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# Some phenotypic and genetic parameters of racing performance in Arabian horses*

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**Summary:** The aim of this study was to investigate the factors affecting racing performance and to estimate the heritability of racing performance in Arabian horses. In this study the records were obtained from 6203 races of 616 male foals of 37 stallions racing at open races in different race tracks in Turkey during the years of 1991-2000. The least squares mean of racing time was found to be 176.29±0.95 seconds and there were significant differences ($p<0.001$) in racing years, racing distances, racing groups and race tracks. The estimated mean value for the amount of earning was 15660.6±556.7 $ (USA). The effect of mare age, year, distance, racing group, race tracks and foal age on the earning were significant ($p<0.05$; $p<0.001$). There were statistically significant differences among mean value of speed (m/second) for all of the investigated factors and the variance among stallions was found to be significant. The heritability of mean speed was estimated as 0.170±0.001 according to paternal half sib correlation method, the heritability according to the mean amount of earnings was 0.46±0.15. In this study heritability for racing performance was found to be moderate and therefore it is concluded that this character was improved by selection.

Key words: Arabian horse, environmental factors, heritability, racing performance.

## Safkan Arap atlarında yarış performansına ait bazı fenotipik ve genetik parametreler

**Özet:** Bu çalışmada, Arap atlarında önemli bir özellik olan yarış performansına etki eden faktörlerin incelenmesi ve yarış performansının kalıtım derecesinin hesaplanması amaçlanmıştır. Araştırmanın materyalini; Türkiye'deki değişik hipodromlarda 1991-2000 yılları arasında düzenlenen açık koşularda koşmuş 37 aygırın 616 erkek tayının toplam 6203 koşusuna ait veriler oluşturmuştur. Araştırmada koşu süresine ait beklenen en küçük kareler ortalaması 176.29±0.95 sn olarak bulunmuş olup; koşu yılları, koşu mesafesi, koşu grubu ve koşu pistleri arasındaki farklılıklar önemli ($p<0.001$) olmuştur. Kazanılan ikramiye miktarlarına ait beklenen ortalama değer 15660.6±556.7 Dolar (ABD) olarak hesaplanmıştır. Kazanılan ikramiyeye etki eden faktörlerden ana yaşının etkisi önemli ($p<0.05$); yıl, mesafe, koşu grubu, pist ve tay yaşının etkisi ise yüksek düzeyde önemli ($p<0.001$) bulunmuştur. Ortalama hızlara (m/sn) göre yapılan variyans analizinde tüm incelenen faktörler arasındaki farklılık ve aygırlar arası variyans önemli bulunmuş; Arap atlarında baba bir kardeşler korelasyonuna göre ortalama hızın kalıtım derecesi 0.170±0.001 olarak tespit edilmiştir. Ortalama ikramiye miktarına göre kalıtım derecesi ise yüksek sayılabilecek düzeyde ve 0.46±0.15 olarak hesaplanmıştır. Bu araştırmada; koşu performansına ait kalıtım derecelerinin orta düzeylerde bulunması nedeniyle bu karakterin seleksiyon ile geliştirilebileceği sonucuna varılmıştır.

Anahtar sözcükler: Arap atı, çevresel faktörler, kalıtım derecesi, yarış performansı.

## Introduction

Despite the differences in the methods and the aims, horse breeding influenced the human life in every stage of history. Generally horse breeders have spent more time and money to obtain high performances from horses. Horses with highly valued genotypic and phenotypic characters bred and traded throughout the world. Since Arabian horse breeding has been recognized as an important activity in Turkey, authorities have built stud farms for breeding horses and stallions centres in various areas. Similar practises were also applied to the English horses. Racing performance of the Arabian horses became important by the 1950s as a result of the decline in the other horse based activities like haulage, riding and transportation (23).

Arabian horses begin their racing life with maiden races when they are three years old and are categorized in the running groups as A, B, and C with respect to the prize they win in a year (9). Since 2003, Arabian horse races are categorised into the races of "Three Year-Olds", "Four Years-Old", "Four and Over" and lastly "Five and Over".

