THE IMPACT OF ENVIRONMENTAL FACTORS AND SIRES ON PERFORMANCE TRAITS IN THE OLD KLADRUB HORSE

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Performance traits of individuals and sires of performance tests on station of stallions and mares were analysed in the Old Kladrub breed from 1988 to 1997. Data on 183 progeny of 29 sires were used. The following traits were scored by means of a scale of 10 points: total score, type and sex expression, conformation, performance, training, rideability, locomotion, marathon, span control, test of pulling reliability. The linear model considered the fixed effects of year and sex and the random effect of sires. In most of the traits with the exception of type, sex expression and rideability significant and highly significant differences were found. The stallions showed higher scores in all traits. The year of test had a highly significant impact on all traits with the exception of total score and pulling reliability. In almost all traits differences between sires were not significant with the exception of rideability. The reason for non-significance was supposed to be the small number of progeny in the sire groups. A BLUP – SIRE MODEL procedure for the estimation of breeding values based on the information on individual and progeny performance was developed and verified. The procedure supposed to be extended to other horse breeds.

Old Kladrub horse; performance traits; environmental factors; sires; breeding values

INTRODUCTION

Unlike the traits in farm animals, most of the desirable traits in sport horses cannot be weighted, measured or determined in another objective manner. This applies to the interior characteristics such as, e.g. temperament, character, willingness, rideability, as well as to the conformation traits (Glodek et al., 1975; Bruns, 1988; Huizinga, 1990). Determination of the spaciousness and cadence of gaits in walk, trot and gallop is insufficient as well.

The lack of objective criteria results in the demand for evaluation of most of the characteristics by experienced experts which is a pre-condition for the choice of selection criteria and the evaluation of breeding values.

Attempts made for many years in both science and practice aimed at procedures as objective as possible for the subjective evaluation and judgement of utility and performance characteristics as well as of conformation traits. A considerable contribution to making the process of scoring characteristics and traits more objective is the evaluation and judgement of horses by a commission, i.e. by more than a single trainer, judge or rider (Grundler, Pirchner, 1991; Schwark et al., 1992).

It is known that the more characteristics and traits are included in a breeding programme, the smaller is the selection progress achieved in individual characteristics and traits. Although the breeding objective is defined by numerous characteristics and traits, it is necessary to concentrate on the most important selection criteria. Selection criteria should be chosen with respect not only to genetic but also to economic aspects. However, the issue of definition of economic values for individual characteristics in horses is still open (Klemetsdal, 1990).

In spite of the above mentioned facts, there are single studies dealing with the definition of economic values. Thus Bruns et al. (1978) and Schwark et al. (1988), tried to derive economic values from prices of horses sold at auctions. According to Kalm (1993), such economic values are but auxiliary quantities as prices at auctions not only vary with the current demand and supply but also represent only a part of the total market. Hence such prices are not representative for the whole horse market.

Information sources

Further steps in horse breeding are the selection of information sources and the data collection for the evaluation of breeding values and selection which is carried out within the framework of performance recording. At the time being tests of the performance of Old Kladrub horses are carried out in the Czech Republic in compliance with the current standard of 1994. Traits of the linear scoring system have been verified and described for the same breed in 1996. The task now is to utilize the information thoroughly for the choice of selection criteria, the evaluation of breeding values and the mating of horses. The first step is the evaluation of breeding values of foals for pre-selection as all born animals are available at this stage. Furthermore, it is the only possibility in the graying Old Kladrub horses to determine the basic colour as foals get gray soon after birth. The selection itself according to the own performance, traits of the linear scoring system and conformation evaluation follows at 3 to 4 years of age in the population which has already been pre-selected on the basis of the evaluation of foals and during their growth. The next step is the evaluation of breeding values of sires based on the information on progeny. A problem in horses is to get a number of progeny higher than 20 for stallions. Some authors consider 8 to 10 progeny as the minimum number. In terms of theory, the breeding of sires with a randomly chosen population of mares is necessary for a reliable estimate of the breeding value based on the progeny information. This condition is hard to meet in horses, especially in the Old Kladrub breed with its limited size. For this reason specific procedures are necessary to enable certain corrections for the estimates of breeding values. Besides the corrections for the systematic effects of the external and internal environment, the genetic level of the mares is to be considered. The application of the "BLUP – ANIMAL MODEL" to the estimation of breeding values allows to include information on all related individuals, i.e. performance of ancestors, individual performance, performance of progeny as well as of half- and full sibs.

