Pigment, Curvature, and a Caution About The Assumed Heritability of Phenotypic Fleece Character

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People who process alpaca fiber into products are well aware that dark fleece behaves differently than lighter fleece in processing as well as in many final products. Even if the fineness and uniformity of a batch of dark fleeces is identical to that of a batch of white, for instance, the yarns made from those fleeces will be denser (and heavier) at the same gauge and exhibit less memory, making its performance in end products different than yarns made from light fiber. The reason for the difference is that the fibers making up the fleeces at the darker end of the spectrum of alpaca colors have less curvature than those from lighter-colored fleeces of similar fineness and length. The question is, why? The analysis below hints at a possible answer.

To confirm that our impressions about the relationship between curvature and fleece color were not spurious, we searched the EPD database to generate groups of different color males controlled for their propensity to produce fineness – that is, their EPDs for AFD – so that we could look at their other EPDs, and in particular their EPDs for curvature, independent of average micron. That is important because we know that fleece curvature is negatively correlated with fineness and staple length in particular: Finer fleeces tend to have higher curvature than coarser ones, and longer-stapled fleeces tend to have lower curvature than shorter-stapled ones. For our analysis, we sampled from males with an EPD for AFD between -1.50 and -1.00, so that we could be confident that differences in the average EPDs by color group were not a function of correlations between color and AFD.

Why use EPDs in this analysis? The brief answer is that they reflect data from a much larger group of animals than for which we could gather comparable phenotypic data on our own, and control for certain other influences that we would like to remove in the analysis. However – and this is important – using EPDs for an animal in place of those harder-to-acquire phenotypic measurements is going to obscure what we are looking for and even introduce some bias in the results. As it turns out, these problems are not enough to hide the possible explanation for variations in curvature that appear to be a function of fleece color. That said, the answer to our question about color and curvature does have implications for the use of the EPDs for curvature. We'll discuss those shortly.

In the meantime, Exhibit One below shows with a blue line the relationship between the EPD for curvature and the phenotypic color group of a selection of males with EPDs for AFD between -1.50 and -1.00. (For those interested, there is a table at the end of this paper that details additional information about this sample, including the number of animals in each color cohort as well as the averages of other EPD traits.)

The average EPDs for curvature among these males is highest in the white group, and drops in slowly as the average phenotypic color of the males darkens through light/medium brown, and then trends more rapidly lower for the darker colors. The red line in Exhibit Two is average relative amount of total melanin present in different colored alpaca fiber, here represented as approximations of measurements taken and presented by Kylie Munyard in her 2011 paper, "Inheritance of White Color in Alpacas."[i] Side-by-side like this, the results appear as rough mirror images and convey a sense that the presence of pigment in alpaca fiber may affect the degree to which the other workings of the follicle, and/or the structure of the hair itself, result in curvature expressed in the fleece.

Exhibit 1: Average EPD for Curvature Relative to Phenotypic Color for a Sample of Males with EPD AFDs between -1.50 and -1.00.

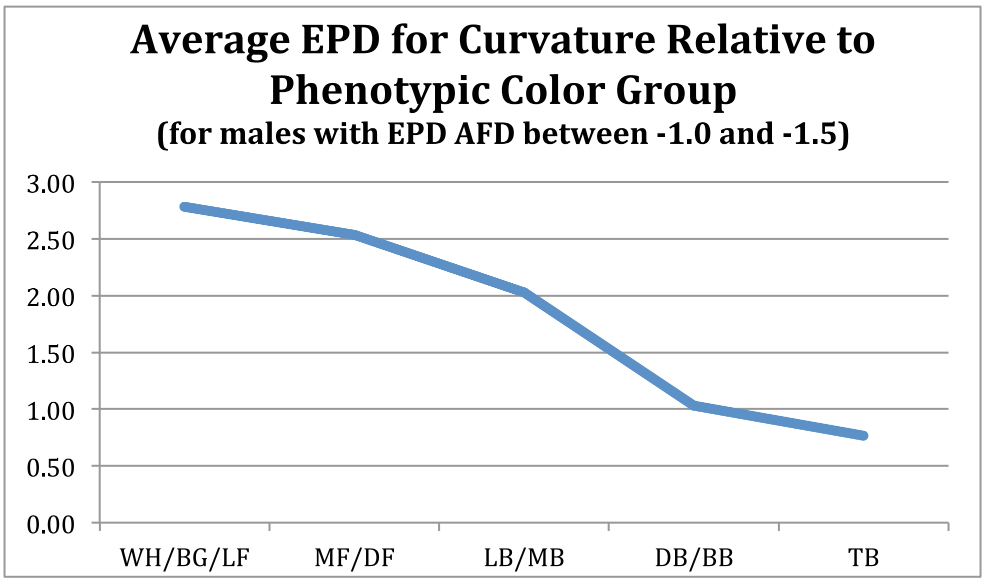
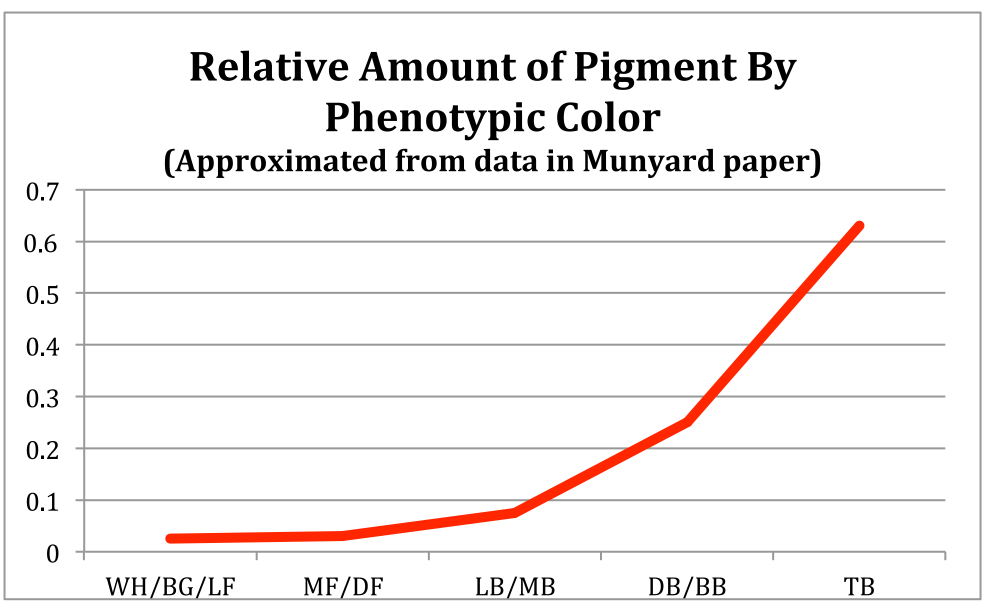


