Genetics – where can we take it?

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Recurring themes in observations made to the geneticists at Hybrid are, firstly, can we increase the growth or bodyweight or alternatively, can we increase the number of eggs laid. The first obviously comes from commercial turkey growers and the second from those producing poults for production. What we have is two competing needs at different levels of the production system and the requirement is a balance between these competing needs.

Ideally, we would like to improve both traits but there are biological limits to the rate at which you can change one trait while maintaining or improving the performance in another.

This article will consider the nature of genetic correlations or how this relationship affects primary breeding stock selection and the rates of improvement seen in parent stock, egg production and body weight in commercial turkeys.

From genes to the turkey

The genetic makeup or DNA of the turkey is comprised of around 30,000 genes or individual areas that control a certain function in the body. There are very few traits that are controlled by a single gene, horned or polled cattle are an example, but for the most part traits are controlled by hundreds or sometimes thousands of genes working together.

Each of these genes has some role to play and the extent to which it affects how a trait is displayed depends on the gene and the trait in question. It should be clear now that for each production trait we are interested in, there are usually a large number of genes interacting and working together to control the expression of that trait.

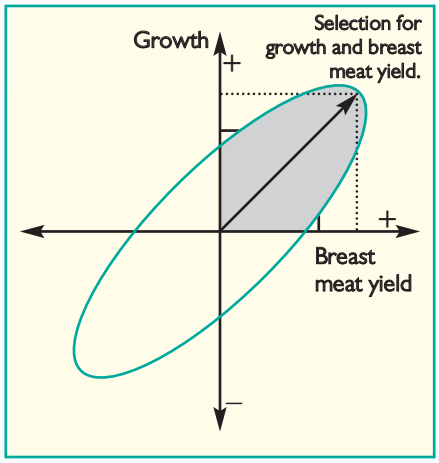

Fig. 1. Positive correlation and positive selection response for growth and breast meat yield.

The large number of interactions leads to individual differences in expression but there is another factor that increases the differences between individuals and that is differences in the genes themselves. It is this variation and importantly the variation in the interaction between the genes that leads to individual variation within a population of turkeys. The primary breeder aims to select the individual with the 'best mix' of genes to breed a new generation that is superior to the last.

Reaching genetic potential

First we will consider the most important product of the turkey – muscle or meat – and use this example to show how individual genes work together to control turkey muscle form and function.

We already know that each of these genes has a small role to play but when we say role what does this mean? Genes contain the code or blueprint to string amino acids together to form proteins.

It is from these proteins that the structure and function of muscle is controlled. Structurally, muscle is composed of many proteins but function is also managed through the actions of regulatory proteins and enzymes used to control the biochemical reactions occurring continuously within muscle.

We do not select on individual genes, rather, on the sum of the actions of the genes working together – or the best mix.

Nutritionally, if the optimal diet is deficient in the amount or ratio of amino acids such as lysine and threonine and the required energy, the result can be sub-standard growth and yield.

This occurs because the genetics to produce the required proteins are present in the turkey, but the turkey does not reach its true genetic potential because the building blocks were not first supplied.

This can be very important when comparing strains on the same diet, but it may be an unfair comparison if the correct nutritional balance is not supplied to one or both in the comparison. By not supplying the nutrition asked for by the genetic blueprint, the response will be different (or sub-optimal) to a situation where all the ingredients are supplied.

Positive correlation

Two of the most important traits to a commercial grower and processor are the growth rate and breast meat yield. These two traits are said to have a strong positive correlation, which means that on average if you have a turkey that has grown to a heavy weight it will also, on average, yield well.

It is not difficult to imagine that the genes that are responsible for increased body weight will do so in some part by increasing the weight of the breast meat and consequently increase yield.

Positively correlated traits are easier to select for at the same time because if you improve one then you will invariably

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Table 1. Range of genetic correlations between body weight (BW) and breast meat yield (BMY), walking ability and egg production and the correlated response in these traits to selection only on body weight.

