

Differences in the Manifested Racing Performance of the English Thoroughbreds: Evaluation of Horses of Different Sexes and Years of Birth by the Parametric and Nonparametric Tests

J. Jelínek, CSc.

Any improvement programme in breeding practice is aimed at the maximum selection gain. If the results are to be reliable, the approaches and the breeding methods must be objective and scientific.

All this applies to the breeding of the English Thoroughbreds, particularly to efforts for the main objective of breeding — the horses' ability to reach the maximum performance in flat racecourses.

The "racing class" (a general term denoting this ability) is absolutely unmeasurable in its essence: it can only be relativized and is constituted by the interaction of a whole intricate complex of genetic and non-genetic factors. A number of more or less accurate criteria is used for its formulation, all bearing considerable error in relation to the objective genotypic value when used for an evaluation of the individual careers of the horses. Hence, their inexpert use may lead to serious mistakes in selection efforts. We already judged the individual criteria (Jelínek, 1986), so it is only to add that the General Handicap is still an officially recognized criterion in Czechoslovakia. A detailed study on the General Handicap was published by Jelínek (1985). Its average heritability under Czechoslovak conditions is estimated to be $h^2 = 0.30 - 0.35$ (Dušek, 1981).

Progeny testing is very important for effective selection of the English Thoroughbreds for performance, or the "racing class".

Comparison of the performance of the parents with that of the progenies is one of the basic methods of progeny testing. There are complications due to the differences in the conditions of phenotype realization of both generations compared (mainly owing to the great lapse of time) and requires, as an essential condition, that the difference between the mean Gh in different years should be insignificant. These differences do not ensue from the measured absolute values but from the more or less accurate mutual relativization of performance within

a group of horses born in the same year. In many cases it is impossible to eliminate the significant influence of the subjective factor. Thus it appears necessary for correct selection work to verify over a longer period of time the magnitude and significance of the differences in the Czechoslovak General Handicap for the English Thoroughbred horses born in different years, and to do this when the horses reach their best condition for use in breeding, i. e. at the age of three years.

It is essential for fast and successful determination of the breeding value on the basis of progeny testing to provide as quickly as possible at least a minimum number of offsprings with known performance and to secure, in this way, the required accuracy of estimation. However, this requirement is hard to meet, owing to the uniparity of the English Thoroughbred horses, to the length of their generation interval, and to the ban on artificial insemination in the breeding of these horses.

Unlike some other traits, the performance of the English Thoroughbred horses is manifested in both sexes, which can be considered as an advantage to some extent. However, it remains a question whether the quantified racing performance of the progenies of both sexes (GH) has the same significance for the estimation of the breeding value of the parents and whether it can be used without any correction. The functional differences between the sexes as well as experience suggest that the relative manifestation of the performance of the mares will be physiologically lower than that of the stallions. No correction has been done as yet in the evaluation of the progenies of the parents, a topic which has been studied — to mention Czechoslovak authors — mainly by Dušek and Jelínek.

The results obtained in both sexes have been combined applying insignificant differences recorded in the horses from several years, chosen at random and tested by one-factor analysis of variance. Considering the disorders of the normal distribution of the GH for the horses from certain years investigated by Jelínek (1985), it appears necessary to examine in detail the differences between the results of the manifested performance in the different years and between the two sexes; this detailed examination by a non-parametric test is an essential prerequisite for further objectivization of the results of progeny testing.

Material and Methods

The English Thoroughbred horses born in Czechoslovakia in the last 32 years (1955—1968) were subjected to the investigation. The General Handicap of the three years old horses in a flat race course in Czechoslovakia is used as a criterion of racing performance. Horses of foreign owners and horses of non-thoroughbred origin were eliminated from the investigation.

During the first part of the investigation, the basis mathematico-statistical characteristics were calculated for the horses from all years under study (\bar{x} , s_x , s , $v\%$). The differences between the years were tested by the parametric test of the analysis of variance of one-way classification (testing criterion — F) and by the Kruskal—Wallis non-parametric test (testing criterion — KW).

During the second part of the investigation, the horses from all years were divided into groups by sex and the basic statistical characteristics were calculated in these groups of horses. The differences between the sexes were on the basis of the calculated values for all investigated horses (1546 stallions and 1783 mares). The parametric test of one-factor analysis of variance and the Kruskal-Wallis non-parametric test were used to determine the significance of differences. Applying these significances, the differences between the sexes in all years and in the whole set of all horses were further subjected to the Wilcoxon-White non-parametric test (testing criterion — U_T). The result of the calculation was compared with the critical tabulated value of normal distribution at the significance levels of 0.05 and 0.01. The construction of the tests agrees with the procedure described by K á - b a (1980).

