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# Selection of racehorses on jumping ability based on their steeplechase race results-H36-7

Á. BOKOR[1], C. BLOUIN[2], B. LANGLOIS[2]

[1] University of Kaposvár, Faculty of Animal Science, 7400, Kaposvár, 40. Guba Sándor Street, Hungary

[2] Station de Génétique Quantitative et Appliquée, INRA, 78352 Jouy-en-Josas Cedex, France

Abstract

The aim of this study was to detect Thoroughbred mare families and sire lines in France, in the United Kingdom and Ireland whose offspring may be successful in steeplechase races and can be recommended therefore for sport horse breeding. Race results were collected from all steeplechase races in these countries between 1998 and 2003 and contained the results of 17 355 horses from 12 861 dams and 2 452 sires. In France also non-thoroughbred horses were included in the analysis because they race and mate together with Thoroughbreds. Performance was measured with two criteria: earnings and ranks after mathematical transformation. The effects of year, sex, age, and race were considered as fixed, animal, permanent environment and maternal environment as random. Pre-correction for the effect of race was done to avoid computational difficulties. Maternal environmental components for ranks were 0.021 in France and zero 0.000 in the United Kingdom and Ireland. Estimated heritabilities for the ranking criteria were 0.18 (repeatability 0.33) in France and 0.06 (repeatability 0.19) in the United Kingdom and Ireland. The high genetic correlation between the two criteria of measurement (0.94 and 0.97 resp.) gives the opportunity to choose the most suitable criteria for breeding value estimation. The ranking value, after statistical normalisation has a great advantage for comparison between the countries.

Keywords: racehorse / Thoroughbred / steeplechase / jumping ability / selection / BLUP / animal model

## 1. Introduction

Historically, all around the world thoroughbreds have been used to improve local coach horse breeds into modern saddle horse breeds. They are still used on some of the world's leading sport horse breeding farms. To avoid the negative effects of the extreme selection of very young animals on races, only those, free from hereditary defects and whose mature results have been proven, are considered suitable for sport horse breeding. Horses with a high percentage of Thoroughbred blood take part in three-day-eventing with success. The reason for the good performance of the Thoroughbred blood in the eventing can be found during the steeple and cross-country part of the event. During the steeple part, horses have to gallop and pass several obstacles with a prescribed speed that depends on the competition level. The cross country course comprises numerous (24to35) fixed obstacles over a distance of 4500 meters (logs, water jumps, ditches and hillocks). Some of the obstacles may have easier options that, however, will induce time penalties as they lengthen the course distance. To complete this stage of the event successfully, horses need speed and stamina, not only good jumping ability and technique. Since the establishment of the new rules of the F.E.I. (Fédération Equestre Internationale i.e. sport organisation), the distances at the cross country are shorter (first applied at the 2004 Olympic Games, Athens). Consequently, the importance of Thoroughbred blood will decrease. The number of Thoroughbred participants is low in show jumping competitions and three-day-events, therefore these competitions are not very suitable for the selection of thoroughbreds for sport.

The selection of thoroughbreds is based on their racing performance usually on flat races, but a few countries have also established hurdle and steeplechase races. Hurdle races are long distance races, where participants have to pass several obstacles during the race. These hurdles are usually not higher than 110 cm. In hurdle races the horse does not need a real jumping ability to pass the fences. Despite this, steeplechasers start their racing career in hurdle races.

Steeplechases are also long distance races. The race track is composed of wooden base and birch or spruce interior obstacles. Plain fences vary in height from a minimum of 135 cm and some are open-ditch fences. Some races also have water jumps as in cross country eventing. For selection of Thoroughbreds for sport, races over jumps seem suitable. However, 95% of the participants are geldings. In steeplechase races, horses and jockeys fall more often than in flat races. Pinchbeck et al., (2002) found that 5.95% of the horses fell in 1999 in the United Kingdom.

Most authors measure performances for racehorses by earnings and ranks. In most cases a mathematical transformation is needed (Langlois, 1975). Earnings and mathematical transformations of earnings (log of earnings per start, log of annual earnings) have been discussed in several studies (Hintz, 1980; Langlois, 1980; 2004). In the case of jump races Langlois et al. (1996) found heritability near 0.25 (logarithms of yearly earnings) in horses that had taken part in steeple and hurdle races in France from 1950 to 1990. There was no significant change over time in heritability; however, repeatability between 4 and 5 years increased significantly.