Racing performance is inherited and, as in all quantitative characters, it depends on the genetic and

* This article was summarized from the PhD thesis.

environmental factors. To improve of any character by the selection, it is necessary to fix the phenotypic and genotypic parameters and the environmental factors affecting these parameters (1, 7, 8). Racing performance of horses is dependent on the criteria of the average racing index, racing time and earning.

Environmental factors affecting racing performance are ordered as age, gender, running track, handicap weight, distance, jockey and dam age (10, 13, 15, 17, 25).

Heritability, which brings about disparities in a population, has been seen in different levels. Without knowing heritability ($h^2$) of the characters, the achievement in the affairs of improvement can not be obtained as expected (1). The criterions in the racing performance of the horses consist of racing time, average speed, amount of average earnings and order in running. The degree of heritability for a given character reported to be different by various researchers, $h^2$ for speed as 0.25-0.50 (14); speed, earnings and order of running as 0.00-0.01; 0.08-0.09 and 0.07-0.10, respectively (11); racing performance of thoroughbred horses as 0.17 (28), on the turf track as 0.29 and on dirt track as 0.18 (21), in the race of Quarter horses as 0.24 (29); 2 and 3 years old colts as 0.25 and 0.18, respectively (12); racing performance of 3 years old Arabian horses as 0.23 and of 4 years old as 0.10 (13); running time in different distances on the turf track between 0.08-0.25 and on the dirt track between 0.09-0.22 (22); pace speed in the race of Standard horses in 3 years old between 0.15-0.83 (27); differentiation of the $h^2$ on dry track between 0.47-0.63, on wet track between 0.28-0.52, and in respect to the age groups between 0.48-0.83 (30); running time, earning and number of race in the Standard trotter horses as 0.27, 0.39 and 0.13, respectively (26).

This study was undertaken to estimate the heritability of racing performance and to find the environmental factors affecting this trait for male Arabian horses in the group races held between 1991 and 2000 in Turkey.

## Materials and Methods

The data used in this study were obtained from the catalogues published among the years of 1991-2000 and kept by The Turkish Jockey Club. The pedigree data of the colts were taken from the Stud Book of Turkish Arabian Horses kept by The Ministry of Agriculture and Rural Affairs (3).

Data were originated from 40 stallions that have the record of higher number of races in the male colts that ran in the A, B and C groups in the racing tracks between 1991 and 2000 in Turkey. The data related to 6636 races of the 702 male colts were recorded in the computer. However, 433 races were excluded for various reasons (such as having lack of information about the running time, the amount of the prize and the mother's age). Hence, the data of 6203 races related to 616 male colts of 37 stallions were used in this study. Stallions, having colts with the data of at least five races have fundamentally been required.

The total of the prize won by the colts between 1991 and 2000 has been analyzed and the prize won by each colt were calculated as USA $ according to the rate of the exchange determined by the Turkish Central Bank (6). While working on the running time, the data in the records was transformed into seconds. Racing performance was estimated by the criteria of the running time and the earning.

The factors affecting on the running time and the earning were analyzed through the Least Squares Analysis Method. Duncan test was applied for the analysis of the significance of the differentiations in the averages (4, 31). The heritability of the running time and the earning were estimated by the General Linear Model. SPSS and JMP 3.2 computer programs were employed for statistical procedures (4, 5).

The effect of the environmental factors, such as running time, year, distance, running track, age of colt and dam age have been analyzed. For this reason, groups are formed for the year (1991-2000), running track (dirt and turf track), running group (A, B, C), running distance (1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2400 meters), colt age (3, 4, … 9+), and dam age (9-12, 13-16, 17-20, 21+). Below formulated analysis of variance was used as statistical model:

*Least squares means:*

$Y_{ijklmno}=\mu+S_i+M_j+G_k+P_l+T_m+A_n+e_{ijklmno}$

$Y_{ijklmno}$= o$^{th}$ evaluation value of the i$^{th}$ running year, j$^{th}$ running distance, k$^{th}$ running group, l$^{th}$ running track, m$^{th}$ colt age, n$^{th}$ dam age (for the running time or the earning).

