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Genetic analysis of racing performance in Irish greyhounds

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Summary

The aim of this study was to analyse racing performance data in Irish greyhounds with regard to genetic and environmental variation. Estimation of heritabilities for racing time (RT) and ranking, and the prediction of breeding values for all greyhounds in the investigated data were carried out. Data from 42 785 races in Ireland in the years 2000–2003 were available. These results were obtained from 42 880 greyhounds on 20 race tracks over a distance of 480 m. Three traits were analysed, RT, ranking and a scaled logarithmic function for RT (ART), which was used to adjust racing time to be normally distributed. The data were analysed with a bivariate animal model. The estimated heritabilities were moderate for RT (0.31) and ART (0.38), but very low for ranking (0.10). The repeatabilities were 0.56 (RT), 0.51 (ART) and 0.13 (ranking). The genetic correlations were very high, 0.99 (RT–ranking) and 0.96 (ART–ranking), while the phenotypic correlation was lower, 0.60 (RT–ranking) and 0.62 (ART–ranking). The genetic trend for the traits as well as the phenotypic change of the average RT was positive.

Introduction

The dog breed greyhound belongs to the group of the sighthounds. All sighthounds hunt by sight and in most cases their preys are rabbits and hares. These breeds are very fast but the greyhound with its height of 68–76 cm and weight of around 27–32 kg is the fastest of all dog breeds.

It is assumed that the greyhound reached the British Isles together with the Celts and became the favourite dog of the nobility because of its excellent ability as a hunting dog. The early hunts of the nobility were the beginning of dog racing as it is known today. In the 18th century and later, these 'coursings' – as the hunts are called – became very popular with attendance figures of up to 75 000 visitors. At the beginning of the 20th century, the type of dog racing changed with coursing in the field being overtaken by track racing on an oval race track with a mechanical hare. It took nearly 20 years until this new type of dog racing became popular; however, it is still a favoured sport on the British Isles, in the USA and Australia. In these countries, greyhound racing is a professional sport and plays an important economic role.

The development of the greyhound breed, the coursing and track racing in Ireland and other countries worldwide are well described in *The Greyhound and Greyhound Racing* by Genders (1975), *The Greyhound* by Clarke (1980) and *Greyhounds – The Sporting Breed* by Lennox (1987). Publications in German also cover the worldwide development of this breed (Daub 1979; Räber 1995).

Especially in Ireland, greyhound racing is a growing industry. On the 20 tracks all over the island (17 in Republic of Ireland, three in Northern Ireland) more than 12 700 races took place in 2003. Every year, more than 1 million people visited the races on the tracks and the attendance figures increased to 1.4 million in 2004. Every year around 25 000 puppies in 5000 litters are born and there was a betting turnover of 140 million € in 2004 (Bord Na gCon, 2004).

These facts illustrate the importance of greyhound racing in Ireland. In contrast to other animal populations, there have been almost no genetic studies of the greyhound population. In the only previous study, Ryan (1976) calculated genetic parameters for racing time (RT). Breeding values were never estimated. Hence, the aims of the study were to quantify the influences of systematic environmental effects, to estimate genetic parameters, to predict breeding values and to calculate a genetic trend for two performance traits (RT and ranking).

Material and methods

Description of the races

The races on all racing tracks in Ireland follow the same scheme. On each track, 2–3 race days per week take place all the year round. On a race day, 10–12 races occur with a maximum of six dogs per race starting from automatic traps. The mechanical hare runs on the outside of the track and is controlled by a hare driver who adjusts the speed of the hare to the speed of the dogs. Male and female dogs are mixed and compete against each other. The dogs are grouped according to their previous RT and within one race only dogs with nearly equal RT run against each other. The races have different lengths, from 300 yd (274 m) to 1015 yd (946 m), flat or with hurdles. The most common distance is the 525-yd (480 m) flat race and this study concentrates only on the results obtained for that distance.

Greyhound racing in Ireland is controlled by Bord na gCon [Irish Greyhound Board (IGB)], which is a commercial semi-state body. It was established in 1958 under the Greyhound Industry Act 1958, chiefly to control greyhound racing and to improve and develop the greyhound racing industry in Ireland.

