

# Quantitative Traits

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As mentioned in the first article “Basics of animal breeding”, different traits show different heritage. Some traits are influenced by one gene only, some of them by a small number of genes but most of the traits in dogs, that are of special interest for the dog breeder are influenced by a very high number of genes. One typical example is the racing speed measured in seconds. This trait can be measured between typical maximum and minimum values, e.g. between 28 and 35 seconds for 480 meters. Between these values, each time that can be measured will be possible. Only the accuracy of the stop watch can set limits. But not all times can be run by all dogs. Let us assume we have an average racing time of nearly 30 seconds. Most of the dogs will run this average time, some animals are faster and some are slower than 30 seconds. Most of the animals will run between 31 and 29 seconds. If we measure 100 dogs and draw a graph of their racing performance, we will get following figure:

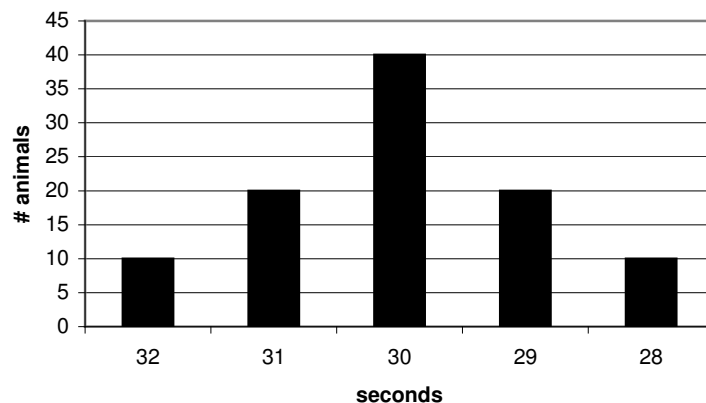


Fig. 1: Results of races. The height of the bar gives the number of animals, that raced the distance in the time below it.

We can see, that 10 animals ran the distance in 32 seconds, 20 in 31 seconds, 40 in 30 seconds and so on. That shows, that most animals are average, the number of animals better or worse than average is smaller.

When we also measure fractions of seconds, we get the following figure:

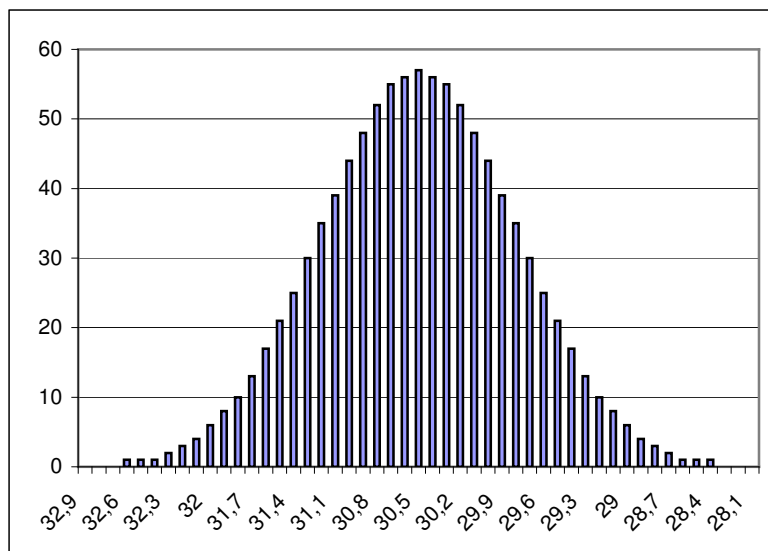


Fig 2: Results of 1000 dogs, shown in 1/10th of a second difference. The height of each bar shows the number of dogs belonging to the time below it.

We can see here the results of 1000 animals and the seconds they needed to run the distance of 480 meters. You can see, that most of them were somehow between 32 and 29 seconds, only a few number can be found better than 29 seconds or worse than 32 seconds.

This distribution of the speed, we have seen on 1000 dogs, is very characteristic for quantitative traits. It is called the normal distribution, because it is found in so many things, that can be measured. You find this distribution in the weight, the growth, in animals and in humans. Even the income of people follows this distribution and it only tells us, that most of us are average and only a very small number of people earn very much money.

So, most of our dogs run an average speed and only a small number of them are very fast. But what we want, is to find these dogs and to breed them. Only a small number of the dogs earn a lot of money, when they win the races.

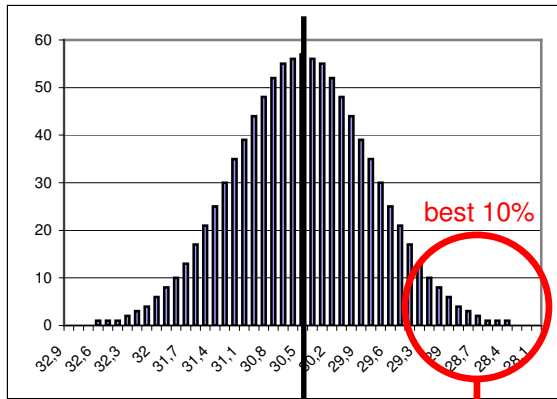
How do we try to find the fast dogs? We know some animals, that are very fast. But we cannot all have them. So breeders try to get the good racing speed of a successful sire in producing offspring. They hope, that the fast sire will inherit his racing ability to his offspring.

But this assumes, that the racing performance is based on genes, because only them can be transmitted from parents to offspring. And the sire only transmits half of the genes, an offspring receives.

