Animal Science Papers and Reports vol. 21 (2003) no. 4, 233-239
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Heritability of racing merit of Arab horses

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(Received November 5, 2003; accepted December 1, 2003)

The study aimed at estimating variance components of racing ability traits in Polish Arab horses as a contribution to defining the breeding objective for the breed. Data collected were 8754 placings at finish (square root), 5805 earnings (log), and 1317 numbers of annual starts (square root) of 928 horses running in races over the years 1998-2001. Age of horses ranged from 3 to 10 years, and the distances were from 1400 m to 3000 m. Horses came from 4 state studs and from private (Polish and foreign) breeders. Variance components were estimated by the REML method. Statistical analysis accounted for fixed effects of race within year, age, sex, weight carried and distance, and for the random effects of rider and permanent environment, as well as additive genetic effect of an animal. Model for number of starts within a season omitted the race, rider, weight carried, and distance effects. Pedigrees were at least three generations deep. Heritability coefficients were 0.14, 0.25 and 0.12, and repeatability 0.29, 0.47 and 0.23 for earnings, placings at finish and annual number of starts, respectively.

KEY WORDS: Arab horse / heritability / racing merit

The main selection criterion in the Polish Arab horses has ever been "a bouquet". Only horses full of oriental beauty, proportionally built, and moving gracefully are accepted for reproduction. Following the introduction of racing performance test in 1927 [Pruski 1983] selection for strong constitution, stamina and resistance to stressors have paralleled the selection for charm, and has been treated as a factor counteracting negative effects of single-sided selection for exterior [Zwoliński 1976]. The Arab horses begin to race at the age of three years, which is one year later than for Thoroughbreds. The average distance is longer and horses are more heavily burdened. A rising interest in races of Arab horses, observed in recent years, drives the demand towards a horse of a more pronounced racing ability [Łojek and Chrzanowski 1998]. In this respect Polish Arabs are inferior to American or Russian ones. Hence, Budzyński and Chmiel [1993]

recommended to broaden the breeding goal of Polish Arabs by the racing quality.

Breeding value estimation using the best linear unbiased prediction requires, however, the variances of traits selected for to be known. It was, therefore, the purpose of the present study to model statistically and estimate (co)variance components of racing ability traits, which can likely be included in the overall index.

Material and methods

The study included the entire population of the Arab horses being performance-tested at the Polish racing tracks during the years 1998-2001. Results on 8754 races of 928 horses, aged 3 to 10 years (3-year, 4-year, and 5+ year-olds), and racing over the distances of 1400 to 3000 m entered the database. The horses came from four state studs, as well as private Polish and foreign breeders. Money prize won in a race, placing at finish, and number of starts within a racing season were recorded for each horse. Money prizes were log-transformed, while the latter two traits were transformed with the square root function. The variance components were estimated by the REML method using Misztal's [1998] software. The final statistical classification for money prize and placing at finish accounted for fixed effects of race within the racing season (year), age class, sex, and linear regressions on weight carried and distance, as well as random effects of rider, permanent environment, and additive genetic. The model for number of starts within a season naturally omitted the race, rider, weight carried, and distance effects. Horses older than four years were grouped into one age class (5+). The only five geldings were classified together with mares. There were 97 riders. Because records having zero money prizes were treated as missing, the number of observations for that trait was 5805. The pedigree information covered at least three generations. Fourteen sires with more than 15 offspring had pedigrees four-generations deep. The number of animals in the pedigree amounted to 2026.

Results and discussion

The data structure is described in Tables 1-3. In consecutive years numbers of horses racing were similar – some 330 a year, out of which 66% were stallions (Tab. 1). The sex distribution varied, however, across age groups – in the group of three-year-olds the mares consisted 45% of the starters, to decline down to 14% in the group of 5+ year-old horses. Depending on the year, in the group of three-year-olds, 53-69% stallions and 33-42% mares remained on track as four-year-olds; there were only few horses which kept racing, older than four years. The number of starts per year (season) oscillated around seven and was significantly higher for 3-year and 4-year old stallions. The frequency of starts of 3-year-olds was significantly lower than of older horses.

