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STUDIES ON THE GENETICS OF TROTTING PERFORMANCE IN *DUTCH TROTTERS* (1)

I. — THE HERITABILITY OF TROTTING PERFORMANCE

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SUMMARY

The heritability of trotting performance in 2 867 *Dutch* trotters, born between 1929 and 1958, was studied using a within-sire regression of progeny on dams. Performance criteria chosen were earnings and time records. Earnings were corrected for economic fluctuations by means of multiplication factors, based on the average amount of money each year available per trotter starting. Time records were corrected for time trends by taking the deviations of individual time records from annual trend values, derived from a smooth curve fitted to yearly running means.

Heritability estimates of earnings and time records increased with increasing length of trotting career. For lifetime performances the estimates of heritability were. 26 for total earnings and .36 for the best time record. A square root transformation, applied to earnings, increased the estimate of the heritability for total earnings to .40.

Also the precocity for trotting performance was studied by expressing the earnings, won as 2- and 3-year-old trotter, as a percentage of the total earnings won during the whole trotting career. The heritability estimate of this criterion was .20, increasing to .27 after applying a logit-transformation to the percentages calculated.

Flying- and staying-ability of trotters were studied by expressing the amount of money won by each horse over each of three distance classes (short, medium and long) as percentages of its total earnings, won in trots over all distance classes. Little or no additive genetic variation was found in these traits.

Female trotters were earlier mature, won less money and showed less stamina than male trotters. No sex by genotype (= sire) interaction could be detected in earnings and time records.

For selection purposes the use of earnings is recommended above time records, since the former allows to include non-starters in the breeding value estimation of horses.

I. — INTRODUCTION

Trotting racing has been popular in the Netherlands for many centuries, and since 1879 breeders have started to improve the trotting performance of their horses by selection within the breed, as well as by importation of good stallions from the United States and France. However, little is known about the possibilities of impro-

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ving trotting performance by means of selection, or in orther words about the amount of additive genetic variation in trotting performance.

As criteria to indicate trotting performance, earnings as well as time records can be used. The aim of this study was to estimate the heritability of these traits.

Since there is a tendency to start with trotters at younger ages, also the genetic variation in precocity for trotting ability was investigated, as well as its relationship with later performance.

Criteria to measure the flying and staying ability of trotters were developed, because trotting races are held over variable distances. The heritability of these criteria and its relationship with other traits were studied.

Finally the interaction between genotype and sex was examined.

2. — MATERIAL

The material analysed consisted of data from all *Dutch trotters* born between 1929 and 1958 inclusive, comprising a total of 2 867 trotters. The data were subtracted from the Yearbooks of the « Stichting Nederlandse Draf- en Rensport » and from the *Dutch Trotters* Studbooks.

The following records were collected for each horse : studbooknumber ; birth year ; studbook-number and birth year of sire and dam ; sex (filly, colt or gelding) ; year of death or exportation (if relevant) ; yearly actual and assessable earnings ; yearly fastest time record per kilometer ; average of the 5 fastest time records made during whole trotting career ; percentage of money won over each of the three distance classes : 1 600 m up to 2 000 m, 2 000 m up to 2 400 m, 2 400 m and longer.

The difference between actual and assessable earnings needs an explanation. All money won by a horse in the Netherlands or abroad at an age of 2 years and older constitutes his actual earnings. Trots for horses aging 3 years and older are based on their total assessable earnings and these are lower than their total actual earnings. For horses born from 1940 up to and inclusive 1957 their 2-year-old earnings were not added to their earnings at a later age. For horses born in 1958 and later only a quarter of their 2-year-old earnings was assessed. Since 1941 prizes won in the so-called classic and semi-classic trots were assessed only by the half. Furthermore money won abroad was assessed partly during some periods.

Since 1951, however, minimum assessable earnings were introduced for horses of older ages. These age handicaps have not been taken into account, since they would give a false picture of a horses real merit.

3. — CHARACTERISTICS STUDIED

3. 1. — *Performance criteria*

Trotting horses can start their trotting career at an age of 2 years. The amount of money won during their second year of life is called : 2-year-actual earnings; the amount won during their second and third year : 2-3-year-actual earnings, etc. In order to get an idea of the development of trotting performance during the trotting career, the actual earnings studied are :

2-y-actual earnings
2-3-y-actual earnings
2-4-y-actual earnings
2-5-y-actual earnings
2-6-y-actual earnings
2-7-y-actual earnings
2-8-y-actual earnings.

Only the earnings of the first three age classes have been investigated more thoroughly.

The amount of money won during the whole trotting career of a horse is a measure of his lifetime performance. Two types of these total earnings have been studied :

total actual earnings
total assessable earnings.

In order to make a comparison between sexes the total earnings of colts and geldings have been calculated over the same part of the trotting career as their female contemporaries were allowed to trot. Since 1943 fillies were not allowed to start in trotting races after their 9th year and in 1958 this age limit was reduced by one year. So fillies born in 1949 and later had to stop their trotting career after their 8th year of age.

Part of the trotters born will never start, they already fail during training. However, their earnings could be taken as 0 guilders. Most statistical analyses of earnings are performed in two ways, viz. comprising all horses (called *Complete material*) or only comprising horses that actually have trotted (called *Restricted material*).

Besides earnings also the time records made during the various parts of the trotting career of the horses have been analysed, viz.

2-y-time record
2-3-y-time record
2-4-y-time record
2-5-y-time record
2-6-y-time record
2-7-y-time record
2-8-y-time record.

Again only the first three have been studied more intensively.
The lifetime performance criteria studied in this respect are :

Best time record
Average time record.

The average time record of a horse is the average of the 5 best time records, made during his whole trotting career. Of course an analysis of time records is possible only for horses, that actually have trotted, so corresponding with the category « Restricted material », mentioned under earnings.

3. 2. — *Precocity criteria*

The amount of money won during the first years of the trotting career, expressed as a percentage of the total actual earnings won during the whole trotting career, is taken as a measure of precocity. Three such proportional juvenile earnings have been examined, viz.

2-y-proportional earnings
2-3-y-proportional earnings
2-4-y-proportional earnings.

Naturally these proportional earnings can only be calculated for horses with a total actual earnings > 0 guilders.

3. 3. — *Flying and staying criteria*

Some horses are winning most of their money over short distances and can be regarded as flyers. Others are most successful over long distances and can be regarded as stayers. In order to develop criteria for this flying and staying ability the trots for horses of 3 years of age and older have been split up into three distance classes, viz.

short distances = trots over 1 600 m up to 2 000 m
medium distances = trots over 2 000 m up to 2 400 m
long distances = trots over 2 400 m and longer.

