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Hello again!

Because it is breeding season for many of us in the Northern Hemisphere, the first two articles in this issue of *The American Alpaca Journal* discuss topics relevant to breeding decision-making. Our first article, “Color In Depth,” presents what we have learned about the phenotypic outcomes associated with three black ASIP alleles, and will be of interest even if you do not breed for black or grey animals. We can report new findings because Neogen Corporation, the laboratory that performs the alpaca coat color tests, is now able to give us specific allelic data and has also been willing to provide it retrospectively for anyone who has previously tested their animals. This is big assist that will accelerate many breeding programs.

We also make a case for breeding to increase the staple length of Huacayas. We believe it is a very important part of maintaining both the supply and quality of American-made alpaca products. But collectively we need to improve our understanding of what a superior long-stapling fleece looks like, especially in the months right before shearing, and we may need to bring the show ring along with the program. Read more in “The Case For Staple Length.”

Also in this issue: A discussion of how nutrition can help animals cope with heat stress, and an article about the value of having a hematocrit centrifuge and refractometer for some simple on-farm blood tests. And in the final story of this issue, we share our shearing data collection system.

Have a wonderful summer!

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Understanding The Black Base Coat Color Genotype

Lynn Edens, Snowmass Alpacas
Jason Gill, Cotton Creek Farms

As most of you reading this will know, in early 2021 we began using an alpaca coat color genotyping test offered by the international biotechnology company Neogen Corporation to learn our animals' base coat color genotypes. This test is based on research by Dr. Kylie Munyard and specifies alpacas' genotypes for relevant sections of the two most important genes affecting alpaca base coat color. It also reveals whether the animal carries a mutation that produces the tuxedo grey pattern.

Knowing the base coat color genotypes of our animals has already made a significant difference in our breeding decisions and has also helped us more accurately select the animals in our herd that are best suited for our customers' breeding programs. However, the results of our first rounds of testing, as well as those of other farms who have joined us in the research effort, also made it clear that we still had much to learn, especially with respect to the genotypes that produce animals with a black base coat color.

We knew from reading Dr. Munyard's research that she had identified three different alleles — that is, alternate forms — of one gene, known as the agouti or ASIP gene, that when paired produced a black animal at least some of the time. These alleles were collectively described with a small "a" in the reports we received from Neogen. If an animal's ASIP genotype included one small "a," we knew it covered black. If an animal carried two small a's, it had a black ASIP genotype and, assuming it was not fully dilute, could be phenotypically black.

However, only a bit more than half of the not fully dilute animals in our database with "aa" test results actually had true black, bay black or silver grey coats (silver greys being black animals with a separate white pattern.) Almost as many were brown or rose grey. This suggested the possibility that the three individual ASIP "black" alleles might differ with respect to their impact on phenotypic color.

We asked Neogen if they could go beyond the summary results previously presented and give us the detailed genotyping results for the animals they had tested for us so we could study this further. They could and did. Other breeders who had genotyped their herds with Neogen also requested their detailed results and contributed them to our research database. From this collective effort, we learned that the three individual black alleles do not have identical impacts on phenotypic color. Two of them appear significantly more likely to produce a black animal than the third.

Understanding how all three of these alleles work, in both homozygous and heterozygous pairs, greatly improves our ability to predict color outcomes from individual matings. We now know how to more consistently produce black alpacas, and how to focus on true black and minimize the production of bay blacks where that is desired. We also have a better idea of how to best choose animals that are not black but cover it for a black breeding program. We discuss these results in detail here so you can use them to inform your own breeding effort.

The ASIP Gene's Black Alleles

The acronym "ASIP" stands for agouti-signaling protein. The ASIP gene encodes the instructions for producing the agouti-signaling protein, which controls the amount of pheomelanin (yellow) versus eumelanin (black) pigment produced by the melanocytes. When the agouti-signaling protein produced is normal in form, both pheomelanin and eumelanin are produced by the melanocytes in proportions which, in the absence of dilution, results in an animal with a dark fawn or brown base coat color. However, when a mutation results in the production of a protein that is altered in a way that makes it less functional, less or no pheomelanin and more eumelanin is produced by the melanocytes, resulting in an animal with a darker or black coat color.

Something else happens, too: When the agouti-signaling protein is not active in the melanocyte, a hormone called the melanocyte-stimulating hormone plays a greater role in pigment production. This hormone does exactly what its name suggests, with the result that the melanocytes produce more pigment than they otherwise would. Animals with "aa" genotypes thus not only have more of the black eumelanin pigment, but a greater absolute amount of pigment in their fiber.