Trait	Correlation to BW	Correlated response (%)
BMY	0.20 to 0.30	+0.4
Walking ability	-0.20 to -0.35	-4.0
Egg production	-0.10 to -0.30	-3.0

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improve the other. Fig. 1 shows the possible response to one round of selection when selecting for two positively correlated traits; the shaded area of the ellipse shows where a positive response in both traits is possible.

The edge of the ellipse represents all the possible results of selection, or in other words all the possible directions selection could go depending on the importance (or economic value) placed on each trait.

If we wanted to have either a strong positive response in breast meat or growth together (shown by the arrow) then we can achieve almost the best selection response in either trait at the same time.

Negative correlation

We have initially only considered muscle but every turkey is comprised of a number of body systems each with their own genetic control. While each system has its own control, that control can quite often be the same gene or sets of genes because the same protein or biochemical reaction is required in each system.

It is when these genes are common to both traits that are being selected for but have opposite actions that the difficulty with negative correlation arises. In this situation if we select to improve one trait it can have a negative effect on the other.

Fig. 2 shows the possible response to selection for two traits when they are negatively correlated. The effect of selection only for growth results in the maximum response in growth (and also presumably in breast meat yield) but results in decreased egg production.

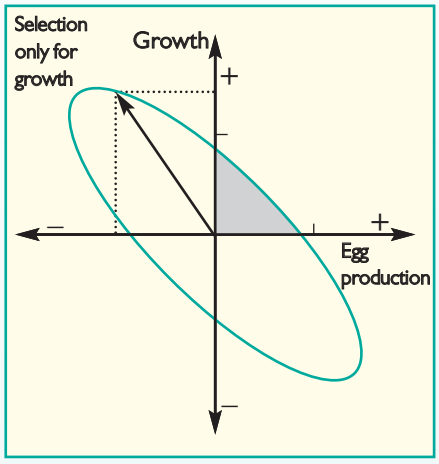
Once again it is not difficult to imagine that if genes are asking the body to place a large amount of energy into the production of body mass and weight deposition, there will be less energy available to invest in egg production, thus decreasing the production of eggs.

Fig. 3 shows the result of selecting for a mix of both egg production and growth. What would be immediately obvious is the decrease in response in growth and increase in response to egg production.

The down side is that there is less room for us to move if we want to improve both egg production and growth at the same time. This room at selection is shown by the size of the shaded area in Figs. 1 and 3 and as the size of the negative genetic correlation increases the size of the shaded area decreases, consequently decreasing our ability to move in a particular selection direction.

The rate at which we can improve egg production and growth together is much smaller than the rate we could move if we were to improve them individually without considering the effect on the other trait.

Fig. 2. Selection only for growth when there is a negative correlation between growth and egg production.



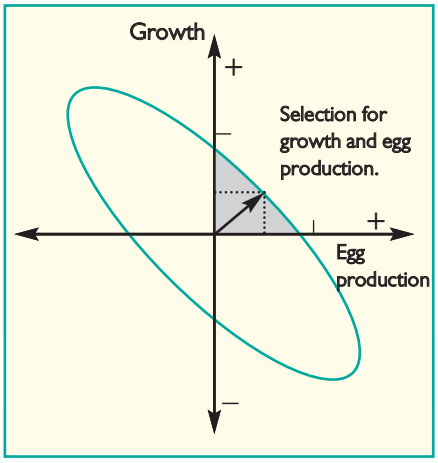


Fig. 3. Selection for growth and egg production at the same time.

The genetic correlations between traits vary between selection lines but the range of genetic correlations for important traits in the Hybrid selection objective are shown in Table 1.

To demonstrate the effect of these correlations, if we were to select turkeys at a given selection intensity of, for example 1%, and then if we selected on bodyweight alone we would be able to get an increase in bodyweight in the range of 1.4lb (0.64kg) per generation.

What is shown in Table 1 is that if we selected only for body weight then we would get a decrease in both walking ability and egg production but an increase in BMY.

The best option is to get the appropriate mix of all the traits that are economically important in production (for example, balanced breeding).