After discussion, the results were generalized and conclusions were proposed for use in the practical evaluation of the progenies of the parents of the English Thoroughbred horse breed in the progeny testing programme.

Results and Discussion

1. Evaluation of the Differences between the Years

The result of one-factor analysis of variance between the years of horses, with $F = 9.783^{++}$, indicates that the differences are significant already at the 1% level.

A similar finding is obtained when the non-parametric Kruskal-Wallis test is evaluated: the value $KW = 264.208$ is high above the 1% significance level (critical value = 52.191).

It is concluded from the demonstrated results that the horses from various years very often differ significantly in the values of the relativized racing performance based on the three-year-old horses' GH and that these values cannot be mechanically compared or combined. It is therefore very difficult to do the progeny testing of the English Thoroughbred horses by comparing the parent with the offspring and to use various methods (including modifications) based on this relationship. A number of our previous findings is confirmed by this: in some cases of practical implementation of progeny testing on the basis of the GH, the evaluation of some parents was illogical with respect to the results achieved by their progenies. This conclusion ensues from the absolute unmeasurability of the racing performance. Relativization bearing a subjective error is often in great contradiction with the objective status of the realized genotype.

It should be added that the absolute value and variation range of the General Handicaps in the different years are also significantly influenced by the number of horses in the relativized year and by greater amendments of the racing regulations. As a rule, the lower the number of horses in the race, the higher the mean for the Handicap, and vice versa, as can be seen in Tab. I. For instance in 1955, the number of horses in the General Handicap was 47 and the mean for that year was 62.71 kg (variation range from 34.5 to 95 kg), whereas in

I. Basic mathematico-statistical characteristics of the GH in the three years old English Thoroughbred horses coming from the years under study

Year	<i>n</i>	\bar{x}	<i>s</i>	<i>s_x</i>	<i>v</i> %
1955	47	62.71	18.26	2.66	29.1
1956	49	60.00	19.15	2.73	31.9
1957	44	64.61	18.08	2.72	28.0
1958	46	66.01	15.25	2.25	23.1
1959	44	65.53	15.86	2.39	24.2
1960	51	62.60	18.11	2.54	28.9
1961	43	65.19	16.89	2.57	25.9
1962	53	61.91	17.12	2.35	27.6
1963	59	63.89	13.50	1.76	21.1
1964	71	62.14	12.54	1.49	20.2
1965	61	66.07	11.33	1.45	17.1
1966	67	66.44	13.32	1.63	20.0
1967	65	64.98	14.69	1.82	22.6
1968	65	55.58	18.07	2.24	32.5
1969	78	54.86	18.72	2.12	34.1
1970	70	62.26	16.07	1.92	25.8
1971	98	56.58	18.22	1.84	32.2
1972	75	55.63	19.01	2.19	34.2
1973	91	60.66	18.45	1.93	30.4
1974	94	54.94	18.47	1.90	33.6
1975	104	55.81	17.00	1.67	30.5
1976	115	52.03	16.97	1.58	32.6
1977	114	52.21	16.78	1.57	32.1
1978	139	50.04	16.81	1.43	33.6
1979	147	49.48	15.35	1.27	31.0
1980	177	52.41	13.94	1.05	26.6
1981	186	55.40	13.19	0.97	23.8
1982	190	56.79	12.50	0.91	22.0
1983	192	56.29	12.54	0.90	22.3
1984	217	58.80	11.35	0.77	19.3
1985	233	58.53	11.32	0.74	19.3
1986	244	58.92	11.01	0.70	18.7

1983 the number of horses in the Handicap was 192 and the mean for that year was as low as 6.29 kg (variation range from 13.5 to 84 kg).