*Estimation of heritability:* For the running time and the earning (6203 records); and for the average earning of colts (616 colts);

$Y_{hijlmnpo}=\mu+B_h+S_i+M_j+P_l+T_m+A_n+H_p+e_{hijlmnpo}$, where;

$Y_{hijlmnpo}$= o$^{th}$ evaluation value of the i$^{th}$ running year, j$^{th}$ running distance, l$^{th}$ running track, m$^{th}$ colt age, n$^{th}$ dam age, p$^{th}$ handicap weight of h$^{th}$ sire group.

For the average speed of colts (616 colts); $Y_{hilmnpo}=\mu+B_h+S_i+P_l+T_m+A_n+H_p+e_{hilmnpo}$

$Y_{hilmnpo}$= o$^{th}$ evaluation value of the i$^{th}$ running year, l$^{th}$ running track, m$^{th}$ colt age, n$^{th}$ dam age, p$^{th}$ handicap weight of h$^{th}$ sire group.

*Expression of the symbols in the equations:* $\mu$= The expected mean; $B_h$= the effect of h$^{th}$ father, $S_i$= the effect of the i$^{th}$ year (i=1, 2, 3, … 10), $M_j$= the effect of the j$^{th}$

running distance (j=1, 2, 3, … 12), $G_k$= the effect of the $k^{th}$ running group (k=1, 2, 3); $P_l$= the effect of the $l^{th}$ running track (l=1, 2), $T_m$= the effect of the $m^{th}$ colt age (m=1, 2, 3, . . . 7); $A_n$= the effect of the $n^{th}$ mother's age (n=1, 2, 3, 4); $H_p$= the effect of the $p^{th}$ handicap weight (p=1, 2); $e_{hijklmnpo}$= The term of error.

Since the number of horses in subgroups were low and the related data were inadequate, we ignored the possible interactions between the factors. In cases where no relativity between the colts and the sires existed, the heritabilities are estimated by paternal half-sib correlation method (4, 7).

Each colt has more than one race in 6203 race records. While heritability was estimating according to the half-sib correlation method by using the data of 6203 races, this condition has not been considered and it was accepted that each running belongs to a different colt.

However, 6203 running records belonged to 616 colts. In order to avoid false calculations, the average of the earnings each colt won in all the races was estimated and taken to the model as the earnings of the same colt won. Mean speed was found as the average of the distance the colt ran in respect to the running time (Speed=distance/time).

## Results

In this study, the factors affecting the running time, the earnings and the heritability of the running time, the speed and the earning are analyzed in respect to the 6203 running records of the male colts in the group races held in Turkey between 1991 and 2000.

*Running time:* The factors affecting the running time and the least squares means were shown in Table 1. For the running time, the general mean is 176.29 seconds and the effect of the year, distance, group and the running track is statistically significant ($p<0.001$). The analysis showed a decline in the running time in the recent years (Table 1). It was found out that the colts running in Group A has the least running time and that the turf track contributes the highest to the running performance. It was seen that the colt age had no statistical significance on running time ($p>0.05$).

*Earnings:* Least square means of the earnings by the male colts in the group races are presented in Table 1. Year, distance, race group, running track, animal age and dam age have significant effects on the earned prize ($p<0.001$; $p<0.05$).

The amount of the prize has a tendency to increase since 1997 until at the end of the investigated period. The highest prize is given to the horses running in the group A, which is followed by the groups B and C. The horses running on the turf track won higher prize than the ones running on the dirt track. There was not any consistency in the earnings by the groups of colt age and dam age.