The last but not the least is the importance of the comprehensive health evaluation for breeding. In comparison to other performance and conformation traits the heritability of health traits is substantially smaller. Therefore, genetic health control is rather important. Some diseases or defects are qualitative characteristics which require not only determination of the frequency of occurrence (phenotypic frequencies) but also genotype and gene frequencies which are the hereditary parameters of these characteristics. Where the mode of inheritance is known for these characteristics, selection measures can be applied which minimize the occurrence of these hereditary diseases and defects. Comprehensive determination of the occurrence and heritability of health traits requires a close cooperation between breeders and veterinarians.

Estimation of breeding value

Direct measurement of the genetic constitution of horses and thus the breeding value of animals is not possible. Phenotypic performance characteristics and traits are more or less influenced by conditions of the external (year, season, herd, location of test, trainer, judge) and internal (age of mares, foal sequence, sex) environment. Sophisticated biometric methods (e.g. of generalized least squares) allow to estimate the size and direction of environmental factors together with the evaluation of breeding values and to eliminate these disturbing factors.

The estimation of breeding values for more than one trait, or by means of selection indices is a special chapter. Selection index allows to consider more than one characteristic or trait in the estimation of breeding values and selec-

tion. Tests on station enable determination of performance usually for animals of the same age under standard conditions. Breeding values are estimated using deviations from group means within year and station. At the same time they enable correction of the data by means of the above mentioned biometric methods. Like for the warmblood and coldblood horses in the Czech Republic, the final evaluation of traits and characteristics for the Old Kladrub horse determined during the performance tests represents the selection index in which individual traits are weighted by weights which are not, however, economic weights. The weights are chosen according to the significance of individual traits in order to achieve the optimum breeding progress. Finally, it is necessary to underline that especially tests on station make the estimated breeding values easier to compare.

Philipsson (1989) analyzed factors with positive or negative impact in particular on horse breeding. A big priority in horse breeding is the possibility to determine most of the performance and conformation traits in both sexes. This fact results in higher accuracy and reliability of the estimation of breeding values and shorter generation interval. Nevertheless, negative factors seem to prevail over the positive ones. In gene resources such as the Old Kladrub horse breed, the factor limiting the achievement of progress is their small size and thus also a potential risk of inbreeding. Big obstacles for effective selection are low reproduction, small number of progeny of stallions and mares, long generation interval and lower accuracy and reliability of the estimated breeding values. Intentional mating brings also the danger of a bias of the estimated breeding values. The problems of inaccurate estimation and of biased breeding values are added to the problem of subjective evaluation by different judges.

Comprehensive methods with respect to the environmental factors and the sources of information for related individuals are available for the estimation of breeding values. The methods based on the BLUP – SIRE MODEL and BLUP – ANIMAL MODEL became standard in the estimation of breeding values. The main characteristic of these methods is the simultaneous estimation of environmental effects and breeding values.

The method of BLUP – ANIMAL MODEL makes use of all available information on related individuals in the estimation of breeding values. Individual records are correlated by means of a relationship matrix and therefore the degree of relationship and statistical accuracy of related individuals are considered in the procedure.

An advantage of the BLUP method, be it the SIRE, SIRE-DAM or ANIMAL MODEL, is the fact that unlike for the method of selection indices, it is not necessary to know the actual population average to estimate breeding values without bias. Every environmental effect included in the model will get the optimum correction. In comparison to other methods, the BLUP –

ANIMAL MODEL has the special advantage of showing the breeding progress (Claus, Reinhardt, 1991). The estimation of breeding values by means of the individual ANIMAL MODEL takes into account all available information in the pedigree which is correlated with individual performance and information on half- and full sibs or progeny. Another advantage is also the possibility of estimating breeding values of horses without individual performance (e.g. mares or young stallions). It is a common practice in evaluating the progeny of sires that the quality of their dams is also considered. When using the ANIMAL MODEL, the genetic level is taken into account in the sense of considering all relatives. This method allows to eliminate the bias resulting from intentional mating. The estimation of breeding values by means of the ANIMAL MODEL is especially advantageous for those individuals that have no or only a small number of progeny. The estimation of breeding values by means of information on the performance of progeny results in a considerable extension of the generation interval. However, the estimation of breeding values by means of the ANIMAL MODEL allows to decrease the generation interval. The above mentioned advantages are described in particular by these authors: Arnason (1984), Klemetsdal (1986) Tavernier (1986), Bruns (1986).

The aim of this analysis was the estimation of breeding values of stallions by means of the BLUP – SIRE MODEL for the main performance traits.

