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Genetic aspects of racing performance in Polish pure-bred Arab horses. I. Genetic parameters

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Abstract. The objective of this study was to estimate variance components of Polish Arab horses' racing performance. The traits studied were the log of annual earnings and rank. Fixed effects of the year of race, herd, sex, the annual number of starts and random animal and permanent environment effects were evaluated on both earnings and rank at finish in Polish Arab horses. The obtained data included 2243 records on 4- and 5-year-old horses by 143 sires. Only races in which 4- and 5-year-olds competed were used. Heritability estimates of earnings and rank at finish were 0.22 and 0.25, respectively. Repeatability estimates of these traits were the same as heritability estimates. All the estimates of genetic and phenotypic correlations between the log of earnings and rank at finish were high and positive. Earnings and rank are good criteria for genetic improvement. Rank seems to be a better measure of racing performance.

Key words: heritability, horse, pure-bred Arab, racing performance.

Introduction

Various measures of racing performance can be derived from the available sources of information. Therefore, measures of racing ability may be based on traits relating to time such as the best racing time, time per kilometer and racing time; measures based on money are earnings per start, total money won in a year, or measures based on rank such as percentage of placings and rank at finish. The majority of studies on racing ability were carried out on thoroughbred horses and trotters representing breeds selected for racing ability for many years.

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Numerous studies concerning racing performance of horses are reported in literature. Racing time is the most frequently reported measure of the racing performance of horses. Many studies, reviewed by LANGLOIS (1980) and TOLLEY et al. (1985) indicate a low to moderate heritability of racing times and rank. Recent studies (CHICO 1994, OKI et al. 1994) show that estimates of racing time heritability are close to zero. On the other hand, the published heritability estimates of log earnings (0.2-0.6) appear to be moderate to high (HINTZ 1980, OJALA 1987, TAVERNIER 1988).

Selection of Arab horses has not been based on speed, but on race success. These factors are reported not to be closely related. The race success is influenced by physical condition, temperament, will to fight, physiological ability to change the rhythm during maximal effort. These components are difficult to measure and they differ from factors affecting the speed of horses.

Most emphasis in breeding Arab horses is put on conformation and less attention is paid to racing success. However, the inclusion of information on racing performance in the selection of Arab horses as an additional criterion would result in a double breeding objective for Arab horses – conformation and success on the track. Races of pure-bred Arab horses have been organized in Poland since 1927 to test their strength and endurance. Besides conformation, this breed has been characterized by such traits as health and fitness, though many Polish authors (SKORKOWSKI 1960, LEWIK 1984, BUDZYŃSKI et al. 1986, KULISA, BRZESKI 1988, KOWNACKI 1992) pointed out a weak constitution and increasing incidence of various diseases. This may indicate that races have not fullfilled their selective role in improving adaptive qualities of the breed.

The first step in any genetic improvement scheme is to estimate parameters (heritability, repeatability, and genetic and phenotypic correlations) of the studied performance. No estimates of genetic parameters for earnings and rank in Arab horses have been reported yet.

The objective of this study was to estimate variance components of Polish Arab horses' racing performance. The traits studied were the log of annual earnings and rank.

Material and methods

The analysis of annual earnings and rank at finish of 1640 pure-bred Arab horses competing as 4- and 5-year olds at the Warszawa race course between 1951 and 1993 included 2234 records. The animals were sired by 143 stallions. The data covered principally stallions and mares, as geldings were very rarely used for racing (12 records on geldings were included among those obtained

by stallions). The horses were mostly from the stud farms in Janów Podlaski, Michałów, Albigowa, Białka, Nowy Dwór and Kurozwęki. Animals from private farms were grouped in one herd. The present data concern the entire population of 4- and 5-year old horses racing on the race course (not all the horses were sent to the race course). The group of 4-year old horses includes the majority of 3-year olds racing a year ago. Each recorded individual had both parents identified. Over 60% of recorded dams had to own performance, while the corresponding value for sires was about 80%.

Three-year old horses compete only within their age group, while the 4-year-olds race also against older horses. The results included in the analysis concerned only horses from races of mixed age groups, i.e. no results concerning 3-year olds were used for the analysis as suggested by SOBCZYŃSKA (1995) and OKI et al. (1994). Only the first four places won financial award. When using the criterion of financial awards, one may face the problem of estimating horses 'out of money' (which rank below the fourth position). Assigning them the value "0" causes complications for two reasons. First, such an attitude is unjust to horses which do not win money in highly priced races, because the higher the winning pool, the lower the place falling to a horse with a "0" position. Secondly, a high number of "0" observations distorts the normal distribution of the trait, and it cannot be eliminated by any transformation. For this reason the unpaid places were assigned a sum of money, equal to a half of that won by the preceding horse.