Table 1. Least squares means of racing time and earning
Tablo 1. Koşu süresi ve ikramiye miktarına ait en küçük kareler ortalamaları

| Factors | n | Racing time (sec) $\overline{X} \pm S\overline{x}$ | Earning ($) $\overline{X} \pm S\overline{x}$ |
|---|---|---|---|
| Racing year | | *** | *** |
| 1991 | 521 | 177.02±1.56$^{c}$ | 4367.7±911.2$^{b}$ |
| 1992 | 638 | 179.17±1.49$^{d}$ | 687.6±868.1$^{a}$ |
| 1993 | 760 | 178.09±1.41$^{cd}$ | 369.8±820.1$^{a}$ |
| 1994 | 544 | 174.53±1.56$^{ab}$ | 1482.9±910.2$^{a}$ |
| 1995 | 609 | 179.02±1.50$^{d}$ | 5727.1±874.7$^{b}$ |
| 1996 | 559 | 176.15±1.53$^{c}$ | 7749.4±894.3$^{c}$ |
| 1997 | 592 | 177.11±1.50$^{c}$ | 17630.1±872.5$^{d}$ |
| 1998 | 600 | 175.45±1.48$^{b}$ | 36081.5±865.5$^{e}$ |
| 1999 | 671 | 173.14±1.38$^{a}$ | 40100.6±805.5$^{f}$ |
| 2000 | 709 | 173.22±1.39$^{a}$ | 42409.8±812.1$^{f}$ |
| Racing distance | | *** | *** |
| 1200 | 160 | 134.40±2.47$^{a}$ | 13518.5±1440.6$^{c}$ |
| 1300 | 154 | 142.92±2.53$^{b}$ | 16547.6±1474.5$^{d}$ |
| 1400 | 1193 | 147.76±1.17 $^{b}$ | 15687.5±680.3$^{d}$ |
| 1500 | 527 | 157.59±1.55$^{c}$ | 16952.4±905.1$^{e}$ |
| 1600 | 1547 | 163.70±1.07$^{c}$ | 23681.1±625.6$^{f}$ |
| 1700 | 96 | 173.40±3.17$^{e}$ | 4435.7±1842.8$^{a}$ |
| 1800 | 113 | 183.19±2.86$^{f}$ | 8804.5±1665.1$^{b}$ |
| 1900 | 692 | 189.96±1.37$^{g}$ | 14987.6±796.7$^{cd}$ |
| 2000 | 833 | 193.14±1.30$^{g}$ | 16169.5±758.1$^{d}$ |
| 2100 | 407 | 198.53±1.66$^{h}$ | 14404.8±966.4$^{c}$ |
| 2200 | 310 | 207.06±1.85$^{j}$ | 16932.8±1079.4$^{e}$ |
| 2400 | 171 | 223.87±2.39$^{k}$ | 25804.7±1392.4$^{f}$ |
| Racing group | | *** | *** |
| A | 2195 | 173.77±1.00$^{a}$ | 31260.4±584.4$^{a}$ |
| B | 2411 | 176.82±1.12$^{b}$ | 10352.3±650.4$^{b}$ |
| C | 1597 | 178.28±1.26$^{c}$ | 5369.1±735.8$^{c}$ |
| Racing track | | *** | *** |
| Dirt | 3738 | 178.14±1.02 | 12012.0±594.4 |
| Turf | 2465 | 174.44±1.06 | 19309.2±618.4 |
| Age | | NS | *** |
| 3 | 50 | 179.27±4.18 | 25149.8±2436.1$^{e}$ |
| 4 | 3024 | 174.20±0.69 | 17169.4±404.6$^{d}$ |
| 5 | 1550 | 175.42±0.87 | 16543.1±508.3$^{d}$ |
| 6 | 832 | 176.43±1.14 | 15916.7±666.7$^{c}$ |
| 7 | 415 | 176.29±1.55 | 15687.5±906.1$^{c}$ |
| 8 | 224 | 175.18±2.10 | 12575.0±1224.1$^{b}$ |
| 9 + | 108 | 177.32±2.94 | 6582.7±1715.1$^{a}$ |
| Dam age | | NS | * |
| 9-12 | 1814 | 175.79±1.19 | 16159.2±693.2$^{b}$ |
| 13-16 | 2045 | 176.22±1.09 | 15033.2±636.3$^{a}$ |
| 17-20 | 1266 | 177.31±1.2 | 14876.4±698.2$^{a}$ |
| 21 + | 1078 | 175.85±1.21 | 16573.6±7031.1$^{c}$ |
| Expected mean (μ) | 6203 | 176.29±0.95 | 15660.6±556.7 |