Ranks can also be a measurement of performance (Langlois, 1980; 1996). Williamson and Beilharz (1996; 1998) used position rates in Australia, Sobczynska and Lukaszewicz (2003) used the square root of the finishing position for Arab horses in Poland. Heritabilities were 0.18 (repeatability 0.34) for the square root of ranks in Poland, and 0.57-0.6 for sires and 0.73-0.74 for dams in Australia for performance rates, but these values are much higher than those reported by other studies.

Heritability of racing time decreases as the racing distance increases (Oki, et al. 1995b). It is a less useful measure in longer races, and it is often recorded only for the winner (Ricard et al., 2002). Steeplechase races are long distance races from 3000 to 7000 m, consequently racing time as a measure of performance is not suggested.

Breeders prefer to breed Thoroughbreds for flat races rather than for steeplechase because the horses take part in races from the age of two, and they can have earnings in this very early age. In Europe, only France, the United Kingdom and Ireland have numerous steeplechase races with a lot of participants. The United Kingdom, Ireland and France have different systems for allocating race prizes. It is therefore difficult to compare earnings in different countries. Belhajyahia et al. (2003) have found high genetic and phenotypic correlations between earnings and ranks for Arab horses in Tunisia as also found by Svobodova et al. (2005) for thoroughbreds in the Czech Republic.

Considering the above information, the best system to select Thoroughbreds for jumping ability is to use steeplechase race records. It is of great importance for sport horse breeders to estimate breeding values of Thoroughbreds and to select sire lines and mare families.

The aim of this study was to detect Thoroughbred families in France, in the United Kingdom and Ireland whose offspring are successful in steeplechase races and can be recommended therefore for sport horse breeding.

## 2. Materials and methods

### 2.1. Description of the data

Race records from the United Kingdom and Ireland have been collected from the Race form Interactive (commercially available dataset) and from "France-Galop" for the French races. From the United Kingdom and Ireland only the "chase" type of races has been used. In France hurdle races were also excluded. Data from the 1st of January 1998 to 31st of December 2003 were analysed (Table 1).

From the data in Table 1, we can calculate average 3.4 starts per year and per horse in France and 3.3 in the United Kingdom and Ireland; however, horses in the United Kingdom and Ireland had a chance to also run in national hunt races which were not available here. In France and UK/Ireland, the average number of participants per race was 10 and the average number of runs per horse during the period was 6.1 in both cases. This means an average career length of not more than two years (1.78 and 1.86 years resp.).

The number of progeny per sire is higher in France with an average of 9 compared with the United Kingdom and Ireland where it is only 6. In Thoroughbred breeding, artificial insemination is not allowed in pure breeding, because the breeders want to limit the number of progeny per sire in order to be able to speculate on stallion fees. In France, non-thoroughbred race participants express a more specialised breeding toward this kind of race. This may explain the higher mean number of offspring per stallion. The number of progeny per dam shows the same tendency: two offspring per dam in France and only one in the other countries were found. This is also the result of some specialised breeding.

Sex repartition also shows differences in the examined countries. In France 61.1% of the race participants are geldings, 1.7% are stallions, and 37.1% are females. In the United Kingdom and Ireland a higher and lower proportion was found for geldings (90.9%) and mares (9.0%), respectively. Similar frequencies were found for all ages because due to the racing regulations, younger horses can take part in numerous races. This contrasts with flat races where 2-year-old horses can participate in only a few races (Sobczynska and Lukaszewicz, 2003).

Jockeys ride an average 6 horses per year in both cases which is a low value compared to other studies (Pinchbeck at al., 2003; Oki et al., 1995a). The number of horses trained by a trainer per year was also low: 20 in the United Kingdom and Ireland and 17 in France.

During the six year period of observation, 31.8% of the horses in France and 28.9% of the horses in the United Kingdom and Ireland were not able to complete the race or were disqualified. The records of horses that were distanced from the winning post were excluded from the analysis. Race records from the United Kingdom and Ireland are more detailed although they contain shorter pedigree records (2 generations) in comparison with the French data (up to 8 generations). Race conditions are different in the above mentioned countries. In France even the non-thoroughbred horses can participate in the races, such as AQPS (Autres Que Pur Sang) and Anglo-Arabs. Horses in France start their racing career in steeple chases at the age of three, in the United Kingdom and Ireland at the age of four, after some hurdle races.

2.2. Measuring performances

Ranks and logarithmic transformations of earnings were used during the analysis to measure performance.

