A REVIEW OF THE GENETICS OF RACING PERFORMANCE IN THOROUGHBREDS

B. GAFFNEY

Livestock Improvement Unit, Dept. Agriculture,
East Melbourne, 3002

INTRODUCTION

There have been many attempts to measure the heritability of racing performance and genetic trends in performance of Thoroughbred horses over the past 20 years, yet the conclusions to draw from these studies are still often unclear and controversial. Even which type of data is the best measurement of performance is a matter of some debate.

Racing times, earnings, performance rates and handicap ratings have been used as a measure of performance. Although of these only handicap ratings are a subjective measurement, the others are all subject to problems in their use in genetic studies. Racing times for all horses except the winner are estimated from their position relative to the winner, and losing horses are often 'eased up' towards the end of a race. Many horses have few or no earnings, and earnings may reflect a horse's opportunity to earn. Performance rates are a type of handicapping in which a horse is rated objectively according to its performance in relation to the finishing position of other horses. Their usage is confined to North America.

None of the objective measurements can account for factors such as the going, the jockey, the trainer or other factors like the horse's temperament. On the other hand, conventional handicap ratings are assigned by experienced judges and claim to take all these effects into consideration. The most respected ratings available on horses running under British Jockey Club rules are those compiled by the Timeform organisation. The ratings represent the weight (in pounds) which handicappers believe a horse would be entitled to carry in an average Free Handicap race. They range from 30 to 145. The ratings are updated throughout the racing season and end-of-year ratings are published annually. Every horse racing in Britain and Ireland is assessed, with only the very poor performers not receiving a rating (about 20%). This review will deal mostly with studies using them.

HERITABILITY

A summary of heritability estimates is given in Table 1. Although there is quite a range of estimates, many workers suggest a value of 0.4-0.5 as reasonable. The upper range of estimates may be positively biased through environmental effects, and the lower range may be due to deficiencies in the data (as, for example, is probably the case for estimates calculated using earnings or winning time).

The first attempts to estimate the heritability of performance using 'Timeform' ratings were done by More O'Ferrall and Cunningham (1974) and Field and Cunningham (1976). Using standard analysis of variance and regression techniques on reasonably large data sets, they concluded that a best estimate of heritability was 0.40. In the largest study of Thoroughbred records, end-of-year ratings for 31,263 three-year-olds that raced between 1961 and 1985 were analysed (Gaffney and Cunningham 1988). This represented approximately 50% of three-year-olds that raced in that period, the rest not receiving a rating due to lack of information or very poor performances. The study was confined to one age group to avoid age effects, and sex (colt, filly or gelding) was recorded. The best-ever ratings of the sire and dam were used, in addition to those for maternal grandsire, where available (all records since 1966).

Table 1. Heritability of performance using several criteria

Criterion	Heritability
Performance rates	0.36-0.68
Log of earnings	0.38-0.60
Earnings	0.03-0.14
Time elapsed	0.06-0.29
Handicap weights excluding 'Timeform'	0.19-0.60
'Timeform' ratings	0.23-0.80

(Sources: Hintz, 1980; Langlois, 1980; Tolley et al. 1985)

Records were adjusted for sex multiplicatively and expressed as deviations from the yearly mean, and heritabilities were estimated by regression (offspring on sire, dam, midparent and maternal grandsire) and paternal half-sib analysis of variance. The results are presented in Table 2.

Any biases in the results are likely to be positive. For example, highly rated stallions command high stud fees, and their offspring often receive above average management, such as in quality of the trainer. This could account for the high offspring-sire regression, and would also inflate the half-sib estimate. The offspring-dam estimate was the lowest, possibly indicating less environmental biases. When the data were restricted to stallions with at least 5 or at least 10 rated progeny, these estimates decreased slightly. A final best estimate of .36, slightly lower than the dam regression value, was taken as reasonable, on the assumption that any biases were likely to be positive.

Table 2. 'Timeform heritability estimates (Gaffney and Cunningham 1988)

Method	Heritability
Regression on sire	0.76 ± 0.023
Regression on dam	0.39 ± 0.013
Regression on midparent	0.47 ± 0.014
Half-sib anova	0.50 ±0.036

Most estimates of heritability, therefore, suggest that there is ample genetic variation present for racing performance, and consequently genetic progress for the trait should be occurring if the selection methods being used in breeding programmes are correct.