NS: Nonsignificant; *:$p < 0.05$; ***:$p < 0.001$
a,b,c,d,e,f,g,h,j,k: Means with different superscripts with in column indicate significantly different value ($p<0.05$).

Table 2. According to racing time, variance analysis, variance components and heritability for total races of colts together in the model
Tablo 2. Koşu süresine göre tayların tüm koşularının birlikte incelendiği model ile elde edilen variyans analizi ve variyans unsurları

| Variance analysis | | | | | |
|---|---|---|---|---|---|
| Source of variation | DF | Sum of squares | Mean of squares | F Ratio | Probability |
| Total | 6202 | 8177628.0 | | | |
| Model | 67 | 2957378.4 | 44140.0 | 51.87 | 0.0001 |
| Error | 6135 | 5220249.6 | 850.9 | | |

| Variance components | | |
|---|---|---|
| Source | Variance | Heritability ($h^2$) |
| Between sires($\sigma_a^2$) | 1.41 | 0.007±0.081 |
| Within sires($\sigma_i^2$) | 850.90 | |

Table 3. Variance analysis, variance components and heritability according to average speed (distance/time)
Tablo 3. Koşu süresine göre modelde her tayın ortalama hızlarının (mesafe/zaman) yer almasıyla elde edilen variyans analizi, variyans unsurları ve kalıtım derecesi

| Variance analysis | | | | | |
|---|---|---|---|---|---|
| Source of variation | DF | Sum of squares | Mean of squares | F Ratio | Probability |
| Total | 615 | 578.98 | | | |
| Model | 56 | 76.42 | 1.36 | 1.51 | 0.011 |
| Error | 559 | 502.57 | 0.90 | | |

| Variance components | | |
|---|---|---|
| Source | Variance | Heritability ($h^2$) |
| Between sires($\sigma_a^2$) | 0.04 | 0.17±0.001 |
| Within sires ($\sigma_i^2$) | 0.90 | |

*Heritability of running time:* The results and components of the variance analysis and the heritability obtained from the model analyzing the data related to all the races of the colts (6203 data) are given in Table 2. Consequently, the effects of all the factors analyzed were found significant ($p<0.001$), but the heritability was low (0.007±0.081) because of the less significant variance between the sires.

*Heritability of average speed:* The analysis of variance and the heritability estimated according to the mean speed (m/sec) are presented at Table 3. The effects of all the factors analyzed were significant ($p<0.05$). The variance between the stallions was also significant. Here, the estimation of $h^2$ was 0.17±0.01. The standard error of the estimated $h^2$ was rather low.

Table 4. According to earnings, variance analysis, variance components and heritability for total races of colts all together in the model
Tablo 4. İkramiye miktarına göre tayların tüm koşularının ele alındığı modelde elde edilen variyans analizi, variyans unsurları ve kalıtım derecesi

| Variance analysis | | | | | |
|---|---|---|---|---|---|
| Source of variation | DF | Sum of squares | Mean of squares | F Ratio | Probability |
| Total | 6202 | 4228270.3 | | | |
| Model | 67 | 2183754.7 | 32593.4 | 97.8 | 0.0001 |
| Error | 6135 | 2044515.6 | 333.3 | | |

| Variance components | | |
|---|---|---|
| Source | Variance | Heritability ($h^2$) |
| Between sires($\sigma_a^2$) | 40.16 | 0.43±0.0002 |
| Within sires ($\sigma_i^2$) | 333.25 | |