The trots for 2-year-old horses have not been taken into account, since these are all held over short distances from 1 100 m up to 1 600 m Older horses are trotting only over distances from 1 600 m upwards.

Now for each horse the amount of money won after his second year of life over each of the 3 distance classes has been expressed as a percentage of the total amount of money won over all distances.

The 3 resulting percentages studied are called :

flyer-percentage
medium-percentage
stayer-percentage.

Naturally the 3 percentages add up to 100 p. 100. The percentages are based on the assessable earnings of the horses, since some highly dotated classic trots (the Derby) are held over long distances. If the percentages calculated were based on the actual earnings, the staying ability of the winners of these trots could be overestimated.

4. — STATISTICAL METHODS

The analyses have been performed for fillies and colts + geldings separately. No distinction was made between colts and geldings, since some colts were castrated during the course of their trotting career, so have trotted as colt as well as gelding. Furthermore the moment of castration was not always known.

Horses that died or were exported before the end of their trotting career have been excluded.

Since the amount of money offered in trots varied considerably during the years, it was found necessary to correct for these differences in order to compare the performance of horses born in different periods. The method developed to correct for these yearly fluctuations is described in section 5.

Also time records made in different periods are not comparable, because the trotting tracks have become faster during the years and because of the fact that since 1958 more and more trots were held with automobile-starting gates. The method to correct the time records for this trend is also described in section 5.

The frequency distributions of several traits showed deviations from normality, in particular those of earnings, proportional juvenile earnings (precocity criteria), and proportional distance earnings (flyer- and stayer criteria). Since many of the standard statistical techniques are based on the assumption of normality, several transformations have been tried to achieve normality. Finally the following transformations were found to work most satisfactorily :

for earnings the square root transformation ;

for proportional juvenile earnings the logit-transformation :

$$\ln\left(\frac{x + .5}{100.5 - x}\right),$$

where ln = natural logarithm and x = proportional earnings, expressed as a percentage ;

for flyer percentage and « medium » percentage also the logit-transformation, and for stayer percentage the logarithmic transformation : $\ln(x + .5)$.

Also the distribution of time records showed some skewness. Although with none of the transformations tried normality was achieved, the reciprocal transformation was chosen as the most adequate one.

Transformation of earnings and time records was always done after correction of the data for yearly differences.

Statistical analyses were performed on both transformed and untransformed variables.

The genetic analysis comprised the estimation of heritabilities of the traits and of their phenotypic and genetic correlations.

The heritability (h^2) was estimated as twice the within-sire regression of progeny mean on dam performance. Since the number of progeny (of the same sex) per dam varied, the progeny mean was weighted by the number (n) of offspring per dam. The calculation was done within sires in order to avoid bias from assortative mating. In trotter breeding there is a tendency to mate the best mares to the best stallions, which have the highest stud fees. This was also one of the reasons that the estimation of the heritability from the regression of offspring on sires was turned down. The other reasons were the fact that the sires formed a highly selected group and that a great number of the sires had been imported from the United States or France, so their earnings and time records were not comparable with those of their progeny.

Also the paternal half sib analysis was regarded as an inadequate method to estimate heritabilities for reasons of the assortative mating mentioned and for the possible confounding of environmental differences with progeny group differences. The total period of investigation comprised 30 years, so stallions serving at the beginning of this period were different from those serving at the end of this period.

Phenotypic coefficients of correlation (r_p) between traits were calculated on a within sire basis. Genetic coefficients of correlation (r_g) were estimated from the arithmetic mean of the reciprocal intra-sire covariances of dam and mean of offspring (see BECKER, 1964).

The interaction of sex × genotype was studied by means of an analysis of variance. This analysis was restricted to dams with progeny of both sexes from the the same sire, so every subclass contained data. Furthermore the model was balanced by subjecting the analysis to the means of the subclasses. The analysis of variance performed was the so-called « analysis of means » method (see e. g. SEARLE, 1971). Regarding sex as a fixed effect, the analysis proceeds as follows :

Source	*Mean square*	*Expectation of mean square*
sires (genotypes)	MS_G	$n_h\sigma_e^2 + k_4\sigma_d^2 + k_5\sigma_g^2$
dams within sires	$MS_{D:G}$	$n_h\sigma_e^2 + k_4\sigma_d^2$
sexes	MS_S	$n_h\sigma_e^2 + k_1\sigma_{sd:g}^2 + k_2\sigma_{sg}^2 + k_3\Sigma s^2$
sexes × sires	MS_{SG}	$n_h\sigma_e^2 + k_1\sigma_{sd:g}^2 + k_2\sigma_{sg}^2$
sexes × dams within sires	$MS_{SD:G}$	$n_h\sigma_e^2 + k_1\sigma_{sd:g}^2$
progeny within sexes and dams	MS_E	σ_e^2

The mean square between progeny within sexes and dams had to be estimated from the individual observations within subclasses, so could be derived from the total, unrestricted, material. In the analysis of the subclass-means of the restricted material the estimator of the variance component concerned (σ_e^2) had to be weighed by the factor n_h, related to the average number of progeny per subclass.

The interaction between sexes and sires was regarded as the relevant sex × genotype interaction. In the analysis of variance this mean square has to be tested against the mean square of the sexes × dams within sires interaction.

5. — CORRECTION FOR ANNUAL FLUCTUATIONS

Earnings are heavily influenced by changes in the amount of prices offered to the trots in the course of time. Before World War 2 the prices were very low, but they increased dramatically during the war. Soon after the war they dropped suddenly and then gradually increased again as a result of inflationary factors. Earnings had to be corrected for these changes in order to compare the performance of horses, trotting in different years. For this reason yearly conversion factors have been derived. The factors for 2-year-old earnings were different from those of older horses, since 2-year-old trotters were competing only with horses of the same age.

The yearly correction factors for 2-year-old earnings were obtained by dividing the total amount of money, supplied to trots for 2-year-old horses in a given year, by the number of 2-year-old trotters, starting in that year. These yearly average earnings for 2-year-old starters are listed in table 1. In an analogous manner the yearly average earnings for trotters older than 2 year were obtained, They are also listed in table 1.