The three ASIP alleles that have been associated with black coat color in alpacas are all of this "loss of function" type and result in the melanocytes producing less pheomelanin than they otherwise would. Each of these alleles involves a change to a particular section of the ASIP gene known as Exon 4. Exons are segments of DNA which contain the instructions for producing a protein. Exon 4 of the alpaca ASIP gene is 177 base pairs long. You don't have to know what this means to find it interesting context for what follows. You may also find the picture shown in Figure 1 helpful for understanding the discussion that follows — we did when it was presented to us.

The genotypic alternation that produces the allele that, following Dr. Munyard's terminology, we describe as "a1" involves a deletion of 57 of Exon 4's 177 base pairs. As you can imagine, that represents a substantial disruption to the coding for the agouti-signaling protein. The "a2" and "a3" alleles both involve mutations at individual base pair locations in Exon 4. Both occur at locations where mutations are known to result in some loss of function of the agouti-signaling protein. Interestingly, the location of the "a3" mutation is within the region that is deleted and thus missing from the "a1" genotype.

All phenotypically black animals have two of the black alleles described above: Two of one allele type, or one each of two different black alleles.

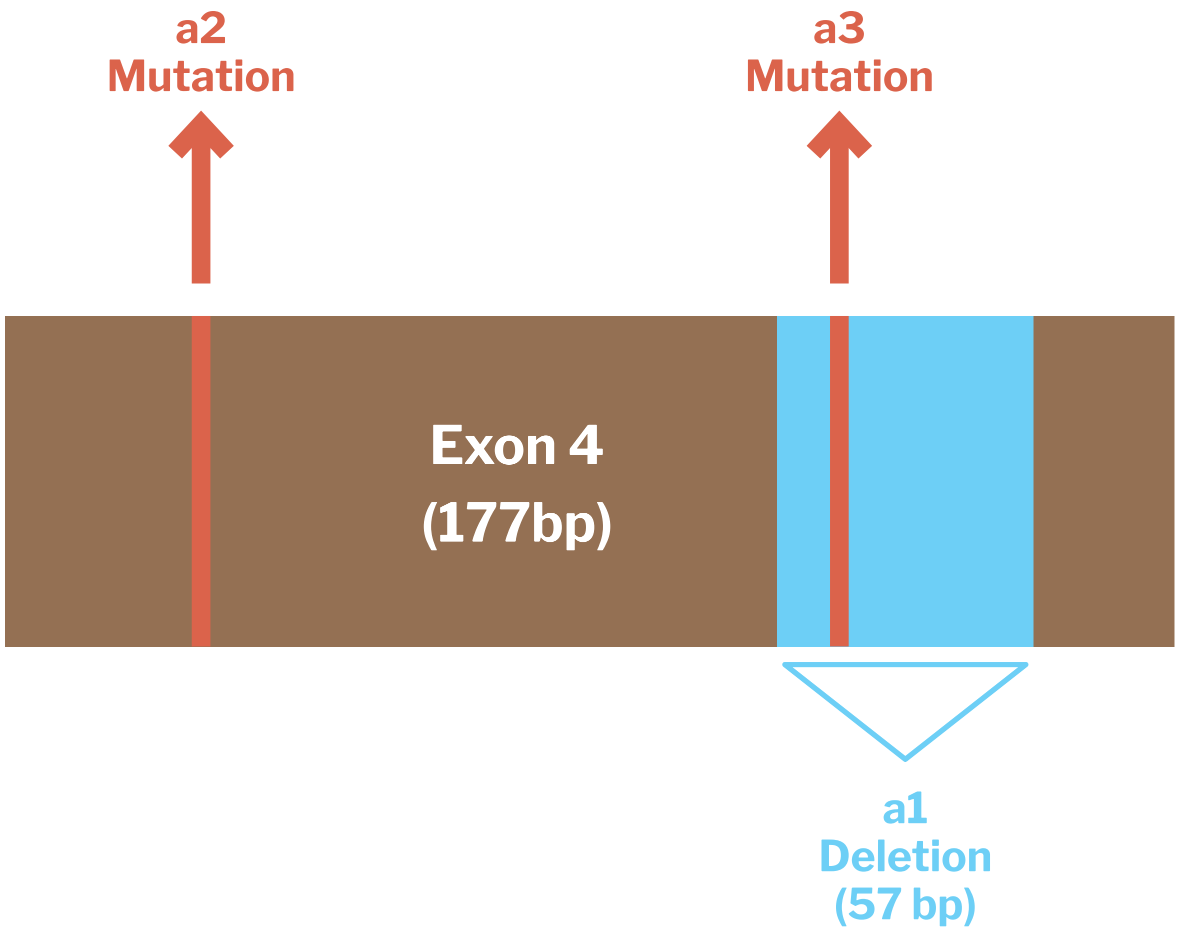
Figure 1: Source: Feeley et al, Three novel mutations in ASIP associated with black fibreVi in alpacas (Vicugna pacos). J Agric Sci 149: 529-538

Allele Combinations And Their Phenotypic Results

To discover potential differences in the phenotypic results produced by different black allele pairings, we combined the detailed genotyping results of animals at four farms to produce a dataset of 181 animals that had "aa" ASIP base coat color genotypes and carried either zero or one Mc1R gene dilution mutations. That is the animal's base coat color genotypes were summarized as either EE aa or Ee aa, both of which can result in a black animal.