The horses were the offspring by 179 stallions out of 556 mares (Tab. 2). Almost half of the sires had only one offspring. The number of offspring per sire averaged to

5.2. When analysing the distribution of offspring per sire it can be concluded that only a small number of sires were intensively used for reproduction. Even higher proportion of dams (59%) had only one offspring. That unfavourable structure of genetic

Table 1. Number of horses (nok) and average number of starts (nos) by age, sex and year of start

Year	Sex	3-year-olds		4-year-olds		5+-year-olds		Total	
		nok	nos	nok	nos	nok	nos	nok	nos
1998	stallions	118	6.5	60	7.6	26	7.9	204	7.1
	mares	105	5.5	28	7.2	2	8.0	135	5.9
1999	stallions	96	7.0	69	6.8	30	6.8	195	6.9
	mares	83	5.7	38	6.7	4	8.7	125	6.1
2000	stallions	111	6.7	66	8.3	33	7.6	210	7.4
	mares	81	5.3	27	7.3	9	7.2	117	5.9
2001	stallions	106	6.3	59	8.7	45	6.1	210	6.9
	mares	79	5.3	34	7.1	4	6.0	117	5.9
Total	stallions	431	6.6	254	7.8	134	7.0		
	mares	348	5.4	127	7.0	19	7.4		

Table 2. Distribution of offspring amongst sires and dams

No. of offspring by sire	No. of sires	No. of offspring per dam	No. of dams
1	85	1	330
2-5	52	2	125
6-10	17	3	69
>10	25	>3	32
Mean: 5.2	Total: 179	Mean: 1.7	Total: 556

Table 3. Number of starts by distance and age of horses; number of horses in parentheses

Distance (m)	3-year-olds		4-year-olds		5+-year-olds		Total	
	n	%	n	%	n	%	n	%
1400	575 (328)	12	349 (120)	12	114 (23)	11	1038 (471)	12
1600	2897 (745)	61	1191 (96)	41	403 (29)	37	4491 (870)	51
1800	1056 (449)	22	782 (140)	27	290 (30)	27	2128 (619)	24
>1800	230 (166)	5	596 (118)	20	271 (26)	25	1097 (310)	13
Total	4758	54	2918	33	1078	12	8754	100

relations, yet specific for the species and found also in Thoroughbreds [Sobczyńska and Łukaszewicz 2003], stresses the need of employing the animal model in genetic evaluations.

The horses raced over the distances of 1400 to 3000 m (Tab. 3). Small number of horses running long distances was the reason of grouping longer races into one class of races exceeding 1800 m.

Most frequent, and with no reference to starters' age, was the distance of 1600 m. The shortest distance, *i.e*. 1400 m, was equally popular in all the annual crops of horses – at the level of 12%. The proportion of starts in the longest races kept increasing with the age of horses (from 5% for 3-year to 25% for 5+-year-olds).

The number of horses ridden by a single rider is an indication of how to treat the effect of rider – either as random or as a fixed one. The fewer the riders, the stronger is the recommendation to treat it as fixed. In the present study about 32% of the riders rode only one horse, 22% started on 2 to 5 horses, and 19% rode more than 50 horses. It was, therefore, decided to treat that effect as random.

Neither the endowments nor the placings were affected by age and sex of the horses. The weight carried correlated with money prizes and placings: more heavily loaded horses won more money and, naturally, were placed higher. Similar relationship in Arabs was reported by Belhajyahia *et al*. [2002].

Distribution parameters of the traits before and after transformation are shown in Table 4. Whereas transformation of earnings and placings resulted in essential normalization of their distributions, the square root transformation of number of starts

Table 4. Distribution parameters of studied traits (Log – natural logarithm, Sqrt – square root)

Trait	Number of observations	Mean	Coefficient of variation	Skewness
Money prize (zł)*	5805	1327	238	18
Log (money prize)	5805	6.5	17.7	0.3
Placing	8740	4.4	56.5	0.5
Sqrt (placing)	8740	2.0	30.7	-0.0
No. of starts	1317	6.6	47.6	0.2
Sqrt (no. of starts)	1317	2.5	26.4	-0.4

*PLN (Polish zlotys).

seems to be of no help.

In Table 5 the ratios of variance components relative to phenotypic variance are presented. The highest heritability (0.25) and repeatability (0.47) coefficients were obtained for the square root of placings. Lower heritabilities and repeatabilities were found in racing Arabs by Belhajyahia *et al*. [2002]. The heritability estimated in the

present study for the placing at finish (0.25) is in good agreement with data published by Sobczyńska and Kownacki [1997]. Their result for log annual earnings is, however, higher (0.22) than reported here for earnings in individual races. The bibliography regarding racing merit of the Arab horses is limited and the results reported here can further be compared mostly with those obtained for other breeds of horses. For Thoroughbreds the heritabilities and repeatabilities of earnings and placings vary from lower (0.09 and 0.1 – Chico [1994]) to higher (0.2 and 0.5 – Williamson and Beilhartz [1996]) than those found in the present study.