Then standard yearly earnings were chosen, viz. 1 500 guilders for 2-year-old trotters and 4 000 guilders for older horses. These figures are approximately the average yearly earnings of the respective age classes in the year 1968. Now all yearly earnings of all horses were multiplied by the appropriate correction factors. This will be demonstrated by an example. Horse W, born in 1929, was earning in 1934 the amount of y guilders. His corrected earnings in that year are $\frac{4\,000}{316} \cdot y$ guilders,

TABLE I

Average yearly earnings per trotter starting (in guilders)

Gains moyens par an par trotteur sortant (en florins néerlandais)

Trotting year	Average actual earnings of 2-year-old trotters	Average actual earnings of 3-year and older trotters	Average assessable earnings of 3-year and older trotters
1931	160	352	352
32	88	365	365
33	94	327	327
34	94	316	316
35	120	276	276
36	70	228	228
37	—	240	240
38	—	297	297
39	—	214	214
40	—	232	232
41	—	666	662
42	871	1 649	1 483
43	1 612	4 022	3 773
44	2 050	3 543	3 321
45	1 125	2 262	1 988
46	319	779	727
47	383	453	407
48	164	366	364
49	242	755	755
50	342	734	722
51	501	920	899
52	411	1 254	1 233
53	581	1 506	1 485
54	771	1 560	1 526
55	921	1 844	1 810
56	1 048	2 366	2 330
57	982	2 224	2 181
58	1 255	2 415	2 356
59	1 040	2 323	2 267
60	1 166	2 401	2 345
61	1 248	2 385	2 328
62	1 379	2 517	2 443
63	1 332	2 355	2 291
64	1 455	2 738	2 677
65	1 359	2 964	2 896
66	1 358	3 224	3 161
67	1 551	3 930	3 830
68	1 518	4 018	3 914
standard earnings	1 500	4 000	4 000

since from table 1 it can be seen that 316 guilders is the average earnings of 3-year-old and older horses in 1934. The use of multiplication factors implies that differences in earnings are essentially regarded as multiplicative.

The total corrected earnings won by a horse over a particular part of his trotting career were obtained by adding his corrected earnings over the number of years, constituting that part of his trotting career.

TABLE 2

Trend values of time records per kilometer (in minutes and seconds)

Évolution des temps record par kilomètre (en minutes et secondes)

Birth year of trotter	2-y-time record	2-3-y-time record	2-4-y-time record	Best time record	Average time record
1929	1.48.5	1.44.2	1.40.0	1.34.7	1.36.9
30	1.48.5	1.44.0	1.40.0	1.34.7	1.36.8
31	1.48.5	1.43.8	1.40.0	1.34.7	1.36.7
32	1.48.5	1.43.6	1.40.0	1.34.6	1.36.7
33	1.48.5	1.43.4	1.39.6	1.34.5	1.36.6
34	1.48.5	1.43.2	1.39.2	1.34.4	1.36.5
35	1.48.5	1.43.0	1.39.0	1.34.3	1.36.3
36	1.48.5	1.42.7	1.38.5	1.34.0	1.36.0
37	1.48.5	1.42.4	1.38.1	1.33.7	1.35.7
38	1.48.5	1.42.0	1.37.8	1.33.3	1.35.4
39	1.48.5	1.41.6	1.37.5	1.32.8	1.35.1
40	1.50.5	1.41.2	1.37.1	1.32.5	1.34.8
41	1.50.4	1.40.9	1.36.7	1.32.2	1.34.5
42	1.50.3	1.40.6	1.36.3	1.32.0	1.34.1
43	1.50.1	1.40.3	1.35.9	1.31.8	1.33.8
44	1.49.8	1.39.8	1.35.5	1.31.6	1.33.5
45	1.49.5	1.39.0	1.35.2	1.31.4	1.33.1
46	1.47.5	1.38.3	1.34.8	1.31.0	1.32.6
47	1.45.2	1.37.6	1.34.4	1.30.7	1.32.2
48	1.43.3	1.37.0	1.33.9	1.30.3	1.31.9
49	1.42.0	1.36.2	1.33.4	1.30.0	1.31.6
50	1.41.3	1.35.8	1.32.9	1.29.6	1.31.1
51	1.41.0	1.35.3	1.32.5	1.29.1	1.30.6
52	1.40.6	1.35.0	1.32.1	1.28.6	1.30.2
53	1.40.2	1.34.6	1.31.6	1.28.2	1.29.8
54	1.39.8	1.34.0	1.31.2	1.27.9	1.29.4
55	1.39.2	1.33.5	1.30.8	1.27.7	1.29.0
56	1.38.2	1.33.1	1.30.4	1.27.5	1.28.8
57	1.37.8	1.32.8	1.30.2	1.27.4	1.28.6
58	1.37.6	1.32.5	1.30.0	1.27.3	1.28.5
standard time record	1.37.6	1.32.5	1.30.0	1.27.0	1.28.5

For the assessable earnings the correction factors for horses of 3-year and older were slightly different from those, used for the actual earnings, see table 1.

The statistical analyses have been performed on actual or assessable earnings, corrected for yearly fluctuations. Also the calculation of the proportional juvenile

earnings have been based on the corrected earnings, in order to get a reliable picture of the precocity for trotting performance of the horses. If these criteria should have been based on the uncorrected earnings, it will be clear for instance that horses, aging 2-4 years just before World War 2 would have been regarded wrongly as much less precocious than horses, reaching this age during the war.

The proportional earnings per distance class (flyer-percentage and stayer-percentage) however have been calculated from the uncorrected earnings. This was justified since any horse was allowed to trot over each of the various distances at each moment during his trotting career (after his second year).

As mentioned before, time records made in different years were also influenced by changes in track conditions and starting methods during the years. The time record of the various age classes have been corrected by the following method.

First of all for each yearly crop of trotters the average time record of the respective age class has been calculated for each of the two sexes separately. The unweighted average of these two means yielded the average time record per yearly crop of trotters. Then for each early crop the running mean, out of the means of 5 consecutive yearly crops, was calculated and a smooth curve was drawn through these running means. The resulting trend values per yearly crop of trotters were read from this curve. For the younger age classes as well as for the best and average time record, made during the whole trotting career, these trend values are listed in table 2.

For each age class a standard time record was chosen, for instance 1 min. 27 sec. for the best time record. For each horse the deviation of his time record from the corresponding trend value was calculated. Addition of the standard time record to this deviation yielded the corrected time record of the horse. This procedure implies that differences in time records essentially are regarded as additive. The genetic analyses of time records have been based on these corrected values.

6. — RESULTS

6. 1. — *Means*

The means of the corrected actual earnings of the different age classes are listed in table 3. The figures are given for three successive 10 yearly periods as well as for the total period under investigation and refer to the Complete material so including horses, that never trotted. From table 3 it is seen that the average earnings per age class are increasing from the first to the third period, not-withstanding the earnings being corrected for yearly fluctuations. The conversion factors, however, were based on the horses, that actually started, while the means of table 3 are based on all horses born (excluding horses that died or were exported before the end of their trotting career). And the percentage of horses born that have trotted, increased during the years. For the 3 successive periods these percentages were 67 p. 100, 74 p. 100 en 80 p. 100 respectively. There is no corresponding difference in total actual earnings between the last 2 periods, but this is caused by the fact that the maximum length of the trotting career of mares of the last period was reduced by one year.