In practical terms, the economic value of growth and yield far outweigh the value of egg production.

Consequently, more emphasis is placed on

growth and we try and minimise the decrease or keep egg production stable.

The value of having distinct male and female lines becomes evident at this stage as, unlike the female lines, the male lines can be selected for growth and yield because these lines never have to display egg production traits when producing poults for commercial production.

The female lines can be selected for a chosen mixture of growth and egg production but as the genetic potential of the poult will have half of the female line genetics, what was given up in weight to maintain egg production will also result in a decrease in the weight of the commercial poult.

The value given to egg production, weight, yield and other important traits such as walking ability and feed conversion depends on the Hybrid product.

The correct product to use of the three Hybrid products – Grademaker, Converter or XL – depends on individual production circumstances, the market, and requirements of the final product.

Fig. 4 shows the range of expected finishing weight of both toms and hens for the three product groups.

As the expected weight range increases the maximum egg production decreases form 124, 109 and 101 for Grade Maker, Converter and XL, respectively, for a 26 week lay.

Genetic tests

After discussing the selection of the best mix of genes there is one method of selection that targets single genes, called marker-assisted selection. A marker or DNA test is able to detect a variation in a gene from a simple blood or tissue sample.

The breeder can then select (on that one gene) on the basis of that one result.

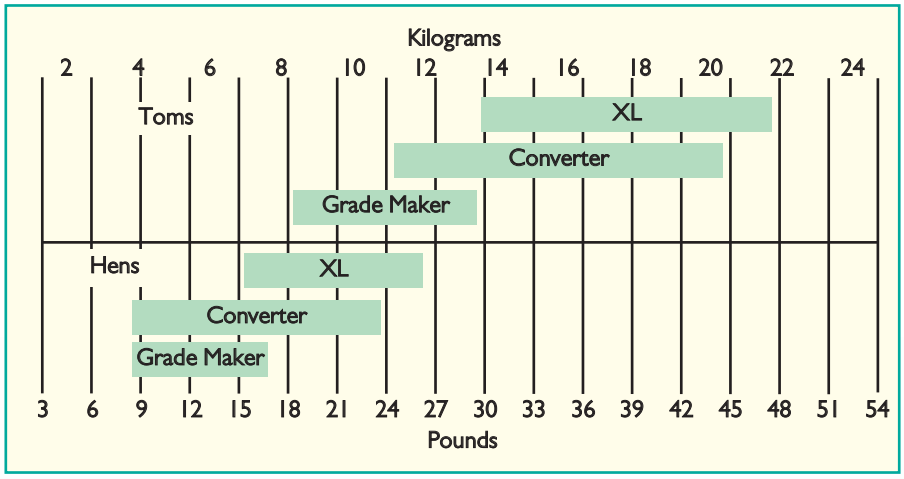


Fig. 4. Range of finishing weights for the three Hybrid product groups – XL, Converter and Grade Maker.

Currently, the available markers for economically important traits are limited in the turkey mostly due to the size of the industry and the investment involved in developing these markers for production.

There has been one development that may help in the identification of markers in the turkey and that is the publishing of the chicken DNA sequence.

The chicken and turkey genome have many similarities and this factor may aid in the discovery of DNA markers in the turkey.

A marker looks at the variation in the DNA and if the variation results in a large change in expression of the trait, then marker selection has the ability to rapidly increase the rate of improvement because it is evident exactly in which birds that variation exits.

Markers can also have the same problem as encountered with negative correlations in that the single gene may have a negative effect on other traits.

In this case a balance approach to selection based on the marker and other traits is again required.

Conclusion

As with all breeding the challenge is to get a balance between available information, economic circumstances and market realities to breed a turkey that is productive in both the parent stock and commercial levels.

In this article we have examined the relationships between individual genes and how these relationships and interaction can affect economically important traits in positive and negative ways.

The science of breeding is to achieve a balance among them all and to select the best mix to produce a turkey that has the genetics not just for weight and egg production but also, for all other important traits such as breast meat yield, fertility and walking ability. ■