An Arab horse is required to be fit and sound. Since those two traits help in achieving frequent starts, the number of starts within a season can be, in turn, considered as an indicator of animal's toughness. Unfortunately, the heritability of number of starts within a racing season is apparently low – 0.12 in present study and 0.08-0.29 as re-

Table 5. Proportion of variance components relative to phenotypic variance (pe – permanent environment, ri – rider-induced, h^2 – additive genetic); r – repeatability

Trait	pe	ri	h^2	r
Log (money prize)	0.15	0.03	0.14	0.29
Sqrt (placing)	0.22	0.04	0.25	0.47
Sqrt (no. of starts)	0.11	–	0.12	0.23

ported by Pikuła and Grzesiak [2003]. Indeed, this particular trait is subjected to the policy, difficult to account for, of putting a horse on track, independent of its fitness. That is especially true for the mares, which may, for instance, be in foal at the time of a potential race.

The proportion of variance caused by rider (Tab. 5) reached only 4% of the phenotypic variance. Equally small proportion of the rider variance component is reported in the Polish Thoroughbreds [Sobczyńska and Łukaszewicz 2003]. Röhe *et al*. [2001] observed significant proportion of the rider variance in racing ability of German trotters due to the fact, that individual riders rode many horses and, thus, did not become an element of a horse's permanent environment.

The permanent environment variance components appeared of the same relative magnitudes as the additive components for all three traits (Tab. 5). This indicates that permanent environment is of similar importance to genes in moulding the horses's racing performance. Probably that pattern is independent of the breed as Sobczyńska and Łukaszewicz [2003] found similar proportions of permanent and additive components of money prizes and placings in Thoroughbreds.

Out of the three racing merit traits studied the number of starts within a season seems to require further effort to define the statistical classification describing its environmental determination. The remaining two, earnings and placings, are very much the same trait although their genetic and environmental parameters differ noticeably. Trait "money

prize" differs from trait "placing" by varying amount of money attributed to a given place. Removing observations with no earnings, which artificially decreases the variance, can contribute to the difference in magnitudes of the heritability coefficients. On the other hand, assigning the non-earning horses the "0" value does not follow the differentiation of endowments in races of different levels. A non-placed horse in a difficult race with high endowment is as penalized as one in an easier race. Horses which have not earned any money in a prestigious race are underestimated. Moreover, including horses with "0" earnings causes deformation of the trait distribution.

It is, therefore, the authors's suggestion that the breeders, to evaluate the racing ability of Arabs, should rely upon the placing of the horses within a race rather than on the earnings. Number of starts within the racing season, which can be considered a valuable measure of persistency of performance requires research to properly account for different effects affecting that trait.

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Odziedziczalność cech dzielności wyścigowej koni arabskich

S t r e s z c z e n i e

Celem badań było oszacowanie komponentów wariancji cech dzielności wyścigowej polskich koni arabskich, jako wkład do dyskusji nad celem hodowlanym dla tej populacji. Baza danych obejmowała wyniki gonitw 928 koni ścigających się w latach 1998-2001. Obok 8754 danych o miejscu zajętym w gonitwie (pierwiastek kwadratowy) analizowano również informacje o wysokości wygranych (logarytm naturalny) – 5805 obserwacji oraz 1317 obserwacji dotyczących liczby startów w sezonie wyścigowym (pierwiastek kwadratowy). Pod względem wieku konie podzielono na trzy grupy: trzylatki, czterolatki oraz konie pięcioletnie i starsze. Dystanse wyścigów wynosiły od 1400 do 3000 m. Konie wystawiane do wyścigów pochodziły z czterech stadnin państwowych oraz od hodowców prywatnych (także zagranicznych). Komponenty wariancji oszacowano metodą REML z wykorzystaniem modelu uwzględniającego stałe wpływy gonitwy w sezonie, wieku, płci, niesionej wagi i dystansu gonitwy oraz losowe wpływy jeźdźca, specyficznego środowiska i addytywny wpływ osobnika. W analizie liczby startów w sezonie pominięto naturalne wpływy niesionej wagi, dystansu i jeźdźca. Rodowody sięgały co najmniej trzech pokoleń. Oszacowane wskaźniki odziedziczalności wyniosły 0,14, 0,25, i 0,12, a powtarzalności 0,29, 0,47 i 0,23 odpowiednio dla wysokości wygranych, miejsca w gonitwie i liczby startów w sezonie.