Another Tool to Help Breed for Micron Uniformity

Little Creek Farm
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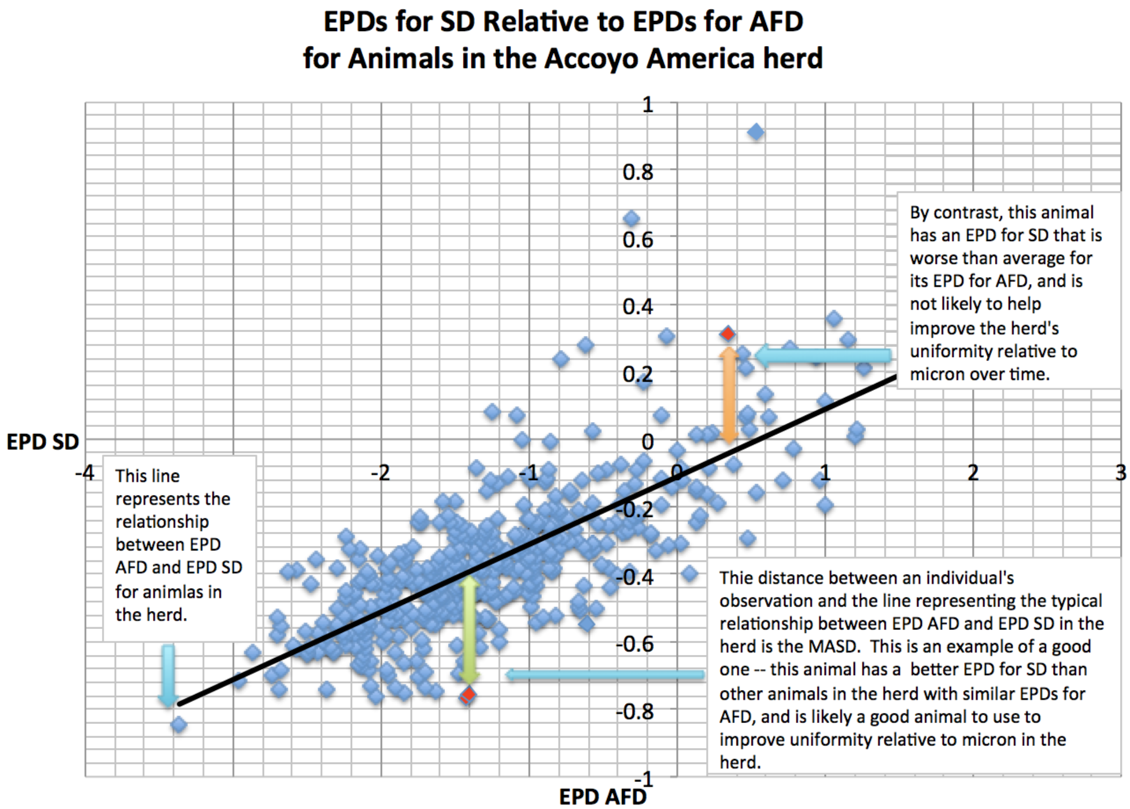
Alpaca breeders have long noticed that as they breed for incremental fleece fineness in their animals, the standard deviation of diameter among those fibers also tends to decrease, the result of an apparent and generally favorable genetic link (or links) behind these economically important phenotypic traits. However, because the uniformity measurements they rely upon do not segregate it, they have generally paid less attention to directly managing the genetic sources of micron uniformity that are *not* linked to those that contribute to incremental fineness. This has been true even though those unrelated genetic sources of uniformity appear to be nearly as important to micron uniformity as those that also contribute to fineness.

In the discussion that follows we present the results of research based on estimated progeny differences (EPDs) for 1781 Huacaya alpacas managed separately in two individual herds.[i] We show evidence that variation in portions of the alpacas' genotypes involved in the determination of the fineness of their fleece (or parts of their genotypes that are closely linked from a heritability standpoint) explain just over half of the variation among animals in their EPDs for the standard deviation of fiber diameter (EPD SD.) We also present circumstantial evidence that strongly suggests that the portion of EPD SD variation that is not genetically linked to fineness is itself heritable, which implies that it has a genetic source or sources that can be selected for in alpaca breeding pair decisions.

The standard deviation of alpaca fiber diameter is an important economic trait when fiber is sold commercially. While variation in SD is not directly priced, it impacts pricing indirectly: If micron variation is too high, it raises the commercial grade to which the fleece is assigned, which in turn lowers its sale price. As a result, breeders must produce animals with uniform fleeces to receive the financial award associated with fleece fineness. In our own experience with grading fleece for commercial sale, we have noted that many if not most fleeces "underperform" their average fiber diameters (AFDs) when assessed by qualified graders for commercial sale. This creates a strong economic motivation to seek to improve uniformity of micron, or SD, independently of fineness.

Within our sample group, the correlation between the EPDs for AFD and SD was 0.75.[ii] This result implies that the two measures are closely associated phenotypically, but do not move in lockstep. In fact, as those with a statistical bent will have already inferred, variation in the EPDs for AFD for animals in the sample group explain just over half of the variation seen in the EPDs for SD for these animals. That leaves a substantial portion of the variation in EPD SD between animals to be explained by other factors, including genetic ones.[iii]

Graph 1: EPDs for AFD relative to EPDs for SD for a sample group.



