Anim. Res. 52 (2003) 481–488

DOI: 10.1051/animres:2003033

Original article

Breeding evaluation of arab horses from their racing results in Tunisia by a BLUP with an animal model approach

Tahar BELHAJYAHIA[a], Christine BLOUIN[b], Bertrand LANGLOIS[b]*, Hanene HARZALLA[a]

[a] Faculté des Sciences, Unité de génétique des populations, 1060 Tunis, Tunisia
[b] Station de Génétique Quantitative et Appliquée, INRA, 78352 Jouy-en-Josas Cedex, France

Abstract — The aim of this study was to estimate the breeding value of Arab horses in Tunisia. Racing results (36203) were available corresponding to 2432 horses issued from 811 dams and 218 sires registered in the Tunisian stud book and in the races organized from 1980 to 2001 by the "Société des courses de Tunis". Performance was described by two criteria: the earning and the rank in the race used after some transformations: (i) attribution of "theoretical" earnings to the not placed horses and normalization by a Log transformation, (ii) normalized rank according to statistical tables on which a "performance rate" calculation was applied (see further). The effects of year, age and sex were significant. The effect of weight carried was also significant but the results appeared paradoxical because the more they carried the better were the performances. Variance component estimation using VCE software gave the following values for heritability: 0.09 and 0.12, respectively, for the Log of earning and the ranking value. Repeatability was the following: 0.25 and 0.35, respectively. The maternal environment component was evaluated as 0.04 for the ranking value and 0.03 for the Log of earning. The genetic correlation of the two criteria was estimated to 0.97 standard error and was around 0.01 in all cases. In conclusion, the Log of earning and ranking value are two appropriate manners to take into account racing performance in selection for Arab horses in Tunisia. It can be remarked, however, that the heritability of the ranking value was higher. The adjustment of earnings with the level of races was probably not precise enough and intra race as a function of the ranks, the respect of a constant relative decrease of the earnings according to the place was too approximate.

horse / racing ability / purebred Arabian / BLUP / animal model / Tunisia

Résumé — **Évaluation génétique par un BLUP en modèle animal des chevaux arabes d'après leurs résultats en course en Tunisie.** L'objectif de l'étude est l'estimation de la valeur génétique additive des chevaux de pur-sang arabe en Tunisie, il est mené sur 36203 données relatives à 2432 chevaux issus de 811 mères et 218 pères de pur-sang arabe enregistrés dans le stud book tunisien et

* Corresponding author: Bertrand.Langlois@dga.jouy.inra.fr

correspondant aux courses organisées de 1980 à 2001 par la SCT. La performance est appréhendée par 2 critères ; le gain et le classement, utilisés après quelques transformations : (i) attribution d'une somme fictive aux chevaux non gagnants et normalisation par une transformation logarithmique, (ii) un classement normalisé d'après les tables statistiques sur lequel une procédure de « performance rate » a été appliquée. Les effets année, âge et sexe s'avèrent significatifs. Pour le poids porté, le résultat paraît paradoxal puisque les chevaux les plus chargés expriment en moyenne de meilleures performances. L'analyse par un modèle animal avec répétabilité grâce au logiciel VCE a conduit à l'estimation des paramètres génétiques : une héritabilité de 0,09 ± 0,01 et 0,12 ± 0,01 respectivement pour le log du gain et la valeur classement ; la répétabilité est de 0,25 ± 0,01 pour le log du gain et 0,35 ± 0,01 pour le classement. L'effet maternel est de 0,04 ± 0,01 pour le classement et 0,03 ± 0,01 pour le log du gain. Il ressort alors que le log du gain et la valeur classement sont deux bonnes façons d'appréhender les performances des pur-sang arabes en Tunisie, mais on peut remarquer que l'héritabilité de la valeur classement est nettement meilleure, celle du gain se trouve influencée par un ajustement trop imprécis de la dotation avec les niveaux des courses ainsi qu'un respect assez approximatif de la décroissance relative constante du gain en fonction de la place.

cheval / aptitude à la course / pur sang arabe / BLUP / modèle animal / Tunisie

1. INTRODUCTION

Purebred Arab-horse-races are well known in Tunisia and have a long history beginning when the SCT (Société des courses de Tunis) was founded in 1884. This organization oriented towards racing gives a special touch to the Tunisian Arab-horse breeding in which other countries are also interested.

