A Possible Link Between Alpaca Staple Length and Depth of Color

Little Creek Farm

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As part of our work using data from the Alpaca Owners' Association (AOA) EPD database to examine whether fleece color affects the expression of fleece traits, we looked at the relationship between color and the EPDs for staple length for over 1300 Huacaya males.[i] We found a pattern that suggests that faster fleece growth rates have a visible dilutive effect on the color we see in fawn, beige and white animals, by increasing the length of the hair relative to the amount of pigment produced to color it. While variations in fleece growth rates would have a similar effect on pigment distribution in the fiber darker-colored animals, we don't see the same relationship between the EPDs for staple length and registration color in the darkest animals. This may be due to the fact that the concentration of pigment is increasing very dramatically as color darks from brown through black. It may also be an artifact of how we classify darker colors.

But back to the key point: The apparent link between color and staple length suggests that two animals with phenotypically different coat colors could have identical genotypes for color, with their color difference caused by a difference in the growth rates of their fleece. In the remainder of this discussion, we review the data supporting this hypothesis, as well as the hypothesis's implications for breeders. (We labeled the two sections for you, making it easy to skip down to the implications if you would like to see them before committing to read the short "Analysis" section.)

Analysis

As noted above, our hypothesis was suggested by analysis of EPD data. EPDs for fleece traits are generated from phenotypic data – histograms and fleece weights – submitted to AOA by the owners of thousands of animals each year. That phenotypic information is combined with pedigree data and analyzed to estimate how each individual animal is likely to influence the fleece traits of its offspring. We in turn use the EPD estimates made publically available by animals' owners to guess at likely phenotypic differences between the animals represented in the database. As we have noted in other analyses of this type, EPDs have their strengths and weaknesses as indirect representations of phenotype. We use them in this analysis because they allow us to include a large number of animals in the assessment, which is an important contributor to our confidence in the results.

In order to assess the relationship between staple length and color, we first have to consider whether there is a need to control for other characteristics believed to be correlated with both staple length and color, the most important of which is average fiber diameter (AFD) – or in this case, the EPD for AFD. The correlation between the propensity to produce fineness and the propensity to produce staple length is positive, with animals that produce fine-fleeced offspring also tending to produce

ones with shorter staple lengths: In our own herd, for instance, the correlation between these two EPD estimates was 0.36 in 2016 – not huge, but meaningful. Accordingly we sorted the 1,316 males included in this analysis into groups based on not just their color, but also their EPDs for AFD. Because fineness is highly heritable, this should produce groups of males that are also phenotypically similar in their degree of fineness.

We then looked at the average difference for the EPD for staple length for animals of different colors but the same propensity to produce fineness. What we found was a consistent trend: As color darkens from white through dark fawn, the average EPD for staple length consistently decreases – and we presume that these animals are likely to produce offspring with shorter staple length because they themselves have shorter staple lengths.

Exhibit 1 shows the average difference in the EPD for staple length by color, controlling for EPD AFD as described above:

Exhibit 1: Average Change in the EPD for Staple Length for Huacaya Males of Similar EPDs for AFD as Phenotypic Color Darkens

	From White To Beige	From Beige to Light Fawn	From Light Fawn to Medium Fawn	From Medium Fawn to Dark Fawn
Change in the Average EPD for SL	-0.24	-0.22	-0.46	-0.53

The important thing to note in this Exhibit is the trend: Each time color shifts one registration shade darker, the average EPD for staple length for the animals so described decreases, controlling for EPD AFD, consistently and by relatively comparable amounts. The same trend is evident within the smaller subgroups contributing to these averages, with notable consistency. While the differences might seem small, it is important to remember that they likely correspond with larger phenotypic differences in staple length. (As one example, in our herd we have two females of the same age and color with different EPDs for staple length: one has an EPD for staple length that is 2.78 mm greater than the other one. But that same animal had a staple length in 2016 that was over 14 mm greater than the one with the lower EPD for staple length.) [ii]

What about the possibility that this pattern of decreasing average EPDs for staple length as color deepens is a function of a third factor potentially correlated with both color and staple length? The most commonly mentioned source of such a potential link stems from the belief that white animals in particular have been bred with more intense selection pressure on fleece traits for a longer period. Could a

pattern trait expression that appears to be color-linked be fact only a reflection of different selection pressures?

We see several challenges to this idea in the available EPD data. One challenge comes from the observation that not all desirable fleece traits appear to have a color-linked pattern of expression. A second and more potent challenge is that we note that average EPDs for staple lengths do not continue to decrease among the darker brown and black animals (in fact they increase on average, relative to dark fawn, among animals with similar EPDs for AFD.) A third challenge is rooted in the fact that alpacas often have ancestors of many different colors in their pedigrees, which means that, even if a historical difference in selection pressure was present, our ability to use an animal's phenotypic color to assess the possible impact of this on its genotype is limited.

It is, however, possible to test our color-blind EPDs in application by looking at EPDs for different-colored offspring from the same sire or dam to see if their own staple lengths and EPDs for that trait match what we would have predicted based on their parents', and if not, to see whether there is a pattern of error that is linked to color. We have done this analysis with one sire that we co-own, a white male that has produced offspring in all solid colors from white to true black, and has also been bred to solid colored dams ranging from white to true black. When we look at the EPDs for staple length of these offspring as a function of their color, we find that we would have over-predicted the average staple length of the fawn and beige based on their sire and dams' trait measures, and under-predicted the staple length of white offspring on average, especially those that this white sire produced from white dams. While the number of offspring observations is too small to generate statistical confidence, we note that the pattern is exactly what we would expect to see if staple length differences were affecting phenotypic color in the manner we are hypothesizing.

Implications

The probable link between fleece growth rates and perceived colors in fawn, light and white animals presents several interesting implications for breeders. One is that breeders seeking to increase the average staple lengths of animals in their herds may notice their herds are also getting lighter-colored on average over time, in particular if they are breeding fawns and lights.

In addition, breeders may be able to use differences in staple length to inform their guesses at the extension (dilution) alleles an animal carries, especially with regard to dark fawn and even light brown animals: It is possible, for instance, that a long-stapled dark fawn animal appears somewhat dilute (compared to darker browns) because his or her fleece growth rate is rapid, rather than because he or she carries two recessive extension alleles. This could be particularly helpful for breeders hoping to use fawns to produce darker-colored animals.

Finally, breeders looking to achieve depth of color in fawn (and even the lighter shades of brown) will want to carefully manage their programs to maintain staple length, as the color range they are targeting has, within this group of over 1300 males, the shortest average EPDs for staple lengths of any solid color in the spectrum, holding the propensity to produce fineness constant.

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[i] The public EPD information made available by AOA and the animals' owners can be aggregated for analysis using the "EPD Search" tool made available by AOA. Anyone with the right (if that is the word) combination of insatiable curiosity and excessive patience can use the information to help answer questions of interest. The long-run potential of the EPD database to produce incremental information and understanding that can help breeding programs advance more rapidly is significant. Hopefully AOA will consider making this data more broadly available to qualified researchers accordingly.

[ii] And for those concerned about the low average accuracies of animals in the EPD database: While we set a floor on the minimum accuracy of the EPDs for any individual animal included in this analysis, it is important to remember the accuracies of the averages above is considerably higher than the average of the individual accuracies of the EPD SL estimates for the animals in the sample, as averaging reduces the impact of random error (because random errors cancel each other out.)