Results from all greyhound races worldwide are collected by Greyhound-Data, a network of international Greyhound owners and breeders. Their website http://www.greyhound-data.com collects and publishes all available information on greyhound racing and breeding, in addition to providing statistics. The community and the members of this service always update the information on racing results and pedigrees. They receive support from the Irish Coursing Club (ICC), which publishes the Irish Greyhound Stud Book every year. Greyhound-Data provided the data used in this analysis.

Data and traits analysed

The data set contained all 480 m races in Ireland in the years 2000 to 2003 with 239 829 results. The results of 42 785 races by 42 880 greyhounds were obtained. It contained information about the:

Race : number of the race track, date of the race, race number.

Animal : animal, sex, date of birth, sire, dam.

Result : time, place, number of dogs in the race.

For analysis, racing age was calculated as the age of the dog at the time of the race, in months. Furthermore, the ranking was adjusted to correct the results in races with different numbers of dogs. It was calculated with the following formula:

$$\frac{R-1}{N-1} * 5 + 1$$

where R is the ranking of animal, and N the number of animals in the race. The formula corrects rankings in races with less than six participants, e.g. an animal finishing fourth in a race with only five animals gets a ranking of 4.75 and the last animal gets the ranking 6. A comparison between races with different numbers of animals is thereby made possible.

The test for normal distribution of RT showed a skewed distribution (skewness 0.289, kurtosis −0.0614). This problem has also been described by Arnason (2001) for racing speed of standardbred trotters. He proposed a logarithmic transformation $y = \ln(k - x)$, where y is the new adjusted time, k the RT and x a constant. The constant x is an estimator of a notional minimum RT. In our case, x was found to be 25.2729 s. The distribution of the ART y showed less skewness (-1.85×10^{-6}) and kurtosis (−0.023). The Kolmogorov–Smirnov test showed that neither the original nor the ART was normally distributed. This may be explained by the inaccuracy of the recorded data and the size of the data set. The recorded times have an accuracy of 0.01 s which, together with the high sample size (number of degrees of freedom), gives a categorical distribution rather than a continuous normal distribution. The genetic analysis was performed for both the original and the adjusted values of the RT.

Mean, standard deviation and the minimum and maximum values for the three performance traits (RT, ART, ranking) are shown in Table 1. The mean values were 30.04 (RT), 1.55 (ART) and 3.45 (ranking) with standard deviations of 0.60, 0.12 and 1.71, respectively.

The number of races per dog is shown in Figure 1. The lowest number was 1, the highest 89. Twenty

Table 1 Mean, standard deviation (SD), and minimum (min) and maximum (max) values for the performance traits

Performance trait	Mean	SD	Min.	Max.
Racing time	30.04	0.60	28.00	34.30
Adjusted racing time	1.55	0.12	1.00	2.20
Ranking	3.45	1.71	1.00	6.00

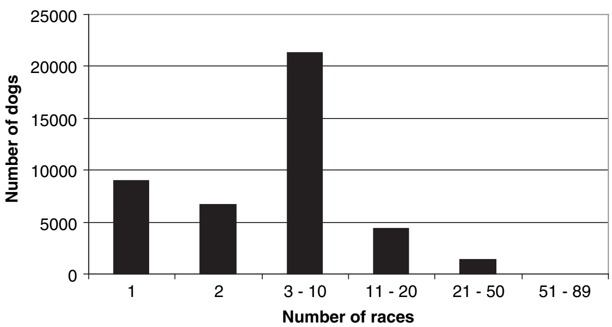

Figure 1 Distribution of dogs for number of races in Irish greyhounds.

per cent of the 42 880 dogs had only one race. Majority of the dogs (66%) had two to 10 races. Only 14% of the greyhounds had more than 10 races. The sex ratio was close to 1:1, as 54% of dogs were male.

The age distribution of the dogs at the time of the race is shown in Figure 2. More than half of all animals were 2 years or younger at the time of the race and altogether more than 90% were less than 3 years. There were only 200 greyhounds which were more than 5 years of age.