In this paper we examined if modern breeding value estimations, Blup animal model methodology, can be applied to the data published in year-books in order to improve the information system and therefore the accuracy of the selection and the genetic progress for this particular racing aptitude. This approach was implemented with success for sport horses and trotters in some European countries. This is the first time that it was done for purebred Arab-horses.

2. MATERIALS AND METHODS

2.1. Animals

The racing results were collected in year-books from 1980 to 2001. The years 1985–86 and 1993–94 were along with 2001, not complete. The data consisted of 36203 racing results corresponding to 2432 purebred Arabian horses issued from 811 dams and 218 sires registered in the Tunisian stud-book. The management and the publication of these results over 21 years, have been run by the SCT (Tunisian Jockey Club) with great care and commitment.

2.2. Measurement of performance

This was achieved by two criteria: earnings and rank in the race used after some transformations.

First, for the non-placed horses a "theoretical earning" was calculated by multiplying by 0.5 each increasing rank as done by Chico [1]. If horses did not receive a rank, an arbitrary rank was given. After normalization by a Log transformation of these "virtual earnings", all the non-placed horses were equalized and received the same value which is the mean of the Log of the "virtual earnings" of the non-placed horses (for more information see Langlois [9]).

A similar procedure was applied for rank but here the transformation in this case was replaced by the use of a score that one can find in statistical tables (i.e. the normal standard deviation expectation of rank k out of N individuals).

In this case, on the contrary to earnings, where the level of the race is taken into account by the amount of money distributed, one makes no differences between the levels of races. We therefore introduced a kind of pre-correction for the level of the race following the method proposed some years ago as the "performance rate" [3, 10] studied by Watanabe [13] and Kieffer [6]. In this approach, the performance S_{ij} of horse i in race j (expressed as intra-race differences between the horses) is considered to be influenced by two effects, that of the race r_j and that of the horse h_i:

$$S_{ij} = h_i - r_j + e_{ij}$$

where e_{ij} is a random residual (to be minimized) and h_i and r_j are considered as fixed (original performance rate). We just add to this proposition to consider the horse's effect as random to take into account the degree of repeatability of the horse's performance.

The resolution of this model alone is not very difficult. But it would be in a more general approach including other fixed or random effects. We therefore proposed this kind of pre-correction of the data for the race level. To approach the true repeatability, we propose to successively apply this model and a more general genetic model (see over) to the data by successive iterations.

2.3. Genetic analysis

The following animal model according to the French method for breeding value estimation [11, 12] was adjusted to these two measures of performance using VCE and PEST software [4, 5]. The effects of year, age, sex and weight carried were considered as fixed. The effect of the animal additive genetic value and that of the specific environment to an animal and the effect of a common environment to the progenies of the same mare were considered as random.

This model leads to the following equation:

$$y = X\,b + Z\,g + W\,m + Z\,p + e$$

where y = vector of observations, Log of earning or ranking value; b = vector of fixed effects (year – age – sex – weight carried); g = vector of additive genetic values; m = vector of maternal environmental effects; p = vector of the specific environment to an animal; e = vector of errors; and X, Z and W are the incidence matrix.

The expectations of this linear model are:

$$E\begin{bmatrix} y \\ g \\ m \\ p \\ e \end{bmatrix} = \begin{bmatrix} Xb \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

The variance covariance matrix is:

$$V\begin{bmatrix} g \\ m \\ p \\ e \end{bmatrix} = \begin{bmatrix} A\sigma_g^2 & 0 & 0 & 0 \\ 0 & I\sigma_m^2 & 0 & 0 \\ 0 & 0 & I\sigma_p^2 & 0 \\ 0 & 0 & 0 & I\sigma_e^2 \end{bmatrix}$$

$$\sigma_g^2 = h^2\sigma_y^2; \sigma_m^2 = \mu\,\sigma_y^2;$$

$$\sigma_p^2 = (r - \mu - h^2)\,\sigma_y^2; \sigma_e^2 = (1 - r)\,\sigma_y^2$$

where A = relationship matrix; I = identity matrix; h^2 = heritability; μ = maternal environment component of variance in %; r = repeatability.