GENETIC TREND

About 6% of colts and 53% of fillies born are later used for breeding, and the generation interval for Thoroughbreds is 11 years (Mahon 1980). With a heritability of 0.36, the expected rate of improvement can be roughly estimated, using these facts, at 0.94 Timeform units per year. However, in analyses of winning times of three of the English Classic races (the Derby, Oaks and St.Leger), Cunningham (1975) and Pattison (1982) found that times improved steadily up to about the 1910s, and appeared to level off thereafter (see Figure 1). Therefore, there is an apparent paradox, in that there is evidence of high genetic variability, yet indications that racing performance may have reached some kind of plateau.

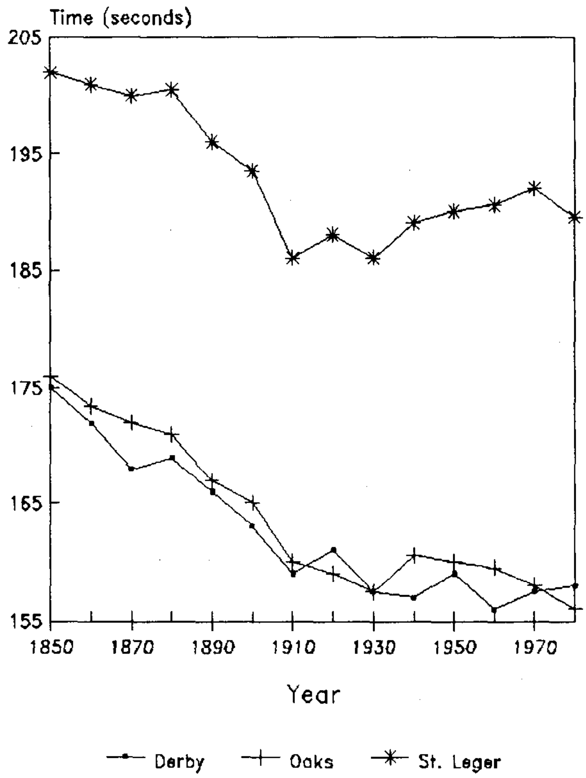

Figure 1. Winning times of English Classic races

trends in the general population were estimated using Timeform ratings.

The first estimate of genetic trend was calculated using the repeated-sire regression method of Smith (1962). The crucial assumption of the method is that dams represent a random sample from the population. The genetic merit of the dam group improves at the same rate as the general population, whereas that of stallions is obviously constant, since the same animals are used repeatedly over time. The data set was restricted to stallions with at least 2 crops of progeny with ratings and at least 5 progeny rated. A maximum of the first four crops of each stallion was used, since progeny performance records then become available and the mares to which he is subsequently mated are unlikely to be selected at random. Progeny performance was regressed on year of performance separately for 58585 sires, yielding an estimate of 1.62 ± 0.26 Timeform units per year. This was considerably higher than expectation, for reasons that remain unclear. It was unlikely to be due to the effects of sex, year, short-term environment, trend in dam ratings or spread of data over years.

The second method involved Least Squares estimation of breeding values for 516 stallions born between 1952 and 1977. Mean breeding values for stallion year-of-birth groups were regressed on time to provide an estimate of genetic trend. The results are shown in Figure 2. The average annual genetic trend was an improvement of 0.94 ± 0.13 Timeform units, or 0.8% of the mean rating.