There is a difference in average earnings between both sexes. The figures for the total period show that 2-year-old fillies win 14 p. 100 more money than 2-year-old

colts and geldings. For the 2-3-year-old trotters only a slight advantage in favour of the fillies is left. From the age class of 2-4-year-olds upwards, colts and geldings reach higher earnings than fillies, which advantage increases to about 23 p. 100 for the total earnings. So it seems that female trotters are comparatively more premature than males. However, during the years this sex difference in precocity became less pronounced, since for the last period 2-year-old females win only 5.4 p. 100 more money than their male contemporaries.

For the total period also the standard deviations of the earnings are given. Also the means and standard deviations of the square root transformed earnings are presented for the total period in table 3.

TABLE 3

Means and standard deviations of corrected actual earnings (in guilders) *per age class of all horses ; complete material*

Valeurs moyennes et écarts-types des gains corrigés (en florins) *par classe d'âge des chevaux ; données complètes*

		untransformed earnings					transformed earnings	
		1st period horses born 1929-1938 (mean)	2nd period horses born 1939-1948 (mean)	3rd period horses born 1949-1958 (mean)	Total period horses born 1929-1958		Total period horses born 1929-1958	
					mean	s.d.	mean	s.d.
2-y-actual earnings	♀♀	257*	427*	648	522	1 548	9.2	20.5
	♂♂	160*	324*	615	458	1 327	9.0	20.3
2-3-y-actual earnings	♀♀	780	2 811	2 900	2 431	5 221	27.5	40.6
	♂♂	818	2 474	3 021	2 394	5 867	27.2	42.0
2-4-y-actual earnings	♀♀	2 276	5 047	5 340	4 609	7 650	46.4	50.0
	♂♂	2 393	5 463	5 986	5 082	8 725	50.0	52.6
2-5-y-actual earnings	♀♀	4 157	7 653	7 840	7 015	10 048	61.5	57.8
	♂♂	4 864	8 646	9 529	8 290	11 993	69.4	62.0
2-6-y-actual earnings	♀♀	6 028	9 473	9 946	8 980	12 270	70.4	65.0
	♂♂	7 239	11 749	13 081	11 456	15 537	83.1	71.0
2-7-y-actual earnings	♀♀	7 954	11 153	11 894	10 838	15 047	76.5	71.5
	♂♂	9 462	14 482	15 971	14 159	19 022	91.6	78.4
2-8-y-actual earnings	♀♀	9 320	12 533	13 760	12 444	17 619	80.9	77.0
	♂♂	11 186	16 582	18 168	16 228	22 143	96.1	84.5
Total actual earnings	♀♀	10 715	13 916	13 760	13 177	18 854	82.9	79.7
	♂♂	13 438	18 283	18 168	17 237	23 387	97.4	87.7
total assessable earnings	♀♀	10 644	13 163	12 938	12 533	17 882		
	♂♂	13 273	17 499	17 254	16 518	21 771		
number of horses	♀♀	263	405	597	1 265		1 265	
	♂♂	228	359	527	1 114		1 114	

* : exclusive horses born 1935 up to 1939.
♂♂ = colts + geldings.

Comparing the large standard deviations of the earnings with the means, it is evident that the frequency distributions of the earnings are very skew, even after transformation. This is caused by the fact that all horses are included in the calculations, also trotters that never raced. This means that for the total earnings at least 20-25 p. 100 of all horses will fall in the class of zero earnings. And for the earnings of the younger age classes this percentage is even much higher.

The mean of the transformed earings ($\overline{\sqrt{x_i}}$) is rather much lower than the square root of the mean of the untransformed earnings ($\sqrt{\overline{x_i}}$). The relation between both means can be found with the aid of TAYLOR's Theorem. For the total earnings a reasonable approximation is :

$$\overline{\sqrt{x_i}} \approx \sqrt{\overline{x_i}} - \frac{\sigma^2_{x_i}}{8\sqrt{\overline{x^3}}}$$

For the earnings of the younger age classes, however, this formula yields too low figures.

In table 4 the average earnings of horses, that actually have trotted during the respective age periods, are given. Comparing the numbers of horses with those of table 3, it is clear that at younger ages the percentage of horses starting is rather low. However, since horses, that died or were exported before the end of their trotting career, are excluded from the numbers of both tables, it is not possible to calculate the actual percentages of horses that have trotted, directly from these tables. The percentages of horses that trotted, related to all horses born alive, are given below :

2-year-old trotters	: 28.0 p. 100
2-3-year-old trotters	: 54.6 —
2-4-year-old trotters	: 70.3 —
all trotters	: 75.9 —

So 24.1 p. 100 of all horses born will never enter the race tracks. About a quarter of these horses (5.5 p. 100 of all horses born) already died before they reached the age, at which they were allowed to trot (so before the trots for 2-year-olds were issued).

For the time records the means of the uncorrected data are given in order to get an idea of the improvement in speed during the years (table 5). For the 2-year-olds there is not much difference between both sexes. Colts and geldings become faster than fillies with increasing length of the trotting career. For the best time record the advantage in speed of colts and geldings over fillies is 1.2 seconds. The picture is in accordance with the findings for the earnings : females are comparatively more premature than males. During the years both sexes became more premature, since in the first period the difference between 2-y-time record and best time record is 13.6 and 15.8 seconds for females and males respectively and in the last period these differences are 10.3 and 11.8 seconds. These figures also confirm that males have become less late mature during the years.

The standard deviations of the time records are given for the total period only. The fastest horse of all trotters under investigation was a mare with a best time record of 1,18.1. Comparison of this value with the mean 1,30.8 and standard deviation of 8.4 makes clear, that time records also are skewly distributed.

TABLE 4

Means and standard deviations of corrected actual earnings (in guilders) *per age class of horses, that actually have trotted ; restricted material*

Valeurs moyennes et écarts-types des gains corrigés (en florins) *par classe d'âge des chevaux, ayant couru ; données partielles*

		1st period horses born 1929-1938		2nd period horses born 1939-1948		3rd period horses born 1949-1958		Total period horses born 1929-1958		
		n	mean	*n*	mean	*n*	mean	*n*	mean	s.d.
2-y-actual earnings	♀♀	19*	2 000	102*	1 609	240	1 613	361	1 632	2 385
	♂♂	23*	842	93*	1 203	199	1 628	315	1 445	2 033
2-3-y-actual earnings	♀♀	70	2 932	237	4 804	412	4 203	719	4 277	6 330
	♂♂	72	2 591	203	4 376	337	4 725	612	4 358	7 357
2-4-y-actual earnings	♀♀	124	4 828	295	6 929	491	6 493	910	6 407	8 357
	♂♂	119	4 586	261	7 514	427	7 388	807	7 015	9 568
total actual earnings	♀♀	175	16 104	328	17 183	520	15 797	1 023	16 294	19 743
	♂♂	164	18 682	292	22 478	457	20 951	913	21 032	24 314

* : exclusive horses born 1935 up to 1939.