3. RESULTS

3.1. Estimation of fixed effects (BLUP)

3.1.1. Year

Figure 1 reveals a slow steady decrease of ranking scores and fluctuations of earnings according to year. These fluctuations

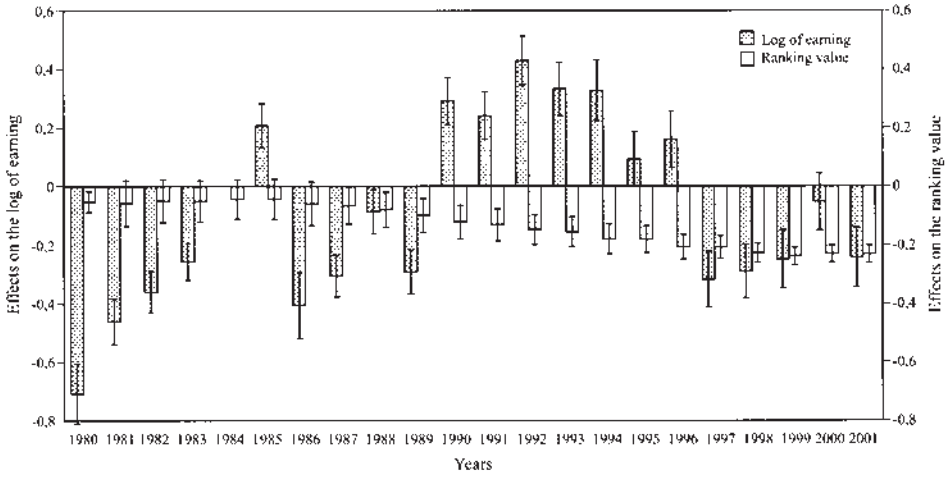

Figure 1. Best Linear Unbiased Estimations of year effect.

are significant for earnings but not for ranking scores.

3.1.2. Age

Figure 2 shows a not significant decreasing ranking score with age which is more pronounced for 6 year-olds and older horses. It is the same for earnings whose expectation is greater for young horses and decreases slowly with age. In this case it was significant.

3.1.3. Sex

Figure 3 shows for the two criteria that males and geldings exhibit superiority over females.

3.1.4. Weight carried

The effect was significant for the two criteria. It is paradoxical because the more they carried, the better were the results for the two criteria. The handicap weight seemed to begin to play its role only with +5 kg or more. Under this, it did not seem to be sufficient to equalize the horse's chances. Figure 4 shows the results.

3.2. Estimation of the components of variance

Heritability parameters ± se (Tab. I) are 0.09 ± 0.01 and 0.12 ± 0.01, respectively, for the Log of earning and the ranking value. Repeatability was 0.25 ± 0.01 and 0.35 ± 0.01, respectively. The maternal environmental component was evaluated at 0.04 ± 0.01 for the ranking value and at 0.03 ± 0.01 for the Log of earning. The genetic correlation of the two criteria was estimated to be 0.97 ± 0.01 and the phenotypic correlation as 0.779 ± 0.001, calculated from all the observations.

4. DISCUSSION

The year of birth effect was easy to understand for the earning criteria. It was due to fluctuations of the allocated purse and to inflation trends. On the contrary, the regular slow decreasing of the ranking value was not so easy to understand. It was indeed not significant.

Age effect on earnings decreases with time (Fig. 2). It was an effect of the policy of donation promoting young horses.