"Computed earnings" were calculated for horses without earnings applying the method developed by Chico (1994). Computed earnings were calculated by halving the earnings with an increase of one in rank (the $5^{th}$ receive the half of the $4^{th}$, the $6^{th}$ the half of the $5^{th}$ and so on). Normal distribution of the earnings was obtained by applying a logarithmic transformation (Langlois, 1975). Unplaced horses (in place 5 or later) were arbitrarily assigned the rank and corresponding earnings for the places 5, 6, and so on. The mean of the log of these assigned earnings was then calculated and given to each of these unplaced horses.

Transformation for ranks was also necessary in order to use a normalized measure of performance. We used scores for ordinal data (Fisher and Yates, 1957) to obtain on a standardized Normal scale the expectation of the $k^{th}$ rank from the n horses competing in the race. Unplaced horses based on the same principle as above received equal value.

2.3. Model of analysis

To estimate breeding values for earnings and ranks the applied animal model followed the method developed by Tavernier (1989, 1990) using PEST (Groeneveld, 1990) and VCE (Groeneveld, 1998) software.

Factors of variation were the following:

Year, from 1998 to 2003,

Sex, 2 levels, (mare, gelding and stallion),

Age, (3, 4, 5 in France; 4, 5 in the United Kingdom and Ireland; 6, and up in both),

Race (6632 in French and 5605 in the United Kingdom and Ireland).

These were considered as fixed effects.

In France there were 9041 participants, progeny of 986 sires and 5927 dams. In the United Kingdom and Ireland there were 8314 horses from 1466 sires and 6934 dams.

Pre-correction for the race effect was needed to avoid some computational difficulties. Adopting the method by Belhajyahia et al. (2003), the performances $s_{ij}$ of horse i in race j is considered to be influenced by two effects, the fixed race effect ($r_j$) and the random horse effect ($H_i$):

$$s_{ij} = H_i + r_j + e_{ij}$$

$e_{ij}$ is a random residual.

The final model was the following:

$$y = Xb+Yg+Yp+Zm+e$$

where y = vector of observations (log of earnings or pre-corrected transformed ranks = $s_{ij}$-$r_j$); b = vector of fixed effects, as year, age, sex; g = vector of additive genetic effects; p = vector of permanent non-genetic effects; m = vector of maternal effect (common environment shared to the offspring of the same mare); e = vector of residuals while X, Y, Z were the known incidence matrices. For earnings, the race effect is not considered because the prize money is the manner to evaluate the level of the race. For the ranking value, because the mean of $s_{ij}$ in a race is zero the race effect is necessary. It is then managed with the pre-correction.

## 3. Results

The applied models and the estimated heritabilities and repeatabilities for the measured traits are shown in Table 2. The bivariate model allows the estimation of the genetic parameters taking into account the correlations between the two traits but limited to the data that are complete for the two traits; the univariate model is given for comparisons. There was almost no difference in the estimation of the genetic parameters.

Estimated heritabilities (repeatabilities) for race earnings and ranks were 0.15 (0.27) and 0.17 (0.35), respectively.

The maternal environmental component was 0.009 (±0.005) for log of earnings and 0.024 (±0.007) for ranks based on the French dataset. The same component was lower in the United Kingdom and Ireland, 0.006 (±0.007) for log of earnings and 0.001 (±0.002) for ranks. Genetic correlations between ranks and log of earnings were 0.935 (±0.008) in France and 0.968 (±0.016) in the United Kingdom and Ireland. Due to this very high genetic correlation, BLUP estimations were made only on the ranking values which give the same measure of the performance for the two files.

The results of the BLUP evaluations made on the ranking value by PEST (Groeneveld, 1990) are shown in Figures 1-2 for France and in Figures 3-4 for the United Kingdom and Ireland. The distributions of the estimations of breeding values look nearly normal and offspring as a probable result of pre-selection appear significantly better than their parents. Paradoxically stallions had very variable estimations indicating that they were not selected to produce steeple-chasers. The distributions of the determination coefficients (the square of the correlation R between the true breeding value and its estimation) were not so regular. They may express some thresholds in the quantity of information available. Offspring as performers were also estimated more accurately than sires and mares. However, in general the mean $R^2$ values were low.

Genetic trends according to the birth years for stallions, mares and offspring are shown in Figure 5 for France and 6 for UK/Ireland. In the United Kingdom and Ireland, we found much lower progress for breeding values for ranks in offspring, and even a decline in mares and stallions. On the contrary sires and dams born between 1960 and 1995 achieved highly significant genetic progress in France (0.0063±0.0013 and 0.0056±0.0008 per year respectively). Offspring of these animals showed also a very highly significant genetic progress of 0.017±0.002 per year. In the United Kingdom and Ireland, much lower progress for breeding values for the same criterion was observed for offspring (0.0023±0.0004 per year), but the decline for sires and dams (-0.001±0.0007 and -0.0005±0.0006 respectively) was not significant. In France, further analyses were made by breeds to determine if the positive trend was only the effect of the non thoroughbred part of the population. We found (results not shown) that Thoroughbreds and non-thoroughbreds show exactly the same tendencies.