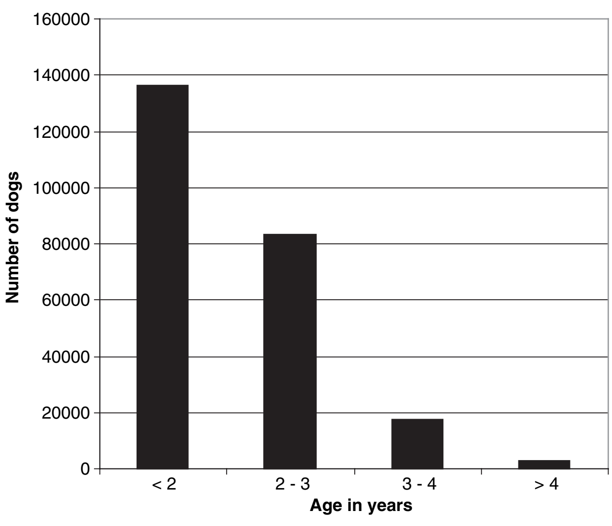

Figure 2 Distribution of age at the race in Irish greyhounds.

In total 793 sires were counted in the data set within the analysed 4 years. Almost 90% had less than 100 offspring within the studied 4 years, whereas only 18 sires had more than 500 offspring; 43.7% of all offspring were sired by these 18 dogs. On the other hand, the group of sires with less than 100 offspring provided the smallest part of the offspring (19.6%). The number of dams was 8136, with up to 39 offspring each; 48% of them had one to three offspring, while only 5% of the dams had more than 15 offspring. Although only the sire and the dam of each dog with a result was provided, the pedigree for the younger animals consisting of up to four generations.

The analysis for the fixed effects and covariates was performed with the program package SAS, version 8.1 (SAS Institute Inc., 1996–2000) using the procedures GLM and MIXED.

The variance components were estimated using the program package VCE 4, version 4.2.5 (Neumaier and Groeneveld 1998) and the breeding value estimation was performed with the program PEST, version 3.1 (Groeneveld 1993).

For the estimation of genetic parameters and prediction of breeding values, the following bivariate animal model was used:

$$y_{ijklm} = \mu + s_i + \mathrm{rt}_j + r_{jk} + b(\mathrm{ra}_l) + \mathrm{pe}_l + a_l + e_{ijklm} \quad (1)$$

where y_{ijklm} is the observation m of dog l (rank together with RT, either original or adjusted, in a given race); μ the population mean; s_i the fixed effect of the sex ($i = 1,2$); rt_j the fixed effect of the race track j; r_{jk} the fixed effect of the race k; nested in the race track j (RT only); $b(\mathrm{ra}_l)$ the regression coefficient of trait on racing age ra of animal l; pe_l the random permanent environmental effect of animal l, $\sim\mathrm{IND}(0, V_{\mathrm{pe}})$; a_l the random additive genetic effect of the animal l, $\sim\mathrm{ND}(0, \mathbf{A}V_a)$, where $\mathbf{A}$ is the numerator relationship matrix; and e_{ijklm} the residual error, $\mathrm{IND}(0, V_e)$.

The influence of the racing age on the RT was independently analysed using a regression analysis within sex. The following statistical model was used:

$$y_{ijkl} = \mu + s_i + \mathrm{rt}_j + r_{jk} + b_{1i}(\mathrm{ra}) + b_{2i}(\mathrm{ra}^2) + b_{3i}(\mathrm{ra}^3) + e_{ijkl} \quad (2)$$

where y_{ijkl} is the RT, b_{1i-3i} the regression coefficients of trait on racing age for each sex i, ra the racing age and e_{ijkl} the residual error, and all other factors are as described in model (1). The use of different models for the two analyses is based on computational limits.

Results and discussion

Influence of systematic environmental factors

The data were examined for the significance of the three fixed effects sex, race track and race, as well as the covariate racing age. The results are shown in Table 2. All four effects had a significant effect on the trait RT. For the ranking only the sex and the racing age had a significant influence.

For RT, least-squares mean values of males were 0.12 s lower than that of females (30.03 s versus 30.15 s). These results are similar to the gender-related differences in the racing performance of whippets (Meissen 1997). Ryan (1976) found no significant influence of sex on the racing performance of greyhounds. The least-squares mean for ranking for the male dogs was better than that for the females (3.35 s versus 3.56 s). This result is consistent with male dogs being faster than females.

The race track had a decisive influence on the average RT. The time difference between the fastest and slowest track was 0.8 s. This result is in concordance with the racing performance of whippets found by Meissen (1997) and greyhounds by Ryan (1976). The reasons for the difference could be due to the track surface. Although all tracks in Ireland are sand tracks, some tracks can be softer or harder than others.