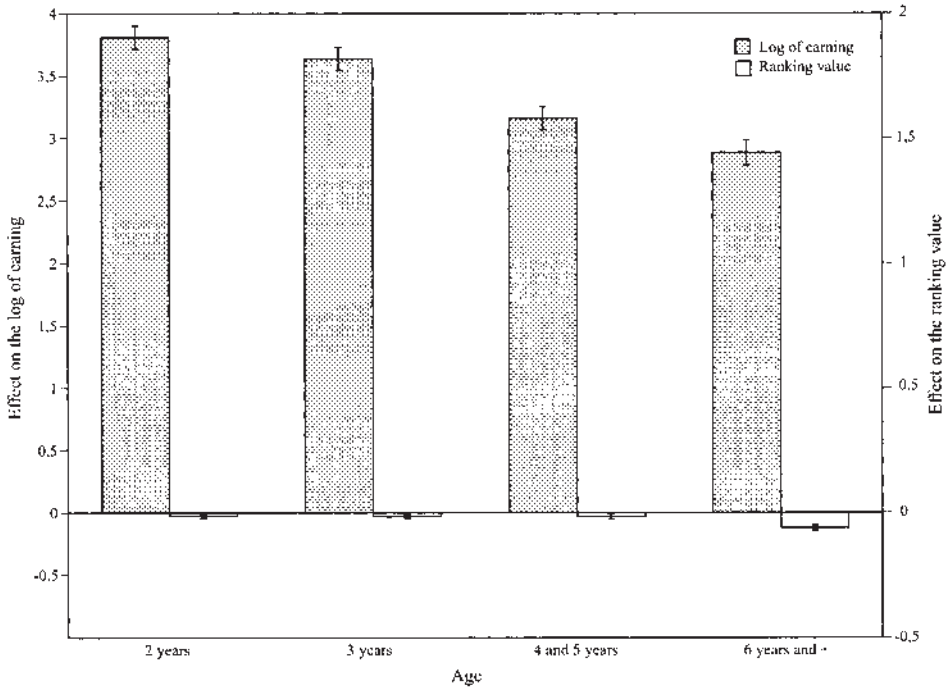

Figure 2. Best Linear Unbiased Estimations of age effect.

Figure 3. Best Linear Unbiased Estimations of sex effect.

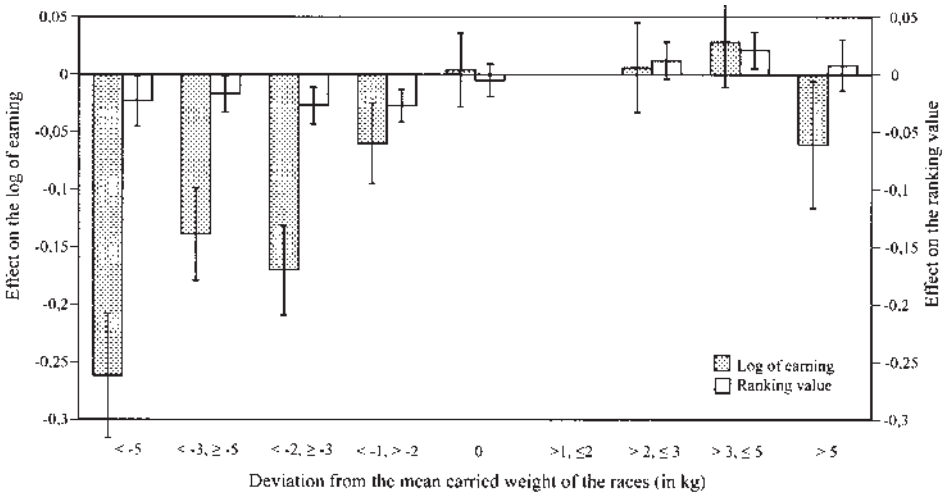

Figure 4. Best Linear Unbiased Estimations of the effect of weight carried.

Table I. Estimation of the genetic parameters (± s.e.).

Criteria	Log of earning	Ranking value
Variance components: Residual	3.138	0.960 0.513
Maternal environment	0.112	0.059 0.031
Repeatability	0.526	0.243 0.145
Additive Genetic Value	0.386	0.188 0.098
Corresponding ratios: Genetic parameters	0.093 ± 0.011	0.966 ± 0.010 0.124 ± 0.013
Repeatability	0.246 ± 0.006	0.348 ± 0.007
Maternal environment	0.027 ± 0.005	0.040 ± 0.006

The sex effect in favor of males and geldings is well known for gallop ability ([2, 7, 8] among many others) and was confirmed for the purebred-Arabian-horses for the two criteria studied but was only significant for earnings not for the ranking value because young females, the majority, were running separately.

The effect of weight carried was paradoxical. The more they carried the better the earnings and ranking values. Handicap weighting seems to begin to play a role with

± 5 kg over or under the mean of the race and at this level appears clearly insufficient to equalize the horse's performances. This was obtained practically only for horses having ± 5 kg. In full gallop, the center of gravity of the horse does not move vertically. There is therefore very little added work with added weight. These results may indicate a general over estimation of the effect of weight carried on gallop racing performance on flat at least for short distances with little variation of the speed.

