Topic 3: Selection effect
Lecture

Hello, and welcome to another video from the Animal Breeding module, where we will talk about the Selection Effect, or the Genetic Gain.
The selection effect, as shown in this slide, is a fundamental concept for the selection of both livestock and domestic animals, it is the so-called genetic gain (ΔG) and is based on the additive effect of genes.
The first to address the selection effect was the English philosopher, physician and mathematician Francis Galton. He studied height in families, comparing the average height of parents with the average height of their offspring. And he found that variations in individual characteristics are never passed on to offspring in whole, but only in part. That is, there is a tendency in the offspring to revert to the population average. He termed this effort as genetic homeostasis, or the effort to maintain an equilibrium state in the population. Francis Galton found that for body height, on average, 2/3 of the variance is inherited, we know that this is the value of heritability, or the coefficient of heritability. And the return to the population mean is 1/3 (the so-called regression number). These values are different for each trait and each population, according to F. Galton.
The response to selection, or selection effect, can be expressed in two ways. The first way is shown in the left part of the slide. This is expressed using a correlation field, where the x-axis shows the individual values of one generation, here the generation of the parents, and the y-axis shows the values of their offspring. If we run a regression line through that field and plot the average values of the population of parents and offspring on that line, as shown in the figure, we get the difference in the trait between the two generations, that is, the selection effect. The second method is expressed on the right part of the slide and we will discuss this method in more detail in the next slides.
The selection effect is best explained by the following figure. The figure shows a normal distribution graph which represents the base population from which the parents are selected for further reproduction, here shown by the hatched area.
The mean of the initial population is denoted as x with a bar and the mean of the selected individuals is denoted as x1 with a bar.
The difference between these two means (x1-x) is called the selection difference and is usually denoted as the difference between the mean of the selected parents and the mean of the whole base population.
The second curve of the normal distribution represents the population of offspring of the selected parents with the mean y with a bar. The selection effect is therefore the difference between the average performance of the offspring of the selected parents and the average performance of the base population from which the parents were selected. In other words, how much better the next generation of offspring is than the base population.
Up to this point, we have been talking about the selection effect realized because we already have the subsequent generation of offspring and their performance and can calculate the size of the selection effect accurately. In animal breeding, however, we are more interested in predicting the future performance of offspring so that we can plan and select parent pairs correctly. The expected selection effect is used for this reason, and it is the expected selection effect that allows us to predict the performance of the subsequent generation.
The slide here shows all the most basic relationships for calculating the expected selection effect.
As it was clear from the above mentioned graph the simplest estimation is based on the relationship between the selection difference and the heritability coefficient. It should be remembered that selection is in most cases based on phenotypic selection, and because genetic

gain or selection effect is a genetic parameter of the population. The only possible converter between phenotypic values and the genetic basis of the population is the heritability coefficient. However, it is not always possible to work directly with phenotypic variation of selected individuals, or so-called selection difference. One example is milk yield and the selection of bulls that do not show the performance. Nevertheless, it is necessary to determine the expected selection effect. For this purpose, another relationship is used, which again includes the heritability coefficient, plus the phenotypic standard deviation and the selection intensity, which is the standardised selection difference, i.e. the ratio of the selection difference to the phenotypic standard deviation. As this is the standardised selection difference, this value can be obtained from the relevant tables.

Again, phenotypic variability expressed in terms of phenotypic standard deviation is not always available. Another possibility is to estimate the realized selection effect using additive genetic variability. However, because genetic variability cannot be obtained directly, as with phenotypic variability expressed in terms of phenotypic standard deviation, the accuracy of its estimation must be taken into account, so the accuracy of the genetic marit of the individual, or breeding value, is also included in the calculation.

The image here shows a selection from a large table of standardized selection differences. It is clear from the table that the smaller the proportion of individuals we select the higher the value of selection intensity we get, and because there is a direct proportionality between selection intensity and selection effect we also get a higher selection effect. The table also shows that the size of the population we are selecting from also matters. If the size of the population is 10 or 50 individuals and we select in both cases, for example, 50% of the population, we will get different values of the selection intensity and therefore different values of the selection effect. Note also that the values of the selection intensity between populations with 50 individuals or very large populations, here represented by the infinity symbol, are already negligible. This means that further increases in populations do not significantly increase the value of the selection intensity.

It should also be noted that in some cases it is necessary to compare the level of selection effect between two species of animals with different performance, for example milk yield (in kg) and fertility (in number of offsprings). For this purpose, the so-called relative selection effect, which is expressed in units of phenotypic standard deviation, is used.

The selection effect determined on the basis of the formulas presented so far interval. And will therefore correspond to the formula shown in this slide. corresponds to the effect per generation. Due to the overlapping of generations, it is therefore more convenient for practical purposes to estimate the selection effect in one year. In this case, the value of the selection effect according to the above relationship is divided by the generation

Where the generation interval represents the average age of the parents at birth of their offspring that in their turn will produce the next generation of breeding animals From this definition, it is clear that the generation interval will take on different values for different species, and even for different breeds of the same species.

Another important part are the possibilities of increasing the selection effect. The first factor is the proportion of the population that should be selected for reproduction, and the second factor is the magnitude of the phenotypic standard deviation of the trait being improved. Last but not least is the heritability coefficient.

The relationship between the variability and the magnitude of the selection differential and consequently the selection effect is shown in this figure. In this figure, three populations are shown by normal distribution curves of phenotypic values. The proportion of individuals selected for further breeding or selection is shown in shaded lines. Given the same population distribution, the selection differences matters. The fewer or higher the selection intensity only

affected magnitude of selection effect. However, the intensity of selection cannot be increased indefinitely and the intensity of selection is influenced by the needs to maintain herd rotation.
Another possible way to estimate the selection effect is to compare the selected population with a control, or unselected, population. As shown in the image here. By dividing the number of generations of selection, when we compare the selected population and the control unselected population, we are able to get a value for the response to selection, or the selection effect. It should also be remembered that even the unselected population is under natural selection and its performance may change over generations.
Thank you for your attention and I look forward to seeing you again for more videos.