This portion of the variation EPD for SD that is unexplained by the variation in EPD for AFD is what we refer to as the micron-adjusted EPD for SD, or MASD. You can see a visual representation of MASD for one of the herds that make up the sample group presented in Graph 1 above, where the EPD SD predicted for a given EPD AFD is shown as the solid line, and the animals' actual EPDs for SD are shown as individual data points. The distance between any individual animals EPD for SD and the solid line holding micron constant is equal to the MASD. A negative MASD is good – it means that the animal is expected to produce offspring that are more uniform (lower SD) than average relative to their fineness. Correspondingly, a positive MASD is not good.

MASDs within our combined sample group ranged from -0.38 to 0.89, expressed in microns just like the EPD SD measurement itself. Interestingly, this range is comparable to that for the EPD SD measure for the animals in the group, which was -0.37 to 0.91, showing the potential incremental opportunity associated with directly managing the aspects of micron uniformity that are not genetically related to fineness.

That said, we can only manage this independent variation in SD if it is genetically linked and not, for instance, simply the result of large errors in the estimates of

EPDs for SD. In other words, we need to see some evidence that it is heritable. Ideally, this heritability would be estimated as part of the EPD analysis that produces the estimates upon which MASD is based. In the absence of such a rigorous demonstration, we can look for other circumstantial evidence. We found several indications that MASD is heritable, described here:

1. Animals at the top or bottom of the MASD rankings of animals within the individual herds included in the sample group were more genetically related to each other than they were to others in their herd. For instance, animals ranking among the top 20 Accoyo America animals with regard to MASD had a mean kinship of 5.1%, compared to 3.1% for the herd overall. The bottom 20 in MASD ranking had a mean kinship of 4.9%. (While all of these numbers are impacted by animal sales and other production-related decisions that affect the composition of the herds over time, it is worth noting that the kinship numbers at either end of the MASD rankings would increase meaningfully with the inclusion of offspring no longer in the herd.)

2. There were multiple generations of directly descending animals present in the positive and negative MASD outlier groups. Dam lines of descent are more obvious, but this is likely in part because the top sires in both programs typically have many offspring included in the sample group, and thus their results contribute more to the calculation of the mean. Among the top MASD performers, the imported female 6Peruvian Accoyo Isis contributed 7.3% of the collective genome of the top MASD animals, versus 2.1% of the genome of the herd as a whole, and the imported male 4Peruvian Legacy contributed 6.9% of the collective genome of the top performers, versus 3.0% of the herd as a whole. Among the MASD underperformers, the import female Ppperuvian Edelweis was significantly overrepresented (6.2% of the collective genome of the bottom 20 animals, versus 0.4% of the herd as a whole.) Notably, the most important founding genetic contributor to the Accoyo America herd, the import male Pperuvian Caligula, was underrepresented in the genome of the low-performing group (7.3%) compared to the high performing group (11.1%) or the herd as a whole (11.4%). These individual statistics further buttress the case for a genetic basis for the MASD measure.

3. As both of the observations above imply would be the case, we have found it possible to breed animals to improve MASDs. In fact, the animal with the best MASD in the 1781-animal sample group, now a working sire in one of the herds, was bred for that result.

Interestingly, as shown in Table 1 below, we find a modest negative correlation (-0.32) between animals' MASDs and another EPD measure, namely the EPDs for fleece weight. As both lower standard deviations in fiber micron and higher fleece weights have been linked to greater follicular density, this association may provide clues regarding the genetic source of micron uniformity that is not linked to fineness.

Table 1: Sample group correlations between MASD and various EPD measures.

	MASD	EPD AFD	EPD SD	EPD %>30	EPD MC	EPD MSL	EPD FW
MASD	1.00						
EPD AFD	0.00	1.00					
EPD SD	0.67	0.75	1.00				
EPD %>30	0.02	0.92	0.70	1.00			
EPD MC	-0.12	-0.76	-0.65	-0.66	1.00		
EPD MSL	-0.03	0.22	0.14	0.12	-0.49	1.00	
EPD FW	-0.32	-0.04	-0.24	-0.10	-0.01	0.41	1.00

The MASD measure's lack of correlation with other EPD measures is, of course, the result of its expression of micron uniformity as relative to fineness – a trait with several other fleece measures are highly correlated. This should make MASD a superior breeding pair selection aid for herds where the top selection priority is improving micron uniformity without breeding for excessive fineness. Furthermore, the basic concept of adjusting EPD measures to remove correlations with other key traits to help identify and manage separate genetic influences has uncovered similar opportunities for statistical tool refinement with regard to the EPD for fleece weight, (EPD FW), and the EPD for percentage of kemp-type fibers, EPD %>30. This area of study is ripe for further research to support improved alpaca breeding outcomes.

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[i] The two herds were the Accoyo America herd, located in New York, and the Snowmass Alpacas herd, located in Idaho.

[ii] Correlations between the EPDs for AFD and SD were nearly identical within the two individual herds that make up the sample, indicating that this relationship is at least somewhat robust to the different breeding goals these programs historically maintained.

[iii] A simple linear regression with EPD SD as the dependent variable and EPD AFD the independent variable has an r-square of 0.56. If you contact us we are happy to provide you with the full regression results. We omit them here due to their tendency to produce the side effects of confusion and drowsiness in many readers.