favour of phase E, fluctuation between phases was evident, it can be said that fluctuation between different phases showed no tendency. Differences in the score expression of the legs side view were insignificant. The legs rear view and foot angle had the maximum in the phase M and the minimum in the phase D. The score difference was significant or highly significant, respec-

IV. Least squares means (LSM) of scores and their standard errors (SE) for the lactation phase

Trait	Lactation phase								
	E		M		L		D		diff.+
	LSM	SE	LSM	SE	LSM	SE	LSM	SE	
1. Angularity	5.53	0.28	5.41	0.29	4.99	0.32	4.99	0.39	0.54**
2. Stature	5.59	0.28	5.99	0.29	5.49	0.31	5.66	0.37	0.50**
3. Strength	5.55	0.22	5.95	0.23	6.13	0.24	5.73	0.29	0.58**
4. Body depth	6.81	0.20	7.05	0.21	7.24	0.22	7.41	0.27	10.60**
5. Rump width	5.26	0.22	5.27	0.23	5.56	0.24	5.32	0.29	0.30**
6. Rump angle	5.86	0.23	5.79	0.24	5.62	0.25	5.84	0.31	0.24*
7. Legs side view	5.57	0.25	5.45	0.25	5.74	0.27	5.78	0.33	0.33
8. Legs rear view	4.38	0.29	4.48	0.31	3.98	0.32	3.87	0.39	0.61*
9. Foot angle	4.24	0.29	4.57	0.29	3.72	0.31	3.57	0.38	1.00*
10. Fore udder attachment	4.39	0.35	4.36	0.36	3.62	0.38	3.35	0.46	1.04*
11. Rear height udder attachment	5.77	0.22	5.86	0.22	5.25	0.24	5.19	0.29	0.67**
12. Rear width udder attachment	4.92	0.26	4.79	0.27	4.15	0.28	3.85	0.35	1.07**
13. Udder support	4.43	0.32	4.57	0.33	3.91	0.35	3.91	0.43	0.66**
14. Udder depth	4.27	0.28	4.17	0.28	3.87	0.31	3.72	0.37	0.55*
15. Teat placement	4.51	0.24	4.71	0.25	4.59	0.26	4.83	0.32	0.32
16. Teat length	5.13	0.21	5.13	0.21	5.35	0.22	5.53	0.27	0.40*

* $P < 0.05$, ** $P < 0.01$

+ difference between extremes

tively. In all traits of udder (front udder attachment, rear height udder attachment, rear width udder attachment, udder support, udder depth) between phases with the maximum (phases E and M) on one hand and the minimum (phase D) on the other hand of the scores prevailingly highly significant differences and in one case significant differences were recorded. Differences in the score expression of teat placement were insignificant, therefore no tendency in change of this property can be found. Teat length in the score expression was highly significantly increasing from phases E and M to the phase D. Practically in all linear type traits was evident that it is favourable to classify the cows in the first two phases E and M, i.e. from 15 to 210 days.

The national methodology for the Black Spotted cattle specifies that the linear type classification is done in cows at the first lactation and in the period from 30 to 180 days after parturition. From the analysis of the lactation

V. Least squares means (LSM) of scores and their standard errors (SE) for the year of classification

Trait	Year of classification										
	1994		1995		1996		1997		1998		diff.[+]
	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	
1. Angularity	5.07	0.31	5.27	0.31	5.21	0.32	5.18	0.32	5.48	0.38	0.41
2. Stature	4.73	0.29	6.49	0.31	6.21	0.31	6.38	0.31	6.36	0.36	1.76**
3. Strength	5.85	0.23	6.06	0.24	5.93	0.24	6.09	0.29	5.79	0.29	0.30
4. Body depth	7.06	0.21	7.48	0.22	6.89	0.22	6.71	0.22	7.19	0.26	0.77**
5. Rump width	5.01	0.23	5.41	0.24	5.41	0.24	5.31	0.24	5.25	0.29	0.40**
6. Rump angle	5.96	0.24	6.01	0.24	5.47	0.25	5.64	0.25	5.69	0.29	0.54**
7. Legs side view	5.29	0.26	5.44	0.27	5.73	0.27	5.75	0.27	5.78	0.32	0.49*
8. Legs rear view	4.28	0.31	4.52	0.32	4.13	0.32	4.27	0.32	4.28	0.38	0.39*
9. Foot angle	3.69	0.31	4.09	0.31	4.11	0.31	4.04	0.31	3.62	0.37	0.49*
10. Fore udder attachment	3.71	0.36	4.09	0.37	4.03	0.38	3.94	0.38	4.07	0.45	0.38*
11. Rear height udder attachment	5.27	0.23	5.31	0.23	5.72	0.24	5.37	0.24	6.06	0.28	0.79**
12. Rear width udder attachment	4.25	0.27	4.91	0.28	4.22	0.28	4.41	0.28	4.81	0.34	0.59**
13. Udder support	3.45	0.34	4.05	0.34	4.39	0.35	4.24	0.35	4.69	0.41	1.24**
14. Udder depth	3.57	0.29	3.62	0.29	4.75	0.31	4.39	0.31	4.03	0.36	1.18**
15. Teat placement	4.02	0.25	4.45	0.26	4.89	0.26	4.68	0.26	4.76	0.31	0.87**
16. Teat length	5.34	0.21	5.38	0.22	5.15	0.22	5.36	0.22	5.24	0.26	0.23*