But an experienced Greyhound breeder and owner knows, that the speed of a dog has many impacts. There are many influences on a dog after it was born, to make him a good racer. Nutrition, training and other effects influence the dog. Some of them are shown in the following picture, but you can surely imagine of many more.

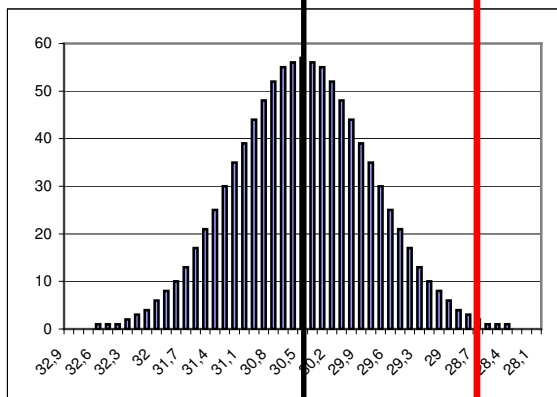


These influences come from the outside and therefore they are called environmental effects. They have nothing to do with the genetic ability of a dog and cannot be transmitted from the parent to the offspring. Only a part of the racing performance is genetically founded. The relative emphasis of the genetic performance on the overall performance is called 'heritability', or  $h^2$ . This term measures, how much of the racing performance is based on genes. If a  $h^2$  equals 0.3, then 30 % of the performance is based on the genes, and 70 % is based on environmental effects. According to our 1000 animals, we measured above, we can see the following: Suggest, we want to breed with the best dogs of our 1000 dogs, then we only take the best animals on the right of the distribution. What do you expect of their offspring. How good will they be?



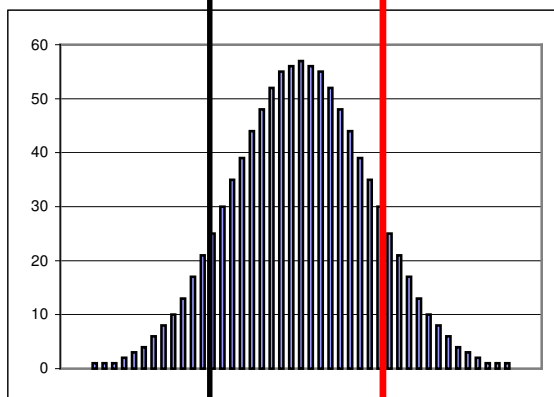
### Parents

To breed for top animals, breeders' choice are only the fastest animals to produce their offspring. These are the animals on the right side of the distribution, surrounded by the red circle



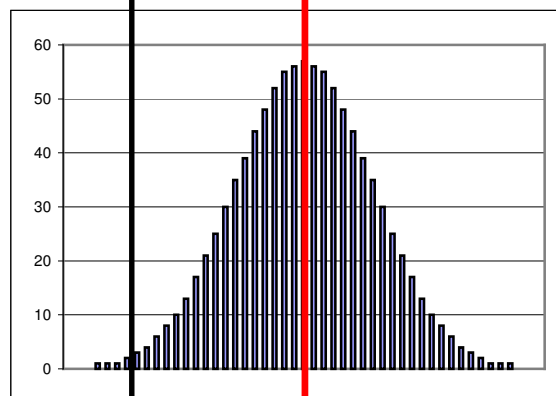
### Offspring $h^2 = 0$

The success in breeding is based on the genetic foundation of a trait. If the heritability is zero, there is no genetic foundation of the trait, and the selection of the best parents has no effect on the offspring. The mean performance has not changed in this graph.



### Offspring $h^2 = 0.5$

If there is some genetic influence on the trait, this can be seen in a partly higher performance of the offspring population compared to their parents. The mean value is higher and this is based only on genetic gain.



### Offspring $h^2 = 1.0$

If the trait is genetically founded on 100%, the average of the offspring is the same as the average of the selected parents. Unfortunately, there are no quantitative traits, that show this behaviour.

In the figures above you can clearly see, that selection and breeding makes only sense, if the trait has a reasonable heritability. Is the heritability zero, no genetic progress in the following generations can be found, independently from selection. Otherwise, if there is a heritability, consistent selection will bring genetic progress in the desired trait in following generations. But you can also see, that the result of the selection of parents is a normal distribution again, so as offspring, good and bad animals are in this new population as well. And again, some of them are better than the average, but some are worse. The only thing, that really has shifted, is the average performance. Remember the random

distribution of chromosomes to the offspring. This is responsible for the distribution of performances in the offspring generation. Although only very good parental animals were selected, some chromosome combinations still will be produced, which have a very bad influence on the desired trait.

For this kind of selection and breeding, the real success can only be seen in the whole population. So, this kind of genetics is called 'population genetics'. Selection and mating will not constrain good animals, some part of chance is always in the game of breeding. But in average, there is progress in the offspring population based on selection.

Another effect of selection is, that animals in the offspring population become better than their parents. Well, this is the goal of each breeder. But breeders have to accept after some years, that their old top-sires are not the best animals in the population anymore, because we have selection progress. And suddenly, the top-sires of the last year drop in each statistics. But these animals do not become worse, their offspring becomes better.

So, in conclusion can be said, breeding and selection is successful, if the desired trait has a genetic background, a heritability. The offspring of the selected animals show a normal distribution and good and bad animals can there be found again. But the average performance is higher than of the parents.