Another reason could be the bend. The tracks have different radii and different angles of inclination. Furthermore, the tracks vary in length and for that reason the dogs start at different points on the tracks, with varying chances to speed up until they get to the bend (Bord na gCon, personal communication). Meissen (1997) found similar differences between average RT of different tracks, though a higher difference (2.38 s) between the slowest and the fastest track.

For analysing the influence of racing age on the performance, a cubic regression specific to each sex was used. The effect of racing age was significant in both traits (RT and ranking) (Figure 3). Meissen (1997) and Ryan (1976) found significant influence of age on RT.

Table 2 Significance of the non-genetic effects on the performance traits of Irish greyhounds

	Effect			
Trait	Sex	Racing track	Racing age	Race
Racing time	***	***	***	***
Ranking	***	n.s.	**	n.s.

Non-significant (n.s.)p > 0.05; *p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001.

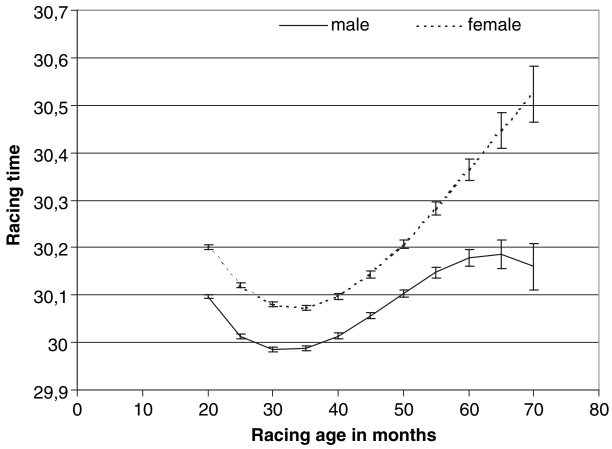

Figure 3 The racing time with respect to age in male and female Irish greyhounds.

Male and female greyhounds improve their RT until the age of 30 months. During the next 10 months the RT remained similar. After that (40 months) both females and males become slower with females having a steeper decline in speed.

At the beginning, all young greyhounds which are licensed to race, start their racing career. At that time no selection takes place. After some races the untalented animals that have very slow RT or are not able to qualify, are dropped out of the racing scene. This is one reason for the improvement of the RT. On the other hand, increasing experience of the greyhounds results in the peak performance at the age of 30–40 months.

Standard errors for the RT increase with age, mainly due to decreasing number of observations. The RT of older males (>60 months) are faster, but taking the high standard error into account, the change is not significant. Males have a different pattern in RT over age. The changes in the data for males older than 60 months can be explained as being censored. In the male greyhounds the selection intensity is higher than in female dogs, because more females are needed for breeding. The number of offspring per male and female dog support this. Consequently, only fast old male dogs remain in races.

The effect of season is accounted for in the statistical model for a single race. This can be compared with the use of a herd–test-day effect in test-day models in other domestic animal species. For illustrating the influence of season, Figure 4 shows the average phenotypic RT over months in the 4 years. It can be seen how the RT change, being slower in the winter (October to March) and faster in the

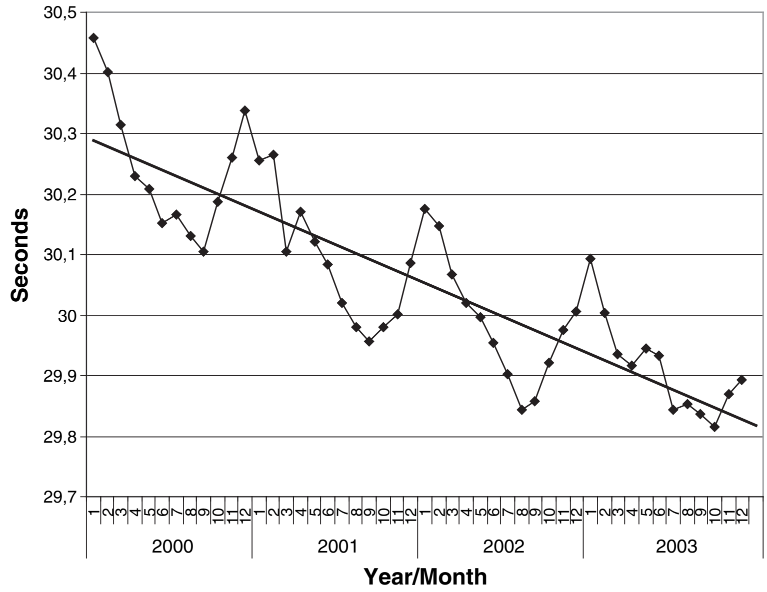

Figure 4 Monthly phenotypic means of the racing time of the Irish greyhounds in 2000–2003.

summer (April to September). The phenotypic trend of the RT shows an improvement from 30.3 to 29.8 s.