Greater amendments in the racing regulations (transition to the system of group races in Czechoslovakia in 1980) also markedly affected the procedure of determining the General Handicap in the different years, because the number of races where the three years old horses could be compared with the older horses was limited; this

II. Basic characteristics of the General Handicaps of the three years old English Thoroughbred stallions and mares coming from the years under study

Year	Stallions					Mares				
	<i>n</i>	\bar{x}	<i>s</i>	<i>s_E</i>	<i>v</i> %	<i>n</i>	\bar{x}	<i>s</i>	<i>s_E</i>	<i>v</i> %
1955	25	62.80	18.21	3.64	28.99	22	62.61	18.74	4.00	29.93
1956	17	66.12	20.53	4.98	31.06	32	56.75	17.84	3.16	31.45
1957	22	68.02	18.19	3.88	26.74	22	61.20	17.72	3.78	28.95
1958	23	66.33	17.13	3.57	25.82	23	65.70	13.50	2.81	20.55
1959	22	73.64	13.21	2.82	17.94	22	57.43	14.25	3.04	24.81
1960	26	65.96	18.17	3.56	27.55	25	59.10	17.72	3.54	29.98
1961	21	64.62	16.83	3.67	26.04	22	65.73	17.32	3.69	26.36
1962	24	62.98	18.29	3.73	29.04	29	61.03	16.37	3.04	26.81
1963	29	65.29	14.62	2.72	22.40	30	62.53	12.41	2.27	19.84
1964	43	64.53	12.89	1.97	19.98	28	58.46	11.23	2.12	19.21
1965	25	72.62	8.93	1.79	12.30	36	61.53	10.65	1.77	17.31
1966	34	70.38	13.68	2.34	19.43	33	62.38	11.82	2.06	18.95
1967	32	69.30	14.67	2.59	21.17	33	60.80	13.65	2.38	22.46
1968	34	60.13	16.20	2.78	26.95	31	50.58	18.94	3.40	37.44
1969	42	59.70	16.61	2.56	27.83	36	49.22	19.66	3.28	39.94
1970	36	64.82	17.48	2.91	26.97	34	59.54	14.19	2.43	23.83
1971	44	59.45	19.61	2.96	32.99	54	54.24	16.83	2.29	31.03
1972	35	54.89	20.57	3.48	37.47	40	56.29	17.78	2.81	31.59
1973	45	62.83	19.98	2.98	31.80	46	58.53	16.78	2.47	28.66
1974	43	55.15	18.16	2.77	32.93	51	54.75	18.91	2.65	34.53
1975	47	58.14	18.76	2.74	32.27	57	53.89	15.31	2.03	28.40
1976	46	55.00	17.88	2.64	32.50	69	50.04	16.16	1.95	32.30
1977	58	53.59	17.43	2.29	32.52	56	50.77	16.12	2.15	31.74
1978	52	55.61	16.28	2.26	29.28	87	46.71	16.31	1.75	34.92
1979	74	49.42	15.41	1.79	31.18	73	49.54	15.40	1.80	31.09
1980	80	54.22	14.79	1.65	27.28	97	50.91	13.08	1.33	25.70
1981	79	56.48	12.88	1.45	22.81	107	54.61	13.42	1.30	24.57
1982	78	59.01	12.45	1.41	21.09	112	55.25	12.36	1.17	22.38
1983	81	58.34	12.90	1.43	22.11	111	54.79	12.11	1.15	22.10
1984	112	59.89	10.85	1.02	18.11	105	57.64	11.79	1.15	20.46
1985	103	59.42	11.18	1.10	18.81	130	57.83	11.43	1.00	19.76
1986	114	61.11	11.34	1.06	18.56	130	57.00	10.38	0.91	18.21
All horses	1546	59.81	15.88	0.40	26.56	1783	55.47	14.92	0.35	26.89

III. The differences in the average values of the General Handicaps found between the stallions and mares from the different years; and the result of the Wilcoxon-White test

Year	Frequency		Testing criterion UT	Significance	Difference of the means for GH ($\bar{x}_o - \bar{x}_o$)
	stallions	mares			
1955	25	22	0.043	n. s.	0.186
1956	17	32	1.470	n. s.	9.368
1957	22	22	1.361	n. s.	6.818
1958	23	23	0.220	n. s.	0.630
1959	22	22	3.450	++	16.205
1960	26	25	1.413	n. s.	6.861
1961	21	22	0.219	n. s.	1.108
1962	24	29	0.411	n. s.	1.945
1963	29	30	0.720	n. s.	2.760
1964	43	28	1.759	n. s.	6.071
1965	25	36	3.680	++	11.092
1966	34	33	2.370	+	8.004
1967	32	33	2.237	+	8.494
1968	34	31	2.206	+	9.552
1969	42	36	2.636	++	10.480
1970	36	34	1.246	n. s.	5.275
1971	44	54	1.257	n. s.	5.214
1972	35	40	0.419	n. s.	1.402
1973	45	46	1.091	n. s.	4.301
1974	43	51	0.175	n. s.	0.396
1975	47	57	1.087	n. s.	4.244
1976	46	69	1.470	n. s.	4.956
1977	58	56	0.813	n. s.	2.827
1978	52	87	3.219	++	8.899
1979	74	73	0.072	n. s.	0.122
1980	80	97	1.359	n. s.	3.313
1981	79	107	1.081	n. s.	1.873
1982	78	112	2.015	+	3.761
1983	81	111	1.884	n. s.	3.551
1984	112	105	1.382	n. s.	2.250
1985	103	130	1.004	n. s.	1.592
1986	114	130	2.900	++	4.106
All horses	1546	1783	8.001	++	4.343