However, there are actually 12 possible combinations of the three "a" alleles and the two dilution genotypes EE and Ee. They appear in the table in Figure 3, on page 11, along with the specific allele combinations with which they are associated. You can use this table to interpret your own detailed Neogen report results if you choose to color genotype your animals.

Three Significant Allele Types In Exon 4 Of The ASIP Gene



Black ASIP Genotypes And Associated Phenotypic Color Results

ASIP Genotype	MC!R Genotype	Percent True Black or Silver Grey	Percent Bay Black	Percent Rose Grey	Percent Other
a1a1	EE or Ee	79%	0%	21%	0%
a2a2	EE or Ee	59%	9%	15%	18%
a3a3	EE or Ee	21%	11%	37%	31%
a1a2	EE or Ee	58%	7%	20%	15%
a1a3	EE or Ee	27%	12%	18%	43%
a2a3	EE or Ee	38%	10%	16%	36%

The table in Figure 2 summarizes coat colors of animals with each of these different "aa" genotypes. We chose the way we tabulated the results with some care. True black and silver grey animals are counted together because both tuxedo and modern silver grey animals are the result of white patterns expressed within a black base coat color. We counted bay blacks separately from true blacks, even though they show together, to see if we could identify specific genotypes that were more likely to produce one versus another. We counted rose greys separately from browns because their genotyping results were not what we expected and we wanted to consider them more closely, which we do later in this discussion. All animals with EE aa or Ee aa genotypes that were not one of these colors we included in the "other" category. The great majority of these were brown.

It can be very tempting to draw some rapid conclusions looking at a table like this, but it is important to first assess the statistical significance of the associations we think we see. We want to know how likely it is that we are observing a real relationship between genotypes and color outcomes as opposed to a pattern produced by chance. We will explain our degree of confidence in the patterns we see as we discuss them.

Figure 2: Black ASIP genotypes and phenotypic color results.

Based on the genotyping results for the 181 animals considered here we are highly confident that an "aa" animal which has one or two of the "a3" ASIP alleles is less likely to be registered as true black or silver grey (black base coat) than one that does not have an a3 allele. The odds are less than 0.1% that this pattern we see in the data is due to chance. Black ASIP genotypes that include one or two a3 alleles are also more likely to produce bay black animals than are genotypes which lack an a3 allele. More broadly, over two-thirds of the animals with an "aa" genotype in our sample group that do not have black fleeces carry at least one a3 allele.

We don't know why this is the case but suspect that the a3 mutation either does not reduce the proportion of pheomelanin produced to the same degree (leading to a warmer, browner coloration), does not allow the melanocyte-stimulating hormone to assume as much of a role in pigment product as do the other black alleles, or both.

There is also a pattern in the data that suggests that the a1 ASIP allele may be more likely to result in a true black base coat color than the a2 allele. However, we don't yet have enough individual observations to be confident that this pattern is not the result of chance. This means that for now, we cannot reliably differentiate between the likely phenotypic coat colors produced by a1 and a2 alleles. We assume they have a similar likelihood of producing black animals. This conclusion may or may not change as we collect more genotyping results.

Finally, we looked at whether carrying a single dilution mutation — that is, having an "Ee" MC1R genotype — reduced the odds of an animal having a true black base coat color. Again, this is a pattern we think we see in the data. Based on the distribution of results and number of observations we have now, there is about a 90% chance that a single dilution allele does have this effect. Those odds do not rise to the level of confidence typically sought by scientific researchers, but this nonetheless likely effect of dilution is worth keeping in the back of your mind while we collect more data.

Even more important to understand, however, is that even if carrying a single "e" MC1R mutation does not result in different phenotypic coat color for an "aa" animal, it makes an enormous difference in the colors of the crias that animal can produce. An animal with an "EE aa" genotype will produce offspring of fawn or darker base coat color regardless of the color genotype of the animal to which it is bred. By contrast, an animal with an "Ee aa" genotype can produce crias in the whole spectrum of base coat colors, including white and light, depending on the color genotype conveyed by the other animal in the pairing.