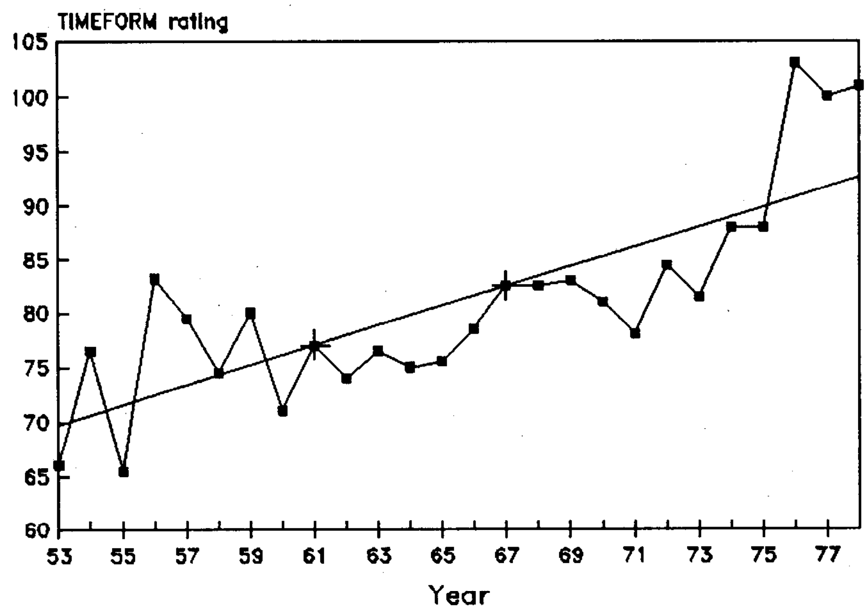

Figure 2. Trend in mean stallion genotype

Of the two methods used, the Least Squares estimate was preferred because it optimally adjusted the raw data for sex and year effects. and sire year-of-birth was included as a fixed effect. The value it gave was also very close to the predicted value.

The conclusion was that genetic improvement was indeed occurring in the population, and at a rate close to expectation. It then remained to resolve the paradox of high variability and lack of progress in Classic race winning times.

There are a few possibilities. One is that horses running in the particular races examined may not be representative of the general population. It is reasonable to assume that such horses generally represent the elite, given the prestige of the races, the prize money and also the cost of entering. It may be that this group of horses comprises the very best of the population, and while this group has reached some sort of plateau, the rest of the population may still be improving. In the British Isles, it is difficult to obtain data on races other than the Classics, so it was not possible to extend the study of Cunningham (1975).

An extensive study by Mahon (1980), involving tracing pedigrees of horses listed in one year of the studbook back to the foundation of the breed, showed that inbreeding rates in Thoroughbreds were no greater than in other domestic species.

The nature of this plateau may be related to blood circulation factors. Firstly, over short, sprinting distances, energy for muscle contraction is provided mainly by the anaerobic breakdown of carbohydrate. Over the 2.5-minutes needed to run an English Classic, however, aerobic respiration predominates. The differing mechanisms for supplying energy may account for the plateau. Secondly, blood circulation (measured by heart rate and cardiac output of blood) increases linearly with increasing speed (Fregin and Thomas 1983). The clearance of lactic acid from muscles, however, does not keep pace with increasing effort, and rapid accumulation occurs at high workloads.

Some supporting evidence for this comes from a study of winning times of the Kentucky Derby, Preakness and Belmont Stakes in the US (Cunningham 1990), which show continuing improvement up to the present. The English Classics are run over 1.5 or 1.75 miles, whereas the US races are shorter sprints. A complicating factor is that English races are run on well-watered tracks, whereas US races are on dirt. However, this practice of watering in England only became common after World War 2, yet winning times for the 3 Classic races show no discernible change in trend since that time. It has also been suggested by racing industry sources that US trainers apply more innovative and scientific methods and are less bound by tradition than their European counterparts, and that this accounts for the continuing improvement of US horses, and the stagnation of English runners.

Furthermore, a study of more than 1 million records on finishing times of American Quarter Horses estimated that genetic trends between 1960 and 1983 averaged 0.47, 0.43 and 0.16% per year for the distances 320, 366 and 402 m respectively (Wilson et al. 1989). Hence, the plateau in performance may only be reached at high levels of exertion.

REFERENCES

CUNNINGHAM, E.P. (1975). Proc. Int. Symp. Genetics and Horse-breeding, RDS, Dublin.
CUNNINGHAM, E.P. (1990). World Convention of Bloodhorse Breeders, Hobart.
FIELD, J.K. AND CUNNINGHAM, E.P. (1976). J. Hered. 67:247.
GAFFNEY, B. AND CUNNINGHAM, E.P. (1989). Nature 332:722.
HINTZ, R.L. (1980). J. Anim. Sci. 51:582.
LANGLOIS, B. (1980). Livest. Prod. Sci. 7:591.
MAHON, G.A.T. (1980). PhD Thesis, Dublin University.
MORE O'FERRALL, G.J. AND CUNNINGHAM, E.P.(1974). Livest. Prod. Sci. 1:87.
PATTISON, A. (1982). Pacemaker, Sept.
SMITH, C. (1962). Anim. Prod. 4:239.
TOLLEY, E.A., NOTTER, D.R. AND MARLOWE, T.J. (1985). Anim. Breed. Abstr. 53:163.
WILSON, D.E., WILLHAM, R.L., BUTTRAM, S.T., HOEKSTRA, J.A. and LUECKE, G.R. (1989). J. Anim. Sci. 66:2817.