TABLE 5

Means and standard deviations of uncorrected time records (in minutes and seconds) *per age class of trotters*

Valeurs moyennes et écarts-types des temps record non corrigés (en minutes et secondes) *par classe d'âge des chevaux*

		1st period horses born 1929-1938		2nd period horses born 1939-1948		3rd period horses born 1949-1958		Total period horses born 1929-1958		
		n	mean	*n*	mean	*n*	mean	*n*	mean	s.d.
2-y-time record	♀♀	19	1.48.0	102	1.50.1	240	1.39.0	361	1.42.6	11.7
	♂♂	23	1.50.2	93	1.49.5	199	1.38.9	315	1.42.9	11.3
2-3-y-time record	♀♀	70	1.43.7	237	1.39.5	412	1.34.3	719	1.36.9	9.1
	♂♂	72	1.43.2	203	1.40.0	337	1.33.5	612	1.36.8	9.1
2-4-y-time record	♀♀	124	1.39.4	295	1.35.3	491	1.31.6	910	1.33.9	8.1
	♂♂	120	1.39.9	261	1.35.2	427	1.30.4	808	1.33.4	8.0
2-5-y-time record	♀♀	150	1.36.7	313	1.33.6	505	1.29.9	968	1.32.1	7.9
	♂♂	142	1.37.1	277	1.33.0	449	1.28.8	868	1.31.5	7.8
2-6-y-time record	♀♀	158	1.35.1	317	1.32.9	505	1.29.3	980	1.31.4	8.0
	♂♂	146	1.35.5	279	1.31.8	451	1.27.8	876	1.30.4	7.7
2-7-y-time record	♀♀	163	1.34.6	318	1.32.5	505	1.28.9	986	1.31.0	8.1
	♂♂	154	1.34.8	280	1.31.3	451	1.27.4	885	1.29.9	7.9
2-8-y-time record	♀♀	166	1.34.5	318	1.32.2	505	1.28.7	989	1.30.8	8.3
	♂♂	156	1.34.5	280	1.31.0	451	1.27.1	887	1.29.6	8.2
best time record	♀♀	170	1.34.4	318	1.32.1	505	1.28.7	993	1.30.8	8.4
	♂♂	157	1.34.4	280	1.30.8	450	1.27.1	887	1.29.6	8.1
average time record	♀♀	170	1.36.4	318	1.33.7	505	1.29.9	993	1.32.2	9.0
	♂♂	157	1.36.1	280	1.32.3	450	1.28.2	887	1.30.9	8.7

TABLE 6

Average proportional juvenile earnings (precocity criteria)
for horses with total actual earnings > 0 guilders

Valeurs moyennes des gains juveniles relatifs (critères de précocité),
pour des chevaux avec des gains de plus de 0 florins

		1st period horses born 1929-1938	2nd period horses born 1939-1948	3rd period horses born 1949-1958	Total period horses born 1929-1958
number of horses	♀♀	79	249	455	783
	♂♂	61	240	407	708
2-y-proportional earnings	♀♀	3.13	4.28	5.53	4.89
	♂♂	4.70	2.39	3.16	3.09
2-3-y-proportional earnings	♀♀	8.43	23.97	23.70	22.24
	♂♂	9.34	12.84	16.12	14.42
2-4-y-proportional earnings	♀♀	21.33	48.41	49.31	46.20
	♂♂	23.01	39.97	37.82	37.27

TABLE 7

Average proportional earnings per distance class (flyer p. 100, medium p. 100, stayer p. 100)
for horses with total assessable earnings > 0 guilders

Valeurs moyennes des gains relatifs par classe de distance,
pour des chevaux avec des gains de plus de 0 florins

		1st period horses born 1929-1938	2nd period horses born 1939-1948	3rd period horses born 1949-1958	Total period horses born 1929-1958
Number of horses	♀♀	150	279	480	909
	♂♂	140	298	481	919
Flyer percentage	♀♀	55.4	25.0	29.1	32.2
	♂♂	45.0	27.7	24.9	28.9
Medium percentage	♀♀	38.6	66.1	61.8	59.3
	♂♂	46.6	63.9	62.1	60.3
Stayer percentage	♀♀	6.0	8.9	9.1	8.5
	♂♂	8.4	8.4	13.0	10.8

The means of the proportional juvenile earnings are summarised in table 6. Except for the first period fillies have higher proportional juvenile earnings than males. For 2-years-olds this advantage for the fillies is 1.8 p. 100, for 2-3-year-olds 7.8 p. 100 and for 2-4-year-olds 8.9 p. 100. However, this greater precocity of females may partly be artificial, since mares quite often retire to stud before the end of the potential length of their trotting career.

Average proportional earnings per distance class are listed in table 7. In the first period the average flyer percentage is much higher than in the later periods, because during this first period the majority of trots were held over short distances. From the figures of the whole period it can be concluded that males have more stamina than females. The stayer percentage of colts and geldings is 2.3 p. 100 more than for fillies, and consequently the flyer percentage of males is 3.3. p. 100 less.

6. 2. — *Heritabilities*

The heritabilities of the traits studied are listed in table 8. The genetic analysis of the earnings is performed on the complete material (all horses) as well as on the restricted material, involving only those horses that actually trotted during the period under consideration. In all cases transformation yields higher heritabilities, so the square root of the earnings of a horse supplies a more reliable measure of its breeding value than the earnings as such.

For the 2-4-y-actual earnings and for the total earnings the heritability estimates are higher in females than in males, but these differences are within the range of statistical error. The picture is variable with regard to sex-differences in h^2-values for the 2-y- and 2-3-y-actual earnings.

The heritability estimates for earnings increase with increasing length of trotting career.

For the 2-4-y-actual earnings and the total earnings the heritability-values are higher for the complete data than for the restricted data. So it seems profitable to include horses, that never trotted, in the estimation of breeding values of horses and to use these data for selection purposes. For the 2-3-y-actual earnings the complete data and restricted data yield almost similar h^2-values, but for the 2-y-actual earnings the h^2-values are much higher in the restricted material. However, these h^2-values have a very large standard error, since the number of horses, that actually trotted as 2-year-olds, is very low.

The heritability estimates of the total actual earnings are slightly higher than those of the total assessable earnings. As there is the added advantage that actual earnings are more easily attainable than the assessable earnings, the former are preferable for use in breeding work.