Variance component estimation

In Table 3, the additive genetic, permanent environmental and residual variances, heritabilities, repeatabilities, genetic and phenotypic correlations for RT, ART and ranking are shown. The heritability for RT (0.31) and ART (0.38) was moderate and low for ranking (0.099). The repeatability for the RT was moderate for RT and ART and low for ranking (0.13).

The logarithmic adjustment of the RT resulted in a somewhat higher heritabilitiy (0.38) than that of the original RT (0.31), with both estimates having low standard errors (0.006). The lower value for the unadjusted data may be ascribed to the skewness of the original distribution.

Table 3 Additive genetic (V_a), permanent environmental (V_{pe}), residual (V_e) variance and heritability (h^2), repeatability (r) and genetic (r_g) and phenotypic (r_p) correlation for racing time, adjusted racing time and ranking in Irish Greyhounds. Standard error (SE) is given in brackets

	Racing time	Adjusted racing time	Ranking
V_a	0.100	0.005	0.285
V_{pe}	0.082	0.002	0.124
V_e	0.143	0.006	2.671
h^2 (SE)	0.307 (0.015)	0.379 (0.006)	0.099 (0.01)
r	0.559	0.514	0.133
r_g with ranking (SE)	0.99 (0.01)	0.96 (0.01)	
r_p with ranking	0.62	0.60	

Our results are similar to those found by Meissen (1997) for the racing performance of whippets. The heritability for RT was very similar, though in that study only the effects sex, race track and height were analysed, whereas effects of the season (climate at the race) and the racing age were not taken into account. Therefore the proportion of genetic variance may be underestimated, because some important environmental effects are not accounted for and they may inflate the variance attached to the error term. The results of Ryan (1976) showed a slightly lower heritability of 0.23 for RT in races over 480 m (525 yd) long. The repeatability for RT (0.56) and ART (0.51) agreed closely with the value (0.52) in the study of Meissen (1997).

In comparison with studies of racing performance of horses, the heritabilities for horse RT are lower. In Chico (1994), Oki et al. (1995), Mota et al. (1998) and Villela et al. (2002) the heritability estimates are between 0.00 and 0.22. Gaffney and Cunningham (1988) used a heritability value of 0.36 to estimate genetic gain. For ranking, the horse values between 0.07 and 0.13 were closer to the results in this study (0.09). In Chico (1994) the repeatability for RT was lower (0.01), while in Oki et al. (1995) and Villela et al. (2002) similar (0.55). For ranking, the repeatabilities were higher by Chico (1994) (0.21–0.26) and in Villela et al. (2002) (0.44) than in this study (0.13).

The genetic correlation between RT and ranking was very high (0.99 for RT and 0.97 for ART). This

Table 4 Number of offspring (in brackets) and breeding values for racing time (positive values are favourable) for the top 10 dogs with respect to number of offspring in Irish Greyhounds

Ranking in number of offspring (number in brackets)	Genetic ranking (breeding value racing time)
1 (2031)	1043 (0.27)
2 (1758)	102 (0.39)
3 (1604)	27 (0.45)
4 (1459)	2463 (0.22)
5 (1445)	10867 (0.10)
6 (1346)	176 (0.36)
7 (1320)	860 (0.28)
8 (991)	23416 (−0.01)
9 (890)	1200 (0.26)
10 (851)	4321 (0.20)

Table 5 Number of sire dogs and proportion of offspring of the total number of offspring in classes formed by the size of the progeny group per sire in Irish greyhounds

	Number of offspring		
	<100	100–500	>500
Number of male dogs	709	66	18
Offspring	19.6%	36.7%	43.7%

was to be expected because the ranking depends very much on the RT. The phenotypic correlation was lower (0.60). The ranking in a race depends highly on the other dogs. Dogs running against each other are grouped by their phenotypic performance in order to make betting more difficult. In this case, very fast dogs will *a priori* be the last ones as often as slow dogs. Fast and slow dogs regularly do not run against each other, except in some open class races.

