

FOR NERDS ONLY!

The difficulty of maintaining and transferring established **POLYGENIC TRAITS**

Explained as if you were 12 years old.



Like wing & tail carriage, leg length and width, body conformation, stance, character, brown eggs, etc

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Text and photos: Sigrid van Dort

Question: What is a polygenic or quantitative trait?

Answer: A polygenic or quantitative trait is one that shows continuous variation along a scale rather than clearly defined categories. This means the trait doesn't appear as either 'present' or 'absent', but can range from weak to strong expression. The phenotype, for example brown eggs, tail or wing carriage, or body conformation, depends not simply on which (versions of) genes a chicken carries, but on how much of each gene is expressed in what combination. Think of it as a volume control from 0 to

11 in gene expression and this for multiple genes that make up the trait.

Q: Why is transferring a quantitative trait to another breed so challenging?

A: Transferring the trait is challenging for several reasons: (1) All contributing factors must be present: missing even one can result in failure; (2) Expression levels must be exactly right, which depends on the breed's overall genetic background; (3) Gene linkage means unwanted DNA is transferred alongside desired genes; (4) Genetic drift in small groups of chickens can randomly lose beneficial genes; and (5) The process typically requires many years of sustained, careful selection with uncertain outcomes.

Q: What is gene linkage and how does it complicate breeding?

A: When breeders transfer genes from one breed to another through conventional breeding, they do not transfer only the genes they want. They also transfer large stretches of DNA flanking those genes, which may carry genes for traits the breeder does not want or work against a trait in the receiving breed. Removing these linked genes takes many generations of backcrossing and selection (often ten or more generations) and by that time, genetic drift and selection for other traits may have affected the expression of the desired genes, or even losing one or more of them.

Q: What is genetic drift and why does it matter in small flocks?

A: Genetic drift is the random change in the number of different forms of a gene or function associated with it over time in small populations. In small flocks, a gene that causes a desired trait could be lost. Such an event has a big effect in a small group. This could mean that trait disappears and an opposite trait becomes the norm because the desired genes and alleles carrying chickens were not used in breeding. This way the genes or alleles would be lost forever. Again, this happens just by chance, not by selection of the breeder who can't see the genes involved in a desired trait, in small groups of chickens.

Q: What is considered the right population size to minimise the impact of genetic drift?A: For chickens, aim for at least 500 breeders to minimise genetic drift over time.

The conservation standard is the 50/500 rule: 50 is the minimum to avoid short-term inbreeding, whilst 500 (representing 1000+ actual birds) maintains long-term genetic diversity. Genetic drift weakens as population size increases because random fluctuations average out. The key metric is "effective population size" (N_e), the number of individuals actually contributing genes to the next generation. Small populations (50 birds) experience strong drift; medium populations (100–500 birds) show slower drift with risk of rare alleles disappearing; large populations (1000+ birds) experience minimal drift. Conservation and commercial programmes typically aim for at least 500 breeders.

Q: Does a quantitative trait maintain itself passively in (historical) breeds that are known for the trait?

A: No. Even in established breeds with the desired trait it does not maintain itself passively. Breeders must actively select for it, or the trait will disappear over generations. This is a consequence of the quantitative nature of the trait.

Q: How does unconscious selection affect a trait consisting of multiple genes and their expression?

A: Breeders often select birds based on traits they value, such as body size, vigour, productivity, character, and/or feather colour. If the desired trait, for example wing carriage or dark brown eggs is not a conscious selection criterion, then alleles related to it may be accidentally selected against. For example, if a particularly good-natured, large, perfectly coloured, fertile cock happens to carry not the right combinations needed for the trait, a breeder might still choose it as a parent because of its other desirable traits. Over generations, these unconscious selection decisions accumulate and in the loss of the desired trait.

Q: Can environmental factors affect a quantitative trait's expression?

A: Yes. Since the trait's phenotype depends on several gene expression levels, environmental factors such as the bird's age, nutrition, stress levels, and other conditions can all influence how strongly gene products are expressed. Without active selection, the average expression level can creep downward, leading to loss of the desired trait over time.

Q: What risks does outcrossing pose for a polygenic trait?

A: Breeders can introduce genetic diversity through outcrossing to birds from other (similar) lines to avoid inbreeding depression or to make the flock larger. This is done to counteract genetic drift. However, if the new chicken(s) has/have a background for the trait that doesn't fully match the background of your flock, this might cause new, not beneficial background factors to enter the flock. Even a single backcross to a new chicken introduces DNA and epigenetic settings from that line throughout the genome. If that newly added chicken from a different line that is less strict selected for the desired trait, the trait will predictably become weaker over time.

Q: Can linkage cause breeders to inadvertently lose desired genes?

A: Yes. If alleles that promote a desired quantitative or polygenic trait happen to sit near alleles for traits breeders do not want, then selection against those undesirable traits will inadvertently drag down the frequency of the desired trait's genes and their products as well.

For example, if the factor promoting dark brown eggs on chromosome 12 is physically close to a gene associated with egg number (involved in calcium ion transport), breeders selecting for dark brown eggs might lose some of the darkness due to the higher number of eggs laid in a shorter time when that gene expresses strongly or the other way around, the total amount of eggs laid goes down while the darkness of the egg goes up. This example brings to a different question: Is there a trade-off between e.g. dark brown egg colour and laying rate?

Well, breeders may observe that hens laying fewer eggs produce darker brown eggs, whilst hens that lay more eggs lay lighter dark brown ones. Yet the mechanism remains unclear. One hypothesis suggests slower laying hens have eggs spending more time in the shell gland, allowing greater pigment deposition. However, we cannot distinguish between longer transit time through the gland itself versus simply longer intervals between the eggs. This is an honest gap between what breeders know empirically and what science can currently explain. Until the mechanism is understood, breeders can work with the observed reality: selecting for dark eggs and accepting lower production, if that is the case at all.

Q: What is the main point about polygenic inheritance?

A: A quantitative trait determined by multiple genes is complex. The trait's effects depend on expression levels. This complexity explains why such a trait is difficult to transfer to another breed and why the trait needs constant, active selection to maintain it, even in established breeds.

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This is a former social media post, saved here for interested breeders.