## 4. Discussion

The results of heritabilities for log of earnings and ranks given in Table 2 are lower than those published previously, but these results are not comparable with other studies because they refer to one race and they are based on steeple-chases and not on flat races. Considering these heritabilities, the repeatabilities and the number of races per horse and year, they can be compared with the values found by Langlois et al. (1996), who found 0.25 for heritability and 0.05 for the maternal component of variance in French steeplechase races for earnings. Comparing the two data files of the present study, lower values were estimated for both of the measured traits in the United Kingdom and Ireland. This may be due for a part to the non-thoroughbred participants in France where the creation of a mixed population selected by steeple-chases increases the genetic variability. At least for the ranking criterion, the phenotypic variance is the same because the data in both files were statistically normalised in the same way. Therefore differences in heritabilities may express differences in genetic variability.

In the United Kingdom and Ireland the estimated maternal environment components were low (0.006 and 0.001) with high standard errors. However, Langlois and Chico (1989) showed a clear difference between the paternal and maternal paths of heredity in racehorses (partial regression coefficient of offspring on mare at constant sire greater than the symmetric one). In the present data sets one has to consider that the low number of offspring per mare do not allow in most cases the estimation of the common environment which is therefore regressed to zero. In other words the maternal effect has no meaning for mares with only one offspring.

A distribution of breeding values (Figure 1 and 3) show that offspring appears as a selected material compared to their mares and stallions. The recruitment of sires is better in the mean but highly variable. Considering mean differences between offspring and dams, 0.194-0.127=0.067 for France and 0.034-0.009=0.025 for UK/Ireland, they are comparable for the two files. The same can be said for stallions (0.017 and 0.015 respectively). In fact because of studying the two files separately, the definition of the base population is not equivalent for the two cases. Comparisons of absolute means therefore need care. In particular we can not conclude of an absence of selection of mares and stallions whose selection appears to be comparable in France and in UK/Ireland at least for the sires when comparing with the offspring mean.

Estimated breeding values (Figures 1 and 3) showed higher variance in France due to the higher determination coefficients (Figure 2 and 4) coming either to higher heritabilities and/or to the higher number of offspring. However, it is surprising that the variance in sire BLUP indices is almost the same as for offspring, and that both are almost twice as high as that for the dams. This pattern was the same in the data from France and from the UK/Ireland. This can be connected with the fact that for the determination coefficient, the mean for offspring and stallions is much higher than for dams. Offspring had the highest coefficients of determination because they were all performance tested. This was not the case of mares and stallions which were mostly progeny tested. Stallions had enough progenies to reach the determination level of offspring but this was not the case for mares.

Are the trends measured on the ranking criterion from Figure 5 and 6 showing real differences in genetic progress?

Sires and dams born between 1960 and 1995 achieved progress in breeding values in France. The offspring of these animals also evidence a genetic progress. This is normal.

In the United Kingdom and Ireland, much lower progress was found in offspring and a slight not significant decline in mares and stallions. This is not normal.

This contradiction may be explained by the fact that the observed trends could be the result of changes in the pre-selection of the offspring material and not only that of genetic trend.

However, despite this remark, we know that the selection in UK/Ireland, even not so intensive on the dam side, seems equivalent on the paternal side; we suggest it is a lower genetic variability that explains the lower selection response observed in UK/Ireland compared to France.

The great variability of the information, reflecting race results from the great number of breeding parents, leads in both files to low determination coefficients. This can be considered to be the main observation of this study. This implies that for steeple chasing, one should not select from the whole population, but should select suitable animals into a specialised breeding population with the aim of concentrating the information on performance in steeplechase race results on a smaller number of animals.

5. Conclusion

Earnings and ranking values in France and in the United Kingdom and Ireland are useful criteria for selection of Thoroughbreds in steeplechase races. Horses taking part in these races also have jumping ability, not only speed and stamina. The high genetic correlation between the ranking and earnings criteria (0.94 and 0.97) provide an opportunity to choose the most suitable criterion for breeding value estimation. The ranking value, when statistically normalised has a great advantage for comparison between countries because it is the same across countries. This is not the case with earnings that depend on national policies of allocating prize money.