Exhibit 2: Relative Amount of Pigment by Phenotypic Color.



Together, these relationships between the amount of pigment in fiber of different phenotypic color and the EPDs for curvature for animals of these phenotypic colors and EPDs for AFD within the ranges noted suggests that the concentration of melanin in the fiber of the darkest animals is likely to be playing a role in the degree of curvature expressed in the fiber. Within any given color, the usual relationships between staple length and AFD and curvature hold, but the percentage of pigment in the hair shaft likely has a third, independent role. In fact as shown at in the second table at the end of this presentation, the maximum EPD for curvature within each male color cohort tends to decline as color deepens, even though the minimum EPD for curvature does not. This, too, suggests that pigment levels are capping expressed curvature in some fashion.

We mentioned moments ago that using EPDs for this analysis is potentially problematic. Here's why that is the case: An animal's EPD for curvature (or anything else) is not calculated based solely (or even, sometimes, at all) based on its own phenotypic fleece characteristics but also include the phenotypic measurements for that animals offspring and ancestors – many, even most of whom, may not be the same color. Yet in this case we have likely identified an instance where the expression of a fleece trait, curvature, is in part a function of the color expressed in the fleece. That means the estimate for the EPD for curvature of a black animal is likely to be higher, all else constant, if that male has lighter offspring on the ground or ancestors in his pedigree than if he does not. Put another way, we would expect a black male to produce different higher curvature fleeces in his white offspring than in his dark ones, and, similarly, a white male to produce dark offspring with less curvature than that of his white offspring. Using EPDs as a proxy for phenotypic information about the 400+ males represented in this analysis probably underestimates the shift in expressed curvature as fleece darkens, because at least some dark males' estimates will include some data from light relatives, and some light males' estimates will contain the reverse. But at least you can see the idea this way.

One broad implication arises from what we have seen above, and one narrower one. The broad implication is that we are likely constrained in our ability to achieve completely uniformity of Huacaya fleece characteristics across the range of phenotypic colors we have. For example, black fleece will always be different from white fleece with regard to its processing characteristics and best product uses. This is worth remembering as we work to develop these animals and the market for their fiber. The second, narrower implication is that EPDs for curvature are missing an important element – adjustment for color – that affects their usefulness in predicting the likely fleece traits of offspring of different colors.

Table One: Average EPDs for males with EPD AFD between -1.5 and -1.0 and accuracy of at least 0.20 (0.40 for white)

Color	# of Males	EPD AFD	EPD SD	EPD %>30	EPD Curv	EPD SL	EPD FW
White	160	-1.25	-0.36	-4.86	3.20	-0.04	0.47
Beige	65	-1.26	-0.36	-5.04	2.62	-0.41	0.41
Light Fawn	75	-1.24	-0.30	-5.04	2.01	-0.54	0.24
Medium Fawn	66	-1.25	-0.27	-4.67	2.48	-1.38	0.23
Dar Fawn	29	-1.23	-0.30	-5.06	2.66	-1.94	0.27
Light Brown	25	-1.27	-0.33	-5.17	2.35	-1.58	0.23
Medium Brown	30	-1.23	-0.24	-4.75	1.76	-1.85	0.13
Dark Brown	19	-1.18	-0.27	-4.72	0.83	-1.28	0.11
Bay Black	10	-1.30	-0.20	-4.68	1.43	-1.69	-0.06
True Black	18	-1.29	-0.28	0.40	0.76	-1.29	-0.11

Table 2: Maximum and minimum EPDs for curvature within color sample groups.

Color	Maximum EPD Curv In Group	Minimum EPD Curv In Group
White	6.91	-1.27
Beige	6.75	-0.16
Lt Fawn	5.00	-2.39
Med Fawn	5.97	-0.92
Dark Fawn	4.70	0.28
Lt Brown	5.82	-0.72
Med Brown	4.26	-0.50
Dark Brown	3.77	-1.29
Bay Black	2.61	-0.34
True Black	3.45	-2.86

[i] Munyard, Kylie: "Inheritance of White Colour in Alpacas", July 2011, Rural Industries Research and Development Corporation, Canberra, Australia.