MATERIAL AND METHODS

The basis for the evaluation of performance traits of individuals and sires by means of information on the progeny performance were the results of performance tests of stallions and mares of the Old Kladrub breed. These tests complied until 1994 with standard ČSN 46 6310 of 21 March 1980 and afterwards with standard ČSN 46 6310 of March 1994. Regarding the modifications of the standard in the period of the analysis of performance traits, it is necessary to say that the modifications concerned only amendments due to new knowledge in the area of professional hippological aspects with respect to the structure of stud books and to keeping basic data. Furthermore, a new approach was defined for the system of keeping data about horses and performance tests from the point of view of legislative legal standards. The evaluation of traits and test disciplines saw no modifications, which allowed to analyze jointly the results obtained under both standards. Individual traits and test disciplines were scored on a scale of 10 points.

Overall, 183 individuals and progeny of 29 sires were tested. Table I shows the distribution of individuals by sex, year and location of test and Table II the progeny numbers for sires.

The following traits were scored: total score, type and sex expression, conformation, performance, training, rideability, locomotion, marathon, span control and test of pulling reliability.

All traits were analyzed by the method of least squares by using the GLM procedure (SAS, 1997).

The following mixed model was used to analyze the data:

$$Y_{ijkl} = \mu + SEX_i + YEAR_j + SIRE_k + e_{ijkl}$$

where: Y_{ijkl} – observed trait
μ – overall average
SEX_i – fixed effect of i-th sex – stallion and mare (i = 1, 2)
$YEAR_j$ – fixed effect of j-th year (j = 1, ..., 10)
$SIRE_k$ – random effect of k-th sire (k = 1, ..., 29)
e_{ijkl} – random residual error

I. Distribution of individuals by sex, year and place of test

Factor	Sex		Year									
	stallions	mares	1988	1989	1990	1991	1992	1993	1994	9951	1996	1997
Number of individuals	35	148	16	10	12	19	20	35	21	8	14	28

RESULTS AND DISCUSSION

Table III presents the least squares means (LSM) and standard errors (SE) of traits for the sexes. Apart from type and sex expression, differences between stallions and mares were highly significant or significant for all scored traits. The fact of higher scorings of stallions in all traits is also interesting. In historical terms, stallions were used exclusively for the real breeding objective – the ceremonial service.

In Table IV the least squares means (LSM) and standard errors (SE) of traits are given for the year of test.

The year of test has a highly significant impact on all traits, except for total score and test of pulling reliability. In case of "C. Performance" this indicates that the inclusion of individual traits in the index by means of weights defined by the standard eliminates the effect of the year of test. The conditions of the test for pulling reliability seem to have been standardized in individual years to such extent that no significant differences were observed.

II. Distribution of progeny by sires

Consecutive No.	Sire No.	Number of progeny	Consecutive No.	Sire No.	Number of progeny
1	1277	23	16	2382	25
2	1278	6	17	4424	9
3	1281	2	18	4425	11
4	1284	2	19	4426	9
5	1288	3	20	7203	6
6	1587	2	21	8242	1
7	1661	7	22	8729	3
8	2051	3	23	8851	3
9	2068	2	24	8852	4
10	2358	4	25	8853	1
11	2366	1	26	9237	5
12	2367	6	27	10615	2
13	2368	11	28	12176	2
14	2369	18	29	12178	1
15	2372	11			

III. Least squares means (LSM) and standard errors (SE) of traits for the sexes

Trait	Sex				Significance
	stallions		mares		
	LSM	SE	LSM	SE	
TOTAL SCORE	8.16	0.18	7.80	0.16	**
PARTIAL SCORES					
A. Type and sex expression	6.88	0.34	6.53	0.31	
B. Conformation	6.61	0.29	6.18	0.26	**
C. Performance	7.63	0.26	7.08	0.23	**
1. Training	8.12	0.25	7.68	0.23	**
2. Rideability	6.76	0.31	6.56	0.27	
3. Locomotion	6.27	0.33	5.73	0.29	**
4. Marathon	7.61	0.73	6.84	0.65	*
5. Span control	7.19	0.41	6.56	0.37	**
6. Test of pulling reliability	8.68	0.73	7.54	0.65	**