To determine how useful these results are in breeding, we propose a genetic evaluation based on the ranking criteria which is more easily comparable among countries. The difference in genetic progress shown between the United Kingdom and Ireland and France may have introduced some difference in mean performance in the two countries. However, the data do not allow its full evaluation. Ignoring this difference, it is possible to promote some sires and dams for the production of steeplechasers in each country.

6. Acknowledgements

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Figure 1: Distribution of BLUP indices for dams, sires and offspring in France based on ranks

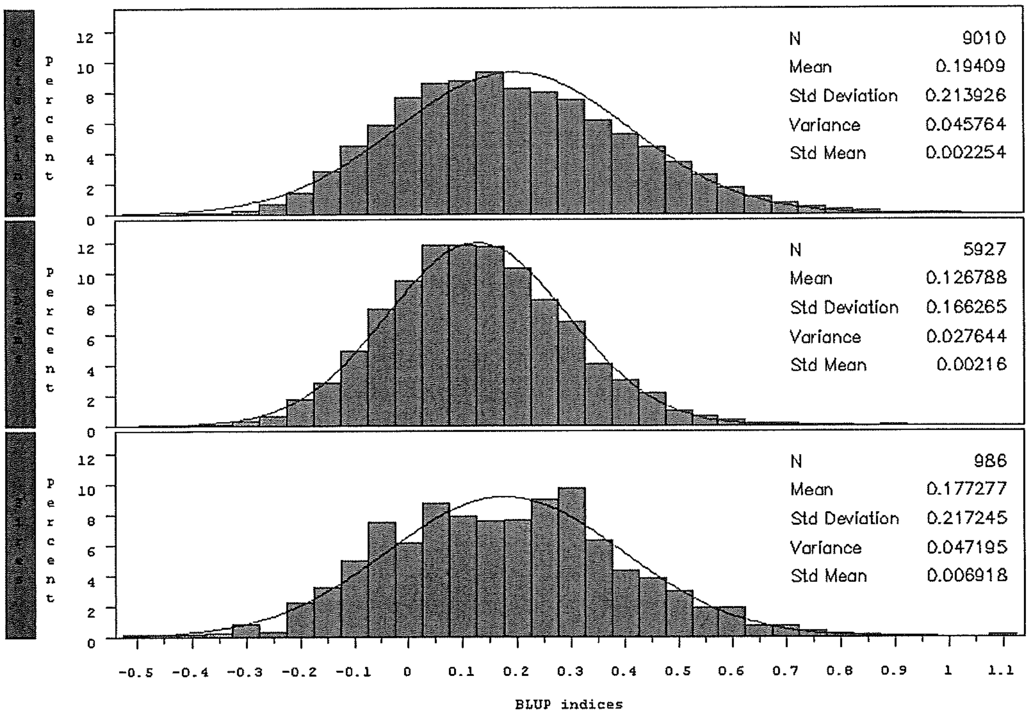

Figure 2: Distribution of determination coefficient for dams, sires and offspring in France