The genetic and phenotypic correlations between the two traits are difficult to interpret because of the distribution of ranking. Even if the categorical trait is based on the same normally distributed trait, the phenotypic correlation will never become 1. For six categories with a uniform distribution this correlation is expected to be high, though not one.

Breeding value estimation

For 51 332 greyhounds (42 880 active animals), the breeding values for both performance traits were predicted. The values for RT ranged from 0.62 to −0.78 (SD 0.15) and for ranking from 1.05 to −1.30 (SD 0.25). Performance measures were rescaled (sign reversed to make the desired breeding values positive).

In Table 4 the breeding values and number of offspring for the ten dogs with the highest number of offspring are shown. The breeding values show a high variation in the group of dogs with the highest number of offspring and vary from 0.46 to −0.02. Similar results were obtained for ranking (not shown). One sire had a negative breeding value. Seven of the sires had more than 1000 offspring and one dog had more than 2000 offspring. These dogs belong to the group of dogs having more than 500 offspring (Table 5) and altogether 44% of the total offspring descended from this group.

In Ireland, breeding dogs are mainly chosen by their race performance, especially in highly endowed races. Therefore it could be assumed that the 10 dogs which are used most intensively for breeding, should have good breeding values. There were, however, discrepancies (Table 4). Only one of the 10 sires with

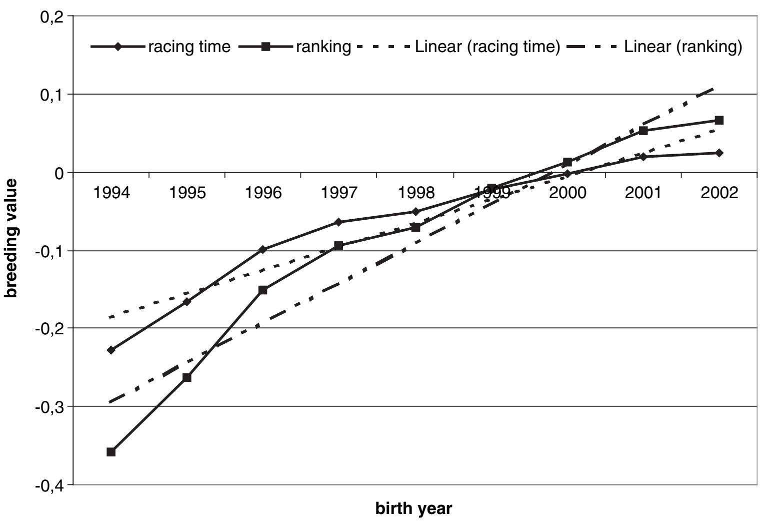

Figure 5 Genetic trend for racing time and ranking in Irish greyhounds. The linear regression of racing time on birth year is $-0.22 + 0.03y$ ($r^2 = 0.92$) and of ranking $-0.35 + 0.05y$ ($r^2 = 0.93$).

most progeny had a breeding value among the best 30 evaluated dogs. The dog with the eighth highest progeny number had a negative breeding value.

These results show that the selection was not optimal for genetic gain in the population. Breeding on phenotypic performance as it is done in Ireland, is effective, because the selected trait has a moderate heritability, but the genetic potential of the population is not utilized at maximum. In Figure 5, the genetic trends of both performance traits are shown. The trend for both traits (RT and ranking) was clearly positive. RT improved by about 0.03 s per year, somewhat more in the early years. Both increases correspond to about 0.1 genetic SD. The phenotypic development of RT was 0.5 s over the four year period (Figure 4), equal to an improvement of 0.125 s per year. The genetic improvement in ranking is difficult to interpret, because no phenotypic improvement is possible. the first rank will always be the best. Calculating breeding values for ranking in a single trait model, no genetic gain can be seen (calculated on current data set, result not presented). The genetic trend in the bivariate model is determined by the high genetic correlation between ranking and RT.

Selection based on breeding values would be more efficient than the practised selection method. The results show a positive phenotypic and genetic trend over four years (Figures 4 and 5), proving that the current selection is effective on RT.

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