Estimation of the variance components led to rather classical results: the maternal effect was in the range of 3 to 4% and heritability and repeatability being between 9 and 12%, and 25 and 35%, respectively. However, the ranking criterion was substantially more heritable and repeatable than were the earnings: the two criteria being very highly correlated phenotypically (0.78) and genetically (0.97). There were therefore no great differences between the two criteria but earning appears less accurate than the ranking value. This was probably due to two things: the commonly used donations were only four in number and for them the relative decrease according to increasing rank between 1 and 4 was not regular. Also these four donations did not efficiently cover the different levels of races. This is certainly the first reason of the decrease of heritability and repeatability of this criterion. Both traits at the race level, however, showed sufficiently high genetic variation, knowing the mean number of races in a horse's career, to lead to an efficient selection on the racing ability of pure bred-Arabians in Tunisia. The question that can be raised is: do we need to maintain a double evaluation on the two criteria or do we have to choose? The genetic correlation presented clearly shows the redundancy of the two criteria. We therefore have to choose the better one which was, in this case, the new ranking criterion.

An information system has to be built on these criteria to inform breeders on phenotypic and breeding values. Phenotypic values could be given at the level of each race or at the level of the racing career and breeding values should be calculated each year using the BLUP animal model methodology described.

5. CONCLUSION

Earnings and ranking values are two appropriate criteria to select purebred Arabians for racing ability in Tunisia. However, the heritability of earnings was substantially lower. A genetic correlation of 0.97 and a phenotypic correlation of 0.78 express the great redundancy between the two criteria. There is not much to gain in the construction of synthetic criteria mixing the two. We therefore recommend the use of the better one which is in this case, the new ranking value.

REFERENCES

[1] Chico M.D., Genetic analysis of thoroughbred racing performance in Spain, Ann. Zootech. 43 (1994) 393–397.

[2] Cunningham E., Genetics of performance traits; Thoroughbreds, in: Bowling A.T., Ruvinsky A. (Eds.), The genetics of the horse, CABI publishing, 2000, pp. 411–418.

[3] Gillespie R.H., A new way to evaluate race horses, Performance Rate, The Thoroughbred Record 17 (1971) 961–977.

[4] Groeneveld E., PEST UIUC V3.1 user's manual, Institute of Animal Husbandry and Animal Behavior, Mariensee, Federal Agricultural Research Center (FAL), D-31535, 1990.

[5] Groenenveld E., VCE V4.2.5 User's guide and reference manual, Institute of Animal Husbandry and Animal Behavior, Mariensee, Federal Agricultural Research Center (FAL), D-31535, 1998.

[6] Kieffer N.M., Heritability of racing capacity in the thoroughbred, Proceedings of the International Symposium on Genetics and Horse Breeding Dublin 17-18 September, 1975, pp. 9–18.

[7] Langlois B., Heritability of racing ability in thoroughbreds a review, Livest. Prod. Sci. 7 (1980) 591–605.

[8] Langlois B., A considerations of the genetic aspects of some current practices in thoroughbred horse breeding, Ann. Zootech. 45 (1986) 41–51.

[9] Langlois B., Utilisation of competition results for the selection of sports and races horses, Atti 4º convegno, Nuove acquisizioni in materia di Ippologia, Campobasso 11-12-13 luglio, Univ. degli studi del Molise (ed.), 2002, pp. 11–20.

[10] Porter R.A., Performance Rate calculations, The Thoroughbred Record 17 (1971) 960.

[11] Tavernier A., Caractérisation de la population des Trotteurs Français d'après leur estimation génétique par un BLUP modèle animal, Ann. Zootech. 38 (1989) 145–155.

[12] Tavernier A., Caractérisation des chevaux de concours hippique français d'après leur estimation génétique par un BLUP modèle animal, Ann. Zootech. 39 (1990) 27–44.

[13] Watanabe Y., Performance rates of thoroughbreds as a criterion of racing ability, Jap. J. Zootech. Sci. 45 (1974) 408–411.