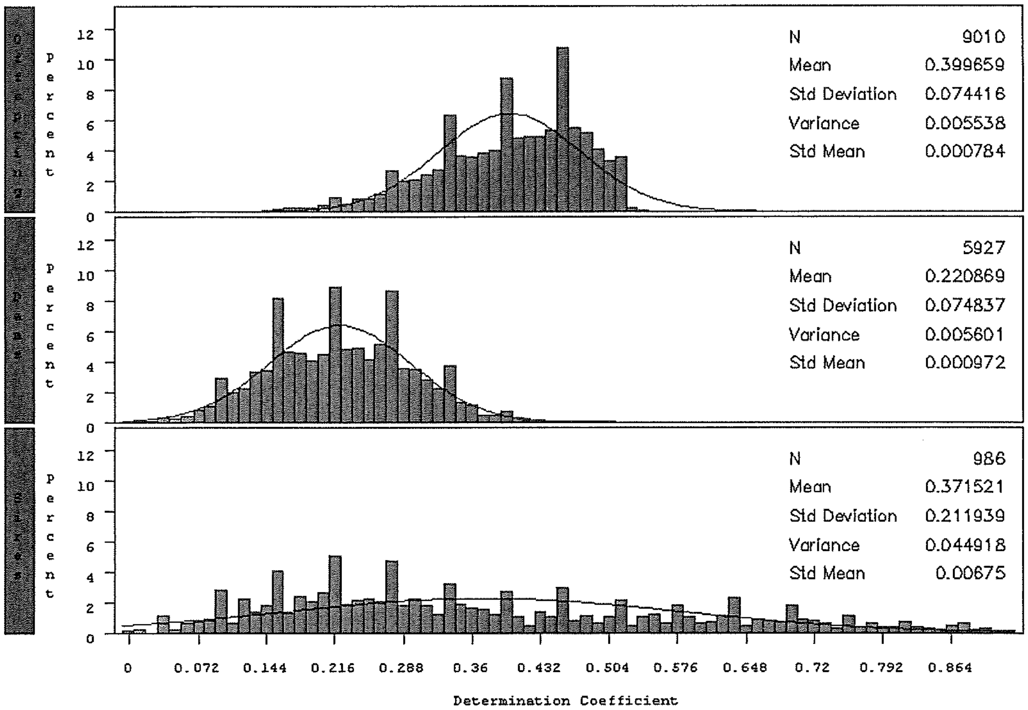

Figure 3: Distribution of BLUP indices for dams, sires and offspring in the United Kingdom and Ireland based on ranks

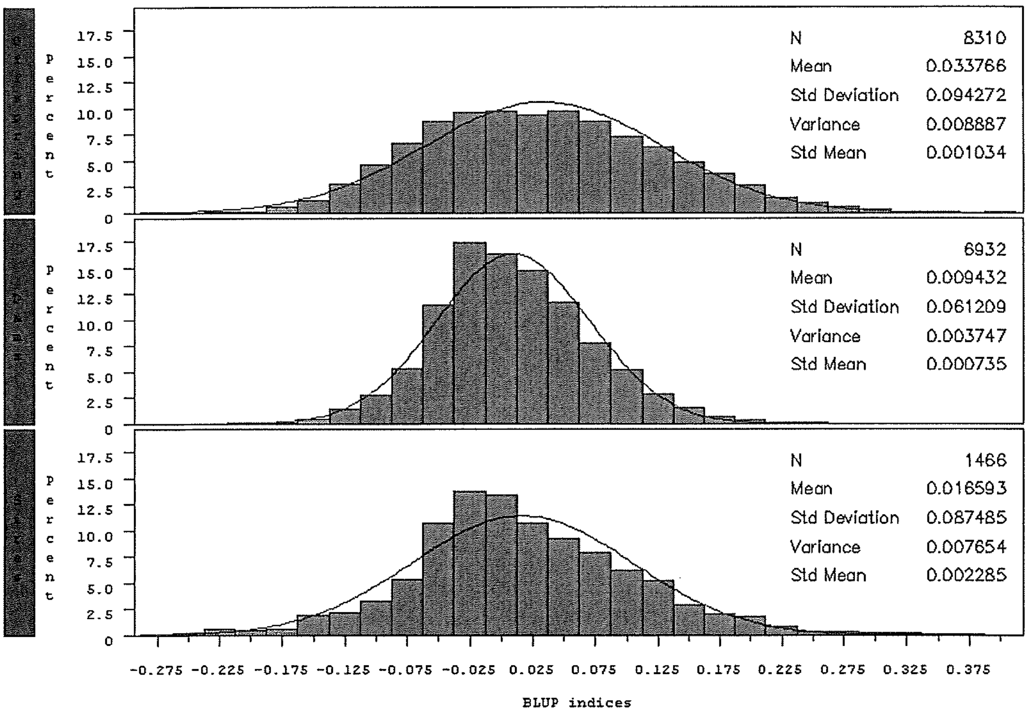

Figure 4: Distribution of determination coefficient for dams, sires and offspring in the United Kingdom and Ireland