Financial awards depend on the rank of the race and are not necessarily linked to the true value of the horse. Besides the financial award, the animals' rank at finish was also examined. A score was assigned to each rank, irrespective of the financial award. The ratio between the ranks was analogous to those of the pay rank (1:4:10:20), assigning 100 points for the first place. Therefore, points granted in a given race are allocated in the following way: the second horse earns 1/4 of the amount of the first one, the third 1/10 of that of the first horse, etc. Two points were assigned to the fifth horse and 1 point to those placed lower. Similarly to the earnings, the points were summarized for each horse over a given year.

The Kolmogorov test for testing the hypothesis that data come from a normal distribution was used. To obtain normality in the distribution of annual earnings, a logarithmic transformation was used: $Y = \ln(X + 1)$, where X stands for annual earnings (LANGLOIS 1980, OJALA, van VLECK, 1981, TOLLEY et al. 1985, OJALA 1987, TAVERNIER 1990).

The restricted-maximum-likelihood (REML) method has been shown to have the most desirable statistical properties of variance component esti-

mates. Therefore, REML computer software developed by MISZTAL (1993) was used for a genetic analysis.

The following two-trait linear model was applied:

$$y_{ijklmno} = \alpha_i + year\_of\_race_{ij} + age_{ik} + sex_{il} + herd_{im} + \beta_i no\_of\_starts_{jklmno} + genetic\_additive\_effect_{in} + permanent\_environmental\ effect_{in} + e_{ijklmno},$$

where $y_{ijklmno}$ denotes vector of the log of earnings and rank at finish of the o-th horse racing in the j-th year, of the k-th age, belonging to l-th sex and m-th herd, α_i is the overall mean of in the trait, β_i is the linear regression coefficient. Effects of the year of race, age, sex, herd and no. of starts included as covariable were regarded as fixed, while additive genetic, permanent environmental and error effects were considered to be random. The year of race ranged from 1951 to 1993. The age was the age at the start, 4 or 5 years.

There were two classes for sex effect-mares and stallions, and ten classes for herd effect. The number of starts implied the number of starts of an individual horse in a particular year of race.

Heritability was estimated as a ratio of additive genetic variance to phenotypic variance, while repeatability was obtained as a ratio of a sum of additive genetic variance and permanent environmental variance to phenotypic variance. Standard errors of genetic parameter estimates were approximated by Taylor series. The model corresponds to 58 levels of fixed factors, 2111 animals (1640 recorded animals with their own performance). The relationship matrix includes all animals in the data set whatever their role: stallions, broodmares, animals with no progeny, animals with and without records. Convergence criterion in the REML procedure was 10^{-7}.

Results and discussion

Parameters of trait distributions before and after transformation are presented in Table 1. As a result of introduction of the logarithmic transformation for earnings, the distribution became approximately normal. Genetic and phenotypic parameter estimates are presented in Table 2.

The estimated heritability for the log of annual earnings was 0.22. The heritability found is in good agreement with those published by OJALA (1987), and OJALA and van VLECK (1981), while MINKEMA (1975), HINTZ (1980) and LANGLOIS (after TOLLEY et al. 1985) reported slightly higher results and SILVESTRELLI et al. (1995) – slightly lower.

Repeatability for the log of earnings (0.22) was of the same magnitude as heritability estimate, and was lower than the corresponding estimates obtained for trotters (KATONA 1979, OJALA, van VLECK 1981).

Table 1. Parameters of distribution of annually summarized race records (traits) for Arab horses

Trait	Mean	SD	Skewness	Kurtosis	D:normal*
Earnings	1674887	6703659	7.93	106.4	0.56
Log of earnings	9.68	2.71	1.2	1.6	0.19
Rank	126.7	101.0	0.7	0.09	0.10

*Kolmogorov test for testing the hypothesis that the data come from a normal distribution; hypothesis was rejected for earnings.

A higher heritability estimate (0.25) was found for the rank at finish. This estimate was almost twice the value reported by PREISINGER et al. (1990). The repeatability for rank is in agreement with that of 0.24 reported by OJALA and van VLECK (1981).