UT — testing criterion — calculated standardized random quantity
 + — significant difference at the 5% significance level (critical value 1.960)
 ++ — significant difference at the 1% significance level (critical value 2.5758)
 n. s. — statistically insignificant difference

is another factor having a significant influence on the determination of the General Handicap: for instance, a younger horse's victory over older horses is often rated by a handicapper as high as the classic victory and the like. All this confirms what has been said above: it is very difficult to use the General Handicap as a basis for comparison of animals born in different years.

2. Evaluation of the Differences between the Sexes

The computed average values of the General Handicap are given separately for the stallions and mares in Tab. II., including the basic statistical characteristics. The differences between the means within the whole group of the tested years exhibited a significant result of the one-factor analysis of variance already at the 1% level: $F = 6.541^{++}$.

A similar conclusion is drawn from the results of the non-parametric Kruskal-Wallis test where the value of $KW = 354.299^{++}$ highly exceeds the 1% significance level.

It is clearly seen from the calculation that the differences between the sexes are significant and should be respected when working with the results of the progenies; these results should be used either separately or after correction. With respect to this we evaluated the differences in the mean values for the stallions and mares within all years and for all stallions and all mares. The Wilcoxon-White non-parametric test was used for this purpose. The result of the tests of the year differences, including the statistical significance, is shown in Tab. III.

The differences in the performance of the stallions and mares demonstrated by the Wilcoxon-White test agree with the earlier findings obtained on the basis of the analysis of variance and the Kruskal-Wallis test. In all 32 years, the performance of the stallions was found to be higher than that of the mares (except for the years 1961 and 1979 when the difference was insignificant). In nine years of horses the difference in favour of the stallions was significant. When the tested horses were considered as a whole (1546 stallions and 1783 mares), the difference between the sexes was 4.343 kg, significant already at the 1% significance level. This difference probably reflects the physiological difference between the stallions and the mares in the manifestation of their racing performance in the Czechoslovak General Handicap. It will be necessary in future to respect this difference. It is therefore recommended to use the +4kg correction of the effect of sex in favour of the mares when the racing results of the progenies, characterized by the General Handicap, are used in the progeny testing programme. If this conclusion is not respected in the mutual comparison of the sires (or dams), the merit of those with a larger proportion of mares in their progeny is derogated whereas those with more stallions in their progeny are overvalued.

References

1. DUŠEK, J.: Udržovací šlechtění v malých populacích — genových rezervách (Maintenance breeding in small populations — gene reserves). [Dílčí závěrečná zpráva.] VSCHK Slatiňany, 1981.
2. JELÍNEK, J.: Studie možnosti využití Generálního handicapu a dostihového času jako měřítka výkonnosti pro plemennou analýzu a kontrolu dědičnosti (Study on a possibility of using the General Handicap and times as performance criteria for breeding analysis and progeny control). [Dílčí závěrečná zpráva.] VSCHK Slatiňany, 1985.
3. JELÍNEK, J.: Měřítka dostihové výkonnosti anglického plnokrevníka (Criteria of the racing performance of the English Thoroughbred horse). In: Sbor. referátů z vědecké konference 100 let hřebčína Napajedla. Brno, VŠZ, 1986, pp. 96-103.
4. KÁBA, B.: Statistika (Statistics). Učební texty vysokých škol, Praha, Stát. pedagogické nakladatelství, 1980.

Received June 24, 1987

The Author's Address:

Ing. Jaroslav Jelínek, CSc., Výzkumná stanice pro chov koní, 538 21 Slatiňany