Table 5. Variance analysis, variance components and heritability according to average earnings
Tablo 5. Ortalama ikramiye miktarına göre elde edilen variyans analizi, variyans unsurları ve kalıtım derecesi

| Variance analysis | | | | | |
|---|---|---|---|---|---|
| Source of variation | DF | Sum of squares | Mean of squares | F Ratio | Probability |
| Total | 615 | 242.84 | | | |
| Model | 66 | 135187.42 | 2048.29 | 10.45 | 0.0001 |
| Error | 549 | 107648.98 | 196.08 | | |

| Variance components | | |
|---|---|---|
| Source | Variance | Heritability ($h^2$) |
| Between sires($\sigma_a^2$) | 25.36 | 0.46±0.15 |
| Within sires ($\sigma_i^2$) | 196.08 | |

*Heritability of earning:* The prize won by each race is separately shown in the model, the variance analysis and the $h^2$ are given in Table 4. In this respect, the $h^2$ was estimated as 0.43±0.0002.

The $h^2$ and the analyses of variance held according to the average earning that the colts won are given at Table 5. As seen in Table 5, quite moderate $h^2$ was estimated (0.46±0.15) for the trait.

## Discussion and Conclusion

Least squares means of running time did not demonstrate a clear trend between 1991 and 1996. However, there was a regular decline after 1997. Correspondingly, the amount of prize almost doubled after 1996. As a result of induced competition, it is likely that the maintenance, the nutrition, the training and the other environmental factors have been improved (23).

Increase in the running distance raised the running time as supported by several researchers (15, 19, 20, 22, 24), it also can be said that effect of the distance on the racing performance was significant. The decline of the running time in the horses in the group A and the increase of the running time in the group C are expected outcomes when the criteria of group forming were considered.

Since the dirt track is strong than the turf track, the running performance on the dirt track was lower than the turf track. In this study, this is the main reason why the running time was found lower on the turf track. Aksüyek (2) also expressed the improvement in the racing performance on the turf track. Hintz (16) also pointed out the negative effect of the dirt track on the running performance.

In this study, the effect of the colt and dam age were not found significant. However, they have been significant on the amount of the prize. Increasing in animal age caused a gradually decrease in earned prize, but this situation can not be logically explained. The amount of prize in the Arabian horse races is high in the races on the turf track. Naturally, total amount of the prize won was high on the turf track as well. Martin et al. (19), Langolish (18) and Moritsu et al. (20) similarly expressed the rise in the prize won on the turf track compared to the dirt track.

According to racing time, the $h^2$ is very low in the model estimating all the data of the colts. This condition resulted from the data of 6203 of 616 colts of 37 horses. Hence, the $h^2$ was estimated very low because of the correlation between the given data. To evade from this negativity, the $h^2$ was estimated from the average speed of 616 colts and a reliable ratio of $h^2$ 0.17, was found. It is a possibility to improve the estimated $h^2$. However, in the consideration of the running time, the genetic variance declines in the running horses.

The reliability of the estimated $h^2$ is moderate in the prize won by the two models. In a study (18), higher heritability than the corresponding study was detected for the mentioned trait. The participation of the colts having high prizes into breeding leads to the birth of the colts that will win high prizes.

On the other hand, in the same groups of horses, the heritability according to the running time is lower than the heritability of the earning. In the order of the horses according to the running time, there are nearly similar degrees of time in seconds. However, the variance increases as the first horse takes the great amount of the prize and as the others take a small amount of the prize or no prize at all. Thus, this can be explained as the increase in the heritability in respect to the prize.

The general outcome of this study can be expressed as; the increase in the distribution of the prize contributes to the shortening of the running time of the Arabian horses in the later years of the stated period; the increase in the running performance and the prize won on the turf track and in the group A; When the estimated heritabilities of the racing performance are considered, the effect of genotype on the running performance is high and it is possible to improve this characteristic through selection.

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