The difference between heritability and repeatability (ignoring the dominance and epistasis effects) is the proportion of total variance attributable to permanent environmental effects. Permanent environmental effects on

Table 2. Heritability (h), repeatability (r), genetic (r_g), phenotypic (r_p) correlation estimates and their standard errors (in brackets) for racing performance traits of Arab horses

Estimates	Log of earnings	Rank
$\hat{h}^2$	0.22 (0.03)	0.25 (0.02)
$\hat{r}^2$	0.22 (0.03)	0.26 (0.02)
$\hat{r}_g$	0.94 (0.03)	
$\hat{r}_p$	0.77	

racing performance may include such factors as trainer, early nutrition and injury. Repeatabilities for the examined traits were of the same magnitude as heritabilities, indicating that these factors have little influence on racing performance in Arab horses.

The published heritability estimates were obtained from different data relationship structures, such as regression offspring-dam, paternal half-sib correlation, animal model. In case of the horse, the two sexes can be recorded and sire models fail to account for the genetic merit of their mates. Stallions have few progeny since artificial insemination is forbidden and consequently

relationships other than parent-progeny are important to consider. Several authors have shown the importance of the relationship matrix in accounting for the selection and assortative mating in genetic studies (SØRENSEN, KENNEDY 1984, HENDERSON 1975, TAVERNIER 1988). The animal model is the only one that includes all matings and therefore is the best approach to estimate genetic parameters.

The genetic and phenotypic correlations for the traits investigated were positive and very high (0.94 and 0.77, respectively) and confirmed the obvious conclusion, that horses winning first places earn the most. One may expect that these correlations could be higher, if horses racing seldom were eliminated from calculations. Earnings and rank are very much the same traits as estimates of genetic correlations are close to 1 and their heritability and repeatability values, as mentioned earlier, are similar. However, ranking due to a higher value of heritability appears to be more suitable as an evaluation criterion of pure-bred Arab performance.

Many factors affect earnings of horses. Sex, age, number of starts and herd were included in the model in this analysis. Jockey is also considered to be an important factor in some reports. The influence of jockey's skill on racing time becomes more important when the racing distance increases (OKI et al. 1995). Consequently, the influence is expected to be significant in Arab horses, which generally start in long distance races. One may expect that the influence of jockey on the earnings of a horse is similar to that on racing time. The latest reports (PREISINGER et al. 1990, OKI et al. 1995) indicate that the heritability estimate may be increased when environmental factors, such as the weight carried during race or the effect of jockey and trainer are not considered. The effect of jockey was not included in the present study because the trait was expressed as annually summarized records. On the other hand, due to the entanglement between trainer and stud, herd effect, which was included in this analysis, comprises trainer and partially jockey effect. Jockey influence may be expressed by jockey weight which includes rider, tack and any assigned handicap. Research on the American Quarter Horse (BUTTRAM et al. 1988) indicated that adjustment for jockey weight was not warranted because of small covariate regressions that were determined. In contrast, WILSON (1990) found finish time to be significantly affected by jockey weight for allowance and stake races, with the exception of races classified as handicap races.

When racing performance is expressed as earnings in individual races, it is possible to include in the analysis factors connected with an individual race, i.e. the number of starting horses, condition of the track or weather conditions. In the case when individual results are summarised, these factors are omitted. Scores allocated to a given rank seem to be a better measure for two reasons.

The first of them is that the money won in a given race is not an independent indicator of horses' merit. A non-placed horse (places lower than the fourth one) in a difficult race with high endowment is treated in the same way as the one in an easier race. Therefore, the higher the endowment of the race is, the more non-placed horses are underestimated. Moreover, endowment is the only measure of the competition level, yet it may not represent the real level and depends on arbitrary decisions. On the other hand, better horses start in races with high endowment, so one may expect that the level of the race is an important factor, which should be included in the analysis.

The second reason of using summarized ranks as a measure of racing performance is its suitability for statistical analysis. The time span covered by the analysis introduces the problem of inflation, which makes the variance of earnings increase with time. Subsequently, the "genetics" of earnings is nonlinear. The increase in variance over time was reduced by the transformation used, but it was not entirely removed. Assigned scores exhibit the same amount of variation in every race and every year, regardless of inflation. This fact may be an additional argument in favour of rank as a selection criterion.

Conclusions

Racing performance of Arab horses is moderately heritable and repeatable in terms of earning and rank at finish. Earnings and rank are good criteria for genetic improvement thanks to heritability, repeatability as well as genetic and phenotypic correlations. Rank seems to be a better measure of racing performance.

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