In time records the reciprocal transformation does not affect the size of the heritability-values. So transformation of time records does not seem to be worthwhile for use in selection work. In general heritabilities are higher in females than in males, except for the 2-y-time record. Here the estimates for males are very high. But the h^2-estimates for the 2-y-time record also have a very high standard error. Neglecting this high value for 2-year-old males it is seen that the h^2-values increase, when the time records are based on a greater part of the total trotting career.

TABLE 8

Heritability estimates of trotting performance criteria

Estimations de l'héritabilité des performances de course

Trait	Material	Untransformed		Transformed	
		♀♀	♂♂	♀♀	♂♂
2-y-actual earnings	complete	.134 ± .067	.139 ± .071	.137 ± .079	.221 ± .082
— —	restricted	.369 ± .150	.338 ± .274	.408 ± .183	.406 ± .311
2-3-y-actual earnings	complete	.248 ± .060	.258 ± .065	.409 ± .068	.318 ± .069
— —	restricted	.192 ± .096	.286 ± .100	.316 ± .104	.381 ± .118
2-4-y-actual earnings	complete	.281 ± .058	.248 ± .068	.453 ± .068	.341 ± .069
— —	restricted	.274 ± .076	.203 ± .087	.403 ± .084	.230 ± .091
total actual earnings	complete	.296 ± .056	.215 ± .073	.456 ± .070	.355 ± .077
— — —	restricted	.235 ± .066	.155 ± .078	.357 ± .080	.281 ± .087
total assessable earnings	complete	.268 ± .056	.202 ± .071	.433 ± .070	.338 ± .078
— — —	restricted	.205 ± .066	.148 ± .076	.331 ± .080	.269 ± .086
2-y-time record	restricted	.170 ± .196	.546 ± .220	.168 ± .187	.516 ± .222
2-3-y-time record	—	.304 ± .100	.192 ± .115	.327 ± .097	.203 ± .116
2-4-y-time record	—	.321 ± .096	.235 ± .076	.320 ± .090	.214 ± .080
best time record	—	.455 ± .096	.264 ± .072	.434 ± .089	.303 ± .075
average time record	—	.411 ± .090	.281 ± .070	.407 ± .084	.306 ± .073
2-y-proportional earnings	⩾ 1 000 glds	.009 ± .102	.176 ± .094	.014 ± .120	.264 ± .108
— —	⩾ 4 000 —	— .022 ± .103	.206 ± .104	.023 ± .138	.280 ± .117
2-3-y-proportional earnings	⩾ 1 000 —	.151 ± .102	.256 ± .072	.264 ± .094	.285 ± .084
— —	⩾ 4 000 —	.160 ± .119	.252 ± .085	.324 ± .109	.269 ± .097
2-4-y-proportional earnings	⩾ 1 000 —	.069 ± .108	.183 ± .094	.090 ± .104	.155 ± .088
— —	⩾ 4 000 —	.147 ± .117	.197 ± .101	.262 ± .112	.193 ± .100
flyer percentage	⩾ 1 000 glds	— .073 ± .088	— .060 ± .088	— .044 ± .080	— .104 ± .084
— —	⩾ 4 000 —	— .090 ± .101	— .018 ± .097	— .021 ± .104	— .053 ± .106
stayer percentage	⩾ 1 000 —	— .006 ± .088	.057 ± .090	.086 ± .102	.227 ± .102
— —	⩾ 4 000 —	— .086 ± .101	.059 ± .108	— .068 ± .113	.227 ± .115

The heritability of the best time record made during the whole trotting career is at least as high as the heritability for the average of the best 5 records. The former is also easier to subtract from the lists, published by the Dutch Trotting Association, and is therefore preferable for breeding purposes.

The heritability estimates for time records have about the same magnitude as those for transformed earnings. However, a drawback of time records is that horses without time records cannot be included in breeding value estimation.

The genetic analysis of precocity criteria is performed on two samples of the data, viz. including horses with a total actual earnings > 1 000 guilders, and > 4 000 guilders respectively. In the latter case the heritability estimates are slightly higher, which could be explained by the fact, that the individual proportional earnings will be less liable to error. The logit-transformation has an enlarging effect on the h^2-estimates. In almost all cases heritabilities are higher in males than in females. The highest values are found for the 2-3-y-proportional earnings, viz. about .20 for the untransformed percentages and about .27 for the transformed percentages. This is one of the reasons to choose 2-3-y-proportional earnings as parameter for precocity. The other reasons are that at an age of 2 years only a small percentage of the trotters will start and that 4-year-old earnings hardly can be regarded as youth performances. The h^2-value found for the precocity parameter chosen implies that selection on early maturity for speed could be effective.

The heritability estimates for the flyer-percentage are all negative and close to zero. So no additive genetic variation seems to be present in this trait. Also the heritability values for the stayer-percentage are very low. The only significant value found is that for males, after applying a logarithmic transformation. So hardly any progress may be expected from selection for increased stamina in trotters.

6. 3. — *Correlations between traits*

Phenotypic and genetic correlations between traits are listed in tables 9, 10 and 11. It should be borne in mind that genetic correlations have a much larger standard deviation than phenotypic correlations. So the genetic correlations are much less reliable, which is also demonstrated by the fact that several estimates are above 1. In general there is not much difference between sexes with regard to the magnitude of the correlations.

Phenotypic correlations between earnings (table 9) are similar in both kinds of data : complete *vs* restricted. These correlations are higher as the correlated periods have a greater part in common. Transformation seems to increase the lower correlations somewhat. Total actual and assessable earnings are almost perfectly correlated. The genetic correlations between earnings show the same trend as the phenotypic ones, but their values are higher.

The correlations between time records (table 10) are not affected by transformation. The correlations are higher as the correlated periods have a greater part in common. Best time record and average time record are very strongly correlated and can be regarded as similar traits. The genetic correlations are somewhat higher than the phenotypic ones, except for those involving time records of 2-year-olds.