Levels of significance: * $P < 0.05$; ** $P < 0.01$

IV. Least squares means (LSM) and standard errors (SE) of traits for the year of test

Trait	Year																				Significance
	1988		1989		1990		1991		1992		1993		1994		1995		1996		1997		
	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	
TOTAL SCORE	8.33	0.28	8.21	0.26	8.06	0.25	8.15	0.22	7.76	0.22	7.75	0.20	8.25	0.20	7.68	0.28	7.95	0.24	7.70	0.20	**
PARTIAL SCORES																					
A. Type and sex expression	7.63	0.50	7.19	0.48	6.47	0.45	6.40	0.41	6.46	0.40	6.35	0.36	7.16	0.37	6.39	0.51	6.78	0.43	6.30	0.36	**
B. Conformation	7.35	0.42	6.81	0.40	6.32	0.37	6.25	0.34	6.04	0.33	5.81	0.30	6.81	0.31	6.09	0.42	6.44	0.36	6.02	0.30	**
C. Performance	7.81	0.37	7.48	0.35	7.72	0.33	7.57	0.30	6.98	0.30	7.41	0.27	7.29	0.28	7.04	0.38	7.08	0.32	7.17	0.27	
1. Training	8.48	0.37	7.42	0.35	8.21	0.33	8.65	0.30	8.35	0.30	7.46	0.27	7.72	0.28	6.96	0.38	7.74	0.32	8.00	0.27	**
2. Rideability	7.92	0.45	7.17	0.43	7.23	0.40	5.98	0.36	5.74	0.36	6.60	0.32	6.66	0.33	6.31	0.46	6.60	0.39	6.36	0.32	**
3. Locomotion	6.76	0.47	6.10	0.45	6.17	0.43	5.33	0.39	5.45	0.38	6.10	0.34	6.65	0.35	5.36	0.48	6.32	0.41	5.72	0.34	**
4. Marathon	8.76	1.06	8.67	1.11	8.67	0.95	7.60	0.86	3.98	0.85	7.39	0.77	6.88	0.79	6.28	1.08	7.05	0.92	6.97	0.76	**
5. Span control	8.12	0.60	8.12	0.60	7.36	0.53	5.91	0.49	6.18	0.48	6.95	0.43	6.76	0.44	6.82	0.61	6.71	0.52	6.37	0.43	**
6. Test of pulling reliability	8.91	1.06	8.05	1.01	9.03	0.95	8.64	0.87	7.87	0.85	7.70	0.77	7.54	0.79	8.18	1.08	7.20	0.92	7.98	0.77	

Levels of significance: * $P < 0.05$; ** $P < 0.01$

The differences between sires in the above mentioned traits, except for rideability, were found to be non-significant for a majority of traits. For rideability, however, highly significant differences were observed between sires. The reason why only few differences were determined in a prevailing majority of traits was supposed to be the small number of progeny of individual sires available for the test although both stallions and mares were tested.

Although the above mentioned reasons reduced the accuracy of the comparison of breeding values of stallions by means of the evaluation of the performance of their progeny, the method allowed to carry out this estimation by means of the linear mixed model (BLUP – SIRE MODEL) which considers the number of progeny of sires. Therefore it is possible to carry out an unbiased estimation of breeding values based on the individual performance of both stallions and mares or on the information on progeny. A more accurate evaluation of sires by progeny will require a definition of the minimum number of progeny per sire.

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Vliv faktorů prostředí a otců na ukazatele výkonnosti starokladrubských koní.

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Byly analyzovány ukazatele výkonnosti jedinců a otců získané zkouškami výkonnosti hřebců a klisen starokladrubského plemene v letech 1988–1997. Celkem bylo hodnoceno 183 jedinců, kteří byli potomky 29 hřebců. Z ukazatelů byly desetibodovou stupnicí hodnoceny: hodnocení celkem, typ a pohlavní výraz, exteriér, výkonnost, výcvik, jezditelnost, mechanika pohybu, maraton, ovladatelnost spřežení a zkouška spolehlivosti v tahu. Byl použit lineární model se smíšenými efekty (efekty fixní – pohlaví, rok testace; efekt náhodný – otec). Mezi pohlavím byly u většiny vlastností, s výjimkou typu, pohlavního výrazu a jezditelnosti, významné a vysoce významné rozdíly. Hřebci vykazovali ve všech ukazatelích vyšší bodové hodnocení. Rok konání testu měl s výjimkou výkonnosti celkem a zkoušky spolehlivosti v tahu vysoce významný vliv. Při hodnocení otců na základě výkonnosti potomstva nebyly mezi plemeníky, s výjimkou jezditelnosti, zjištěny významné rozdíly. Rozdíly byly nevýznamné pro nízký počet potomků, přestože bylo možno do počtu potomků zahrnout jak hřebce, tak i klisny. Byl vypracován a ověřen metodický postup odhadu plemenné hodnoty na základě vlastní výkonnosti a výkonnosti potomstva plemeníků (BLUP – otcovský model) pro plemeno starokladrubský kůň, který je však použitelný i pro jiná plemena koní.

starokladrubský kůň; užitkové vlastnosti; faktory prostředí; otcové; plemenné hodnoty

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