* $P < 0.05$, ** $P < 0.01$

[+] difference between extremes

number and lactation phase follows that the determined methodological principles are correct and no innovation is needed.

Table V presents the least squares means of the scores (LSM) and their standard error (SE) for the factor year of classification. This table has a complementary character and will not be analysed in detail with respect to the fact that no generalizing tendency can be found for the classsification of different traits in different years. The frequency distribution with respect to the year of classification was favourable, except the year 1998: 1994 – 346 cows, 15.5%, 1995 – 524 cows, 23.5%, 1996 – 802 cows, 36.0%, 1997 – 504 cows, 22.6% and 1998 – 51 cows, 2.3%. In 1994 minimum values were

found in the majority of traits, in 1997 the score expression was intermediary in most traits. The year 1995 showed maximum and average score values in different traits.

The identical number of highly significant and significant differences in the analysed traits was found for the factor sire line (angularity, stature, rump angle, rump width, legs side view, front udder attachment, udder support, teat placement, rear width udder attachment, legs rear view). In the remaining five traits the differences were insignificant. In the design of mating schemes with respect to linear traits and the corresponding sire lines these traits can be deleted: strength, body depth, foot angle, rear height udder attachment and udder depth.

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V letech 1990–1995 bylo do České republiky dovezeno 8 445 většinou vysokobřezích jalovic plemene holštýnsko-fríské z Francie, Německa, Nizozemí a Dánska.

U 2 227 krav tohoto plemene bylo popsáno 16 znaků lineárního typu: hranatost, velikost, šířka hrudníku, hloubka těla, sklon zádě, šířka zádě, postoj zadních končetin, postoj pánevních končetin zezadu, utváření paznehtů pánevních končetin, přední upnutí vemene, výška zadního upnutí vemene, šířka zadního upnutí vemene, závěsný vaz, hloubka vemene, rozmístění struků a délka struků. Pomocí lineárního modelu s fixními efekty byly u 16 znaků lineárního typu analyzovány tyto faktory: stádo, rok hodnocení, pořadí laktace, fáze laktace a otcovská linie. Faktor stáda byl vysoce významný pro všechny znaky. Rozdíly mezi stády zahrnovaly nejen rozdíly v prostředí, nýbrž i genetické rozdíly, které byly způsobeny rozdíly mezi původem těchto zvířat, která byla dovezena z různých zemí. Faktor pořadí laktace a fáze laktace vykazovaly vysoce významné a významné rozdíly u 15 znaků. Pro sklon zádě byly pro oba faktory rozdíly nevýznamné. Pro černostrakatý skot je celostátní metodikou určeno, že se lineární popis provádí u prvotelek, tj. na první laktaci, a v období od 30 do 180 dnů po otelení. Z analýzy jak faktoru pořadí laktace, tak i fáze laktace vyplývá, že stanovené metodické zásady jsou správné a nepotřebují žádnou inovaci. Rozdíly v rocích hodnocení byly vysoce významné a významné pro velikost, šířku hrudníku, hloubku těla, sklon zádě, šířku zádě, postoj zadních končetin, výšku zadního upnutí vemene, závěsný vaz, hloubku vemene, rozmístění struků a šířku zadního upnutí vemene. Pro ostatních pět znaků byly rozdíly nevýznamné. Stejný počet vysoce významných a významných rozdílů mezi znaky byl zaznamenán u faktoru otcovské linie (hranatost, velikost, sklon zádě, šířka zádě, postoj zadních končetin, postoj pánevních končetin zezadu, přední upnutí vemene, šířka zadního upnutí vemene, závěsný vaz, rozmístění struků, délka struků). U zbývajících pěti znaků byly rozdíly nevýznamné. Znaky lineárního typu, jakožto sekundární znaky, jsou velmi důležité pro účinnější odhad plemenné hodnoty a optimalizaci připařovacích plánů.

dojnice; znaky lineárního typu; analýza; faktory prostředí; otcovské linie

Contact Address:

Prof. Ing. Václav J a k u b e c, DrSc., Česká zemědělská univerzita, Agronomická fakulta, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika, tel.: 02/24 38 30 31, e-mail: jakubec@af.czu.cz