The phenotypic correlations between time records and earnings (table 10) are

TABLE 9

Phenotypic and genetic correlations between earnings

Corrélations phénotypiques et génotypiques entre gains

Traits correlated	Material	Sex	Phenotypic		Genetic	
			untrans-formed	trans-formed	untrans-formed	trans-formed
2-y-actual earnings	complete	♀♀	.84	.80	1.03	1.14
× 2-3-y-actual earnings	—	♂♂	.72	.77	.89	1.00
	restricted	♀♀	.85	.85	1.08	.97
	—	♂♂	.74	.81	.87	.81
2-y-actual earnings	complete	♀♀	.74	.70	1.01	1.19
× 2-4-y-actual earnings	—	♂♂	.65	.67	.90	.96
	restricted	♀♀	.77	.78	1.04	.92
	—	♂♂	.67	.74	.82	.72
2-y-actual earnings	complete	♀♀	.31	.38	.72	1.05
× total actual earnings	—	♂♂	.35	.37	.74	.73
	restricted	♀♀	.43	.51	.55	.61
	—	♂♂	.46	.48	.50	.46
2-3-y-actual earnings	complete	♀♀	.96	.93	1.00	.99
× 2-4-y-actual earnings	—	♂♂	.97	.92	.99	.96
	restricted	♀♀	.96	.94	1.00	1.00
	—	♂♂	.97	.94	1.00	.99
2-3-y-actual earnings	complete	♀♀	.53	.62	.98	.92
× total actual earnings	—	♂♂	.57	.61	.61	.73
	restricted	♀♀	.53	.60	1.11	1.03
	—	♂♂	.56	.59	.72	.81
2-4-y-actual earnings	complete	♀♀	.66	.77	.97	.95
× total actual earnings	—	♂♂	.67	.77	.73	.90
	restricted	♀♀	.65	.72	1.04	.98
	—	♂♂	.65	.72	.44	.63
total actual earnings	complete	♀♀	.99	1.00	1.00	1.00
× total assessable earnings	—	♂♂	.99	1.00	.99	1.00
	restricted	♀♀	.99	1.00	1.00	1.00
	—	♂♂	.99	1.00	.99	1.00

in the order of -.55, increasing to about .80 after transformation of the variables. The sign is reversed because of the reciprocal transformation of the time records. The genetic correlations are higher than the phenotypic ones.

TABLE 10

Phenotypic and genetic correlations between time records

Corrélations phénotypiques et génotypiques entre temps record

Traits correlated	Material	Sex	Phenotypic		Genetic	
			untrans-formed	trans-formed	untrans-formed	trans-formed
2-y-time record	restricted	♀♀	.68	.69	.66	.59
× 2-3-y-time record		♂♂	.68	.69	.45	.49
2-y-time record	—	♀♀	.57	.58	.68	.74
× 2-4-y-time record		♂♂	.61	.62	.33	.32
2-y-time record	—	♀♀	.51	.52	.44	.41
× best time record		♂♂	.46	.48	.46	.45
2-3-y-time record	—	♀♀	.78	.78	1.10	1.06
× 2-4-y-time record		♂♂	.78	.79	1.01	.98
2-3-y-time record	—	♀♀	.67	.65	1.21	1.15
× best time record		♂♂	.56	.58	.80	.80
2-4-y-time record	—	♀♀	.83	.81	.95	.97
× best time record		♂♂	.74	.76	1.05	1.04
best time record	—	♀♀	.98	.98	1.00	1.00
× average time record		♂♂	.98	.98	1.00	1.00
2-y-time record	restricted	♀♀	— .56	.76	— 1.10	1.16
× 2-y-actual earnings		♂♂	— .63	.78	— 1.04	1.04
2-3-y-time record	—	♀♀	— .51	.76	— 1.09	1.02
× 2-3-y-actual earnings		♂♂	— .50	.74	— .90	1.01
2-4-y-time record	—	♀♀	— .49	.75	— .86	.93
× 2-4-y-actual earnings		♂♂	— .48	.76	— .67	.89
best time record	—	♀♀	— .59	.84	— .82	.95
× total actual earnings		♂♂	— .57	.85	— 1.15	1.10

The phenotypic correlations between the precocity parameter chosen (2-3-y-proportional earnings) and total earnings as well as time records are very low (table 11). So it seems that early mature trotters don't win more money during their whole trotting career than later maturing horses. The genetic correlations involving the precocity parameter show a variable and unreliable picture.

Flyer- and stayer-percentage are mutually negatively correlated (table 11). Flying ability shows a very slight positive relation with precocity for trotting performance. Staying ability is slightly negatively correlated with precocity. Flyer percentage is negatively related with total earnings and stayer percentage shows a clear

favourable relation with total earnings. So it can be concluded that stayers are less premature but win more money in the long run than flyers. The majority of the genetic correlations could not be estimated because of negative denominators.

TABLE II

Phenotypic and genetic correlations between precocity criterion, flyer- and stayer-percentage, earnings and time records

Corrélations phénotypiques et génotypiques entre pourcentage de précocité, pourcentages par classes de distance, gains et temps record

Traits correlated	Material	Sex	Phenotypic		Genetic	
			untrans-formed	trans-formed	untrans-formed	trans-formed
2-3-y-proportional earnings	⩾ 1 000 glds	♀♀	.51	.72	.68	.88
× 2-3-y-actual earnings		♂♂	.55	.80	.91	.90
2-3-y-proportional earnings	—	♀♀	— .11	— .02	.35	.37
× total actual earnings		♂♂	.02	.17	— .15	— .16
2-3-y-proportional earnings	—	♀♀	— .45	.60	— 1.68	.59
× 2-3-y-time record		♂♂	— .46	.65	— 1.44	1.26
2-3-y-proportional earnings	—	♀♀	.26	— .15	— .35	.24
× best time record		♂♂	.06	.08	.03	— .23
flyer percentage	⩾ 1 000 glds	♀♀	— .42	— .33	x*	x
× stayer percentage		♂♂	— .40	— .35	x	x
flyer percentage	—	♀♀	.06	.01	x	x
× 2-3-y-proportional earnings		♂♂	.08	.05	.28	x
flyer percentage	—	♀♀	— .18	— .07	x	x
× total assessable earnings		♂♂	— .20	— .13	— 1.39	x
flyer percentage	—	♀♀	.10	.01	x	x
× best time record		♂♂	.21	— .10	.11	x
stayer percentage	—	♀♀	— .08	— .07	x	.50
× 2-3-y-proportional earnings		♂♂	— .13	— .02	— 1.13	— .46
stayer percentage	—	♀♀	.37	.53	x	1.40
× total assessable earnings		♂♂	.37	.49	— .16	.53
stayer percentage	—	♀♀	— .29	.46	x	1.07
× best time record		♂♂	— .28	.45	— 1.24	.58

* x = not estimable.

6. 4. — *Interaction between sex and genotype*

The possible existance of an interaction between sex and genotype has been investigated for the total actual earnings and the best time record. The results of the analyses of variance on both untransformed and transformed variables are given in table 12. The sire effect and sex effect are significant in all cases. In 3 out of 4

analyses also the effect of dams within sires is significant. But in none of the analyses the interaction between sexes and sires proves to be significant and the same holds true for the interaction between sexes and dams within sires. So it seems safe to conclude that the ranking of genotypes (sires) is the same in both sexes.