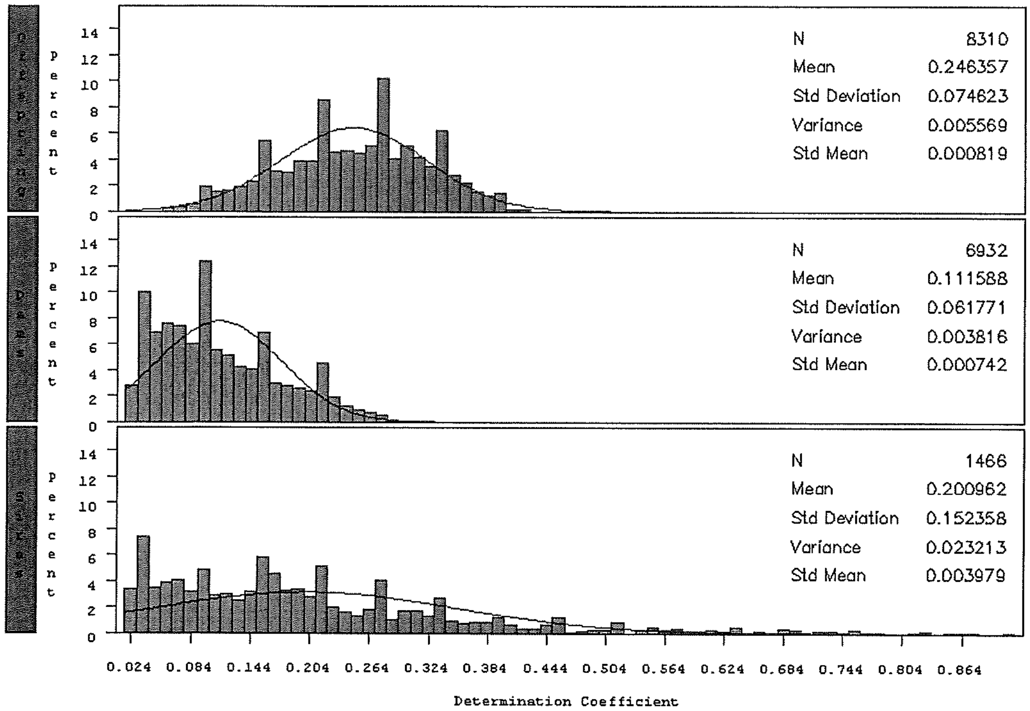

Figure 5: Evaluation of BLUP indices according to the birth years in France

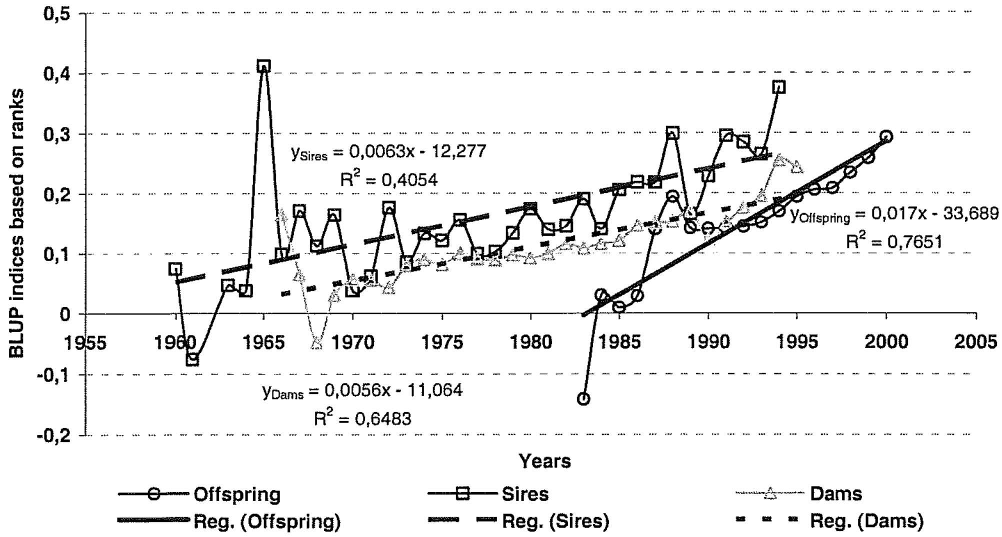

Figure 6: Evaluation of BLUP indices according to the birth years in the United Kingdom and Ireland