TABLE 12

Analysis of variance for the detection of interaction between sex and genotype for earnings and time records

Analyse de variance pour la détection de l'interaction entre sexe et génotype pour les gains et les temps record

	Untransformed			transformed	
	d. f.	mean square	F-ratio	mean square	F-ratio
		Total actual earnings			
Sires	52	930 494 082	1.99***	15 980	2.34***
Dams within sires	242	467 207 681	.94	6 830	1.39***
Sexes	1	2 807 688 711	13.93***	34 703	10.47**
Sexes × sires	52	201 545 344	.51	3 314	.71
Sexes × dams within sires	242	398 937 025	.81	4 636	.95
progeny within sexes and dams (n_h = .822 56)	503	602 374 401		5 954	
		Best time record			
Sires	45	75.349 3	1.51*	$.117\,2 \times 10^{-7}$	1.61*
Dams within sires	177	49.742 8	1.30*	$.072\,9 \times 10^{-7}$	1.38**
Sexes	1	180.945 0	7.22*	$.419\,2 \times 10^{-7}$	13.69***
Sexes × sires	45	25.049 2	.75	$.030\,6 \times 10^{-7}$	.62
Sexes × dams within sires	177	33.439 1	.88	$.034\,9 \times 10^{-7}$	.93
Progeny within sexes ans dams (n_h = .835 08)	351	45.756 2		$.063\,4 \times 10^{-7}$	

* : $0.01 < P < 0.05$ ** : $0.001 < P < 0.01$ *** : $P < 0.001$.

7. — DISCUSSION

The performance parameters chosen — total earnings and best time record — have been corrected for time trends only in our study. It is, however, a well known fact that performance of trotters is also influenced by many other factors, like rearing and feeding. Since reliable information on these factors is lacking, it is impossible to take them into account.

Some trainers and drivers reach better results whith their horses than others. Nevertheless it is difficult to correct for these influences and perhaps the necessity

to do it is not great, because in many cases owners are bringing their horses, when the results are disappointing, to other trainers. This implies that these horses will get more apportunities to show their intrinsic trotting abilities.

Differences between trotting tracks, weather conditions, starting methods and trotting race distances certainly will affect time records. However, almost all horses will start many times during their life on a number of tracks, under variable weather conditions, with both starting methods and over various distances. So each horse will get several opportunities during its life to realise a time record under optimal conditions. Therefore it does not seem necessary to take these factors into account.

In this study the heritability of lifetime performance, averaged over both sexes, was .36 for the best time record and .26 for total earnings. The latter estimate increases to .40 when the square roots of the earnings are taken.

Although GALTON (1898) already pointed out « the existence in the registers of the American Trotting Association of a store of material most valuable to inquirers into the laws of heridity... », only a few investigations into the heritability of trotting performance are published so far. OCSAG and TOTH (1959) obtained an estimate of heritability of .04 for time record in Hungarian trotters by means of offspring-dam regression. GOPKA (1971), analysing time records of Russian trotters, found heritability estimates of .32 — .48 by means of daughter — dam regression and estimates ranging from .039 to .128 by means of an analysis of variance. KALMYKOW (1973), also analysing time records of Russian trotters using various methods, gave estimates of heritability ranging from .053 to .390. LINNER and OSTERKORN (1974), using data of German trotters, obtained estimates of heritability of .220 and .206 for time records (in 2-year-old and 3-year-old trotters respectively and of .000 for earnings, by means of a half sib analysis.

On average the estimates of heritability for trotting performance, found in the literature, are about .15, which is rather much lower than the heritability, estimated in this study. There is a better agreement with the heritability of speed in race horses, since the average heritability of about 10 studies, published so far, is about .35. (OCSAG and TOTH, 1959 ; ARTZ, 1961 ; BORMANN, 1962 and 1966 ; DUSEK, 1965 ; WATANABE, 1966 and 1969 ; PERN, 1970 and 1971 ; SCHWARK and NEISSER, 1971 ; FOYE *et al.*, 1972 ; MORE O'FERRALL and CUNNINGHAM, 1974).

The relative amount of additive genetic variation present in the performance criteria studied, guarantees that these criteria can be used successfully in practical breeding. The advantages of earnings above time records is, that they also allow to take non-starters into account in the breeding value estimation of horses. The relative magnitude of the heritability makes an effective selection possible on the basis of the performance of the horses themselves as well as on the basis of a progeny test. In a second study in this series the construction and application of a selection index for the breeding value estimation of trotter stallions will be outlined. And in a third study the genetic progress in trotting performance actually achieved, will be discussed.

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RÉSUMÉ

ÉTUDES GÉNÉTIQUES DES PERFORMANCES DES *TROTTEURS HOLLANDAIS* EN COURSE.
I. — L'HÉRITABILITÉ DES PERFORMANCES EN COURSE

L'héritabilité des performances en course de 2 867 *Trotteurs Hollandais* nés de 1929 à 1958 a été estimée par la régression intra-père des descendants sur les mères. Les critères de performance retenus ont été les gains et les temps record au kilomètre. Les gains ont été corrigés pour des fluctuations économiques au moyen de facteurs multiplicatifs, fondés sur la dotation annuelle par cheval sortant. Les temps record ont été corrigés pour les influences annuels en analysant les déviations des temps record individuels par rapport à une courbe curvilinéaire établie à l'aide des moyennes annuelles.

Les estimations de l'héritabilité des gains et des temps record ont été d'autant plus élevées que la durée de la carrière de course était plus longue. Les estimations de l'héritabilité obtenue pour la carrière de course totale ont été de 0,26 pour les gains et de 0,36 pour le temps record. Après l'application d'une transformation racine carrée aux gains l'héritabilité des gains s'est élevée à 0,40.

La précocité a également été étudiée en exprimant les gains à l'âge de 2 et 3 ans comme un pourcentage du montant gagné dans la carrière de course totale. L'estimation de l'héritabilité de ce critère a été de 0,20 augmentant jusqu'à 0,27 après l'application d'une transformation logit aux pourcentages calculés.

L'aptitude à la distance a été étudiée en exprimant les montants gagnés par chaque cheval sur chacune des trois classes de course « courte, moyenne et longue » en pourcentage des gains totaux. Il n'a été trouvé presqu'aucune variation génétique d'origine additive sur ces critères.

Les juments se sont révélées être plus précoces, gagner moins d'argent et montrer moins d'endurance que les étalons et les hongres. Il n'a pas été mis en évidence d'interaction entre le sexe et le génotype pour les gains comme pour les temps record.

Dans la sélection des *Trotteurs* l'usage des gains doit être préféré aux temps record, puisque le premier critère permet l'inclusion de chevaux qui n'ont jamais trotté chronométrés, dans l'estimation de la valeur génétique des chevaux.

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