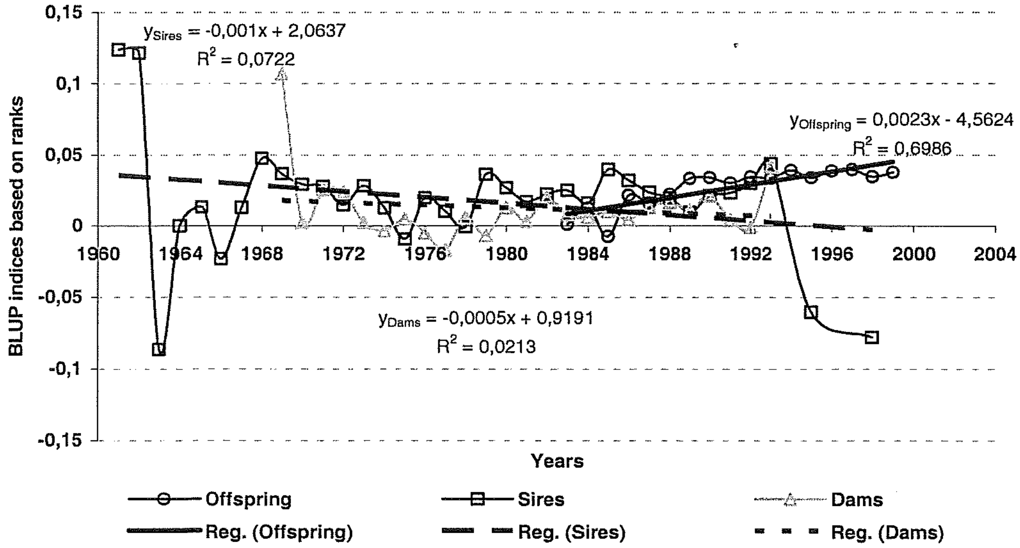

Table 1. Description of the data at the given year

| Category | Years | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 1998-2003 |
| France | | | | | | | |
| Individual records | 9176 | 9222 | 9153 | 9049 | 9307 | 8982 | 54889 |
| Did not finished | 3313 | 4615 | 3107 | 2698 | 2687 | 2340 | 17484 |
| Races | 926 | 928 | 931 | 923 | 947 | 950 | 5605 |
| Horses | 2663 | 2635 | 2690 | 2677 | 2723 | 2752 | 9041 |
| Sires | 560 | 569 | 542 | 538 | 535 | 549 | 986 |
| Dams | 2225 | 2227 | 2235 | 2252 | 2310 | 2337 | 5927 |
| No earnings | 4607 | 4615 | 4543 | 4416 | 4566 | 4233 | 26980 |
| Racecourses | 91 | 91 | 87 | 85 | 84 | 83 | 93 |
| Race distances (mean in meter) | 3860 | 3839 | 3843 | 3839 | 3849 | 3835 | 3844 |
| Jockeys | 461 | 469 | 439 | 433 | 421 | 420 | 834 |
| Trainers | 486 | 482 | 454 | 452 | 437 | 431 | 809 |
| United Kingdom and Ireland | | | | | | | |
| Individual records | 8835 | 8846 | 8050 | 8717 | 8550 | 8142 | 51140 |
| Did not finished | 2646 | 2537 | 2251 | 2650 | 2506 | 2230 | 14820 |
| Races | 1134 | 1152 | 1083 | 1000 | 1110 | 1153 | 6632 |
| Horses | 2628 | 2662 | 2524 | 2759 | 2638 | 2508 | 8314 |
| Sires | 781 | 763 | 759 | 794 | 776 | 755 | 1466 |
| Dams | 2435 | 2496 | 2370 | 2555 | 2458 | 2340 | 6934 |
| No earnings | 4533 | 4470 | 4024 | 4954 | 4321 | 3816 | 26118 |
| Racecourses | 41 | 40 | 40 | 41 | 40 | 40 | 42 |
| Race distances (mean in meter) | 4248 | 4264 | 4275 | 4257 | 4286 | 4287 | 4270 |
| Jockeys | 315 | 306 | 289 | 305 | 299 | 302 | 695 |
| Trainers | 519 | 521 | 475 | 511 | 510 | 486 | 934 |

Table 2. Estimated values for heritabilities and repeatabilities in France and in the United Kingdom and Ireland (1998-2003)

| | Model with two variables | | Model by variable | |
|---|---|---|---|---|
| | Log of earning | Rank | Log of Earning | Rank |
| Effects in the model | | | | |
| ▪ year | X | X | X | X |
| ▪ sex | X | X | X | X |
| ▪ age | X | X | X | X |
| ▪ race | - | Pre-corrected | - | Pre-corrected |
| ▪ maternal | X | X | X | X |
| Results from France | | | | |
| Repeatability | 0.267±0.025 | 0.347±0.029 | 0.273±0.026 | 0.328±0.028 |
| Maternal environmental component | 0.009±0.005 | 0.024±0.007 | 0.010±0.006 | 0.021±0.006 |
| Heritability | 0.155±0.011 | 0.170±0.012 | 0.155±0.012 | 0.178±0.013 |
| Genetic correlation between traits | 0.935±0.008 | | | |
| Results from the United Kingdom and Ireland | | | | |
| Repeatability | 0.271±0.026 | 0.223±0.016 | 0.274±0.027 | 0.190±0.015 |
| Maternal environmental component | 0.006±0.007 | 0.001±0.002 | 0.005±0.007 | 0.000±0.000 |
| Heritability | 0.089±0.009 | 0.067±0.007 | 0.086±0.010 | 0.062±0.007 |
| Genetic correlation between traits | 0.968±0.016 | | | |