Using This Information

Based on what we have learned so far, we believe that breeders focused on producing true black and silver grey animals should have a preference for breeding animals that carry the a1 and a2 ASIP mutations relative to those that carry the a3 mutation, all else constant. That last phrase is very important. Animals carrying one or two a3 mutations still produce offspring that are registered true black and silver grey, albeit at a lower frequency than those animals with “aa” genotypes that do not include an a3 mutation. We would not exclude them from true black breeding programs, but rather make sure they provide additional incremental advantages to compensate for their less frequent production of the desired true black base coat color. Superior genetics for other fleece traits, genetic diversity value, and potential branding and marketing advantages are among the potential reasons to include these animals in a true black breeding effort.

Top image: The fleece of an animal with an Ee a3a3 MC1R/ASIP genotype.

We want to stress, too, that breeders will increase the number of black animals they produce from other black animals if they maintain as many animals as possible that do not carry a dilution mutation. An “EE aa” animals bred to another “EE aa” animal will never produce a light fawn, for instance, while pairing two phenotypically black, “Ee aa” animals will produce a light fawn 25% of the time. Again, though, animals with black ASIP genotypes and one or even two dilution alleles may bring other important attributes to the program that make the reduced odds of true black offspring worth the trade-off. For instance, we are excited to breed an exceptional young light fawn male with an ee a1a3 genotype to black females in the coming season: His fleece is incredibly dense, long and uniform, and he will bring important genetic diversity to the colored breeding effort at Snowmass.

The Rose Grey Base Coat Color Genotype

As we mentioned earlier, the base coat color genotypes for the 51 rose greys for which we had detailed genotyping results surprised us. Of those 51, close to two-thirds had “aa” genotypes. We presumed that we would see a much higher proportion of rose greys — which we perceive as brown animals with a white pattern — that had ASIP genotypes of Aa or AA, because many brown animals have these ASIP genotypes. Instead, an “aa” ASIP genotype was most common, and of the rose animals in our sample only four that had been registered as rose grey did not cover black. When we went back to check the phenotypes of those four, we discovered they were actually all fawns with some white contamination in their blankets. They would not be considered rose grey for show purposes, or by most breeders.

Bottom image: The fleece of an animal with an EE a1a1 MC1R/ASIP genotype.

When we compared the base coat color genotyping results of rose grey animals to those of dark brown animals, we saw similarities. Almost half of the dark brown animals we have tested to date have also “aa” ASIP genotypes, and 90% of them carry at least one “a” allele and thus cover black. By contrast, only 18% of the nearly 100 medium brown animals we have color genotyped have black ASIP genotypes. Seventy-five percent of the medium browns we have tested carry at least one “a” allele.

It is interesting that rose grey animals have base coat color genotypes that in their distribution most closely match those of phenotypically dark brown animals, and that the animals that would be described by broad consensus as rose grey in our sample all carry at least one black allele. We would have imagined that an animal

with an EE AA color genotype, which typically produces an animal with a base coat color of dark fawn to medium brown, along with the white pattern produced by classic grey or roan mutations would also appear rose grey to the typical observer.

However, we have not uncovered any such animals to date. This makes us wonder if the presence of at least one black ASIP allele is required for animals to reveal a pattern that we would describe as classic or modern rose grey based on AOA's current color classification system. Many rose greys have fleeces that combine black, brown and white fibers. The top fleece image shown on page 9, which is from an animal that would show as a light rose grey, is a good example of this. This may be a clue.

Figure 3: Translating Reported Neogen genotyping results into the ASIP and MC1R genotypes described here.

The Blue Black Genotype

One of our personal hopes for our study of black genotypes is that the results will reveal the genotype(s) responsible for producing animals with fleeces we would describe as blue black. There is not yet agreement or even much discussion about what a blue black alpaca looks like compared to true black. While we hope to eventually quantify degrees of blackness with results from a spectrophotometer (the international testing laboratory SGS, which many of you use for histogram analyses, can provide spectrophotometer analysis as well) our sense of the blue black phenotype is as follows: 1) the animal appears an especially deep, cool black even compared to other true black animals, and 2) its fleece looks black even when compared to dyed black fabrics (some true black fleeces often look brown when compared to commercially dyed fabric.)

These animals are not common in the United States. And they share other fleece attributes besides their exceptional black coloration, because the greatly increased amount of total pigment in the hair shafts of the fibers of a blue black fleece reduces the amount of curvature that can be expressed. These fleeces are typically silky in style with a bold, low-frequency crimp, like that shown by the cria fleece in the bottom picture on page 9. Their lack of curvature makes them comparatively bright as well (and, we have learned, difficult to photograph).

We asked the breeders who submitted their animals' detailed genotype information to help build our database to indicate which of their animals they felt were blue black in color. Of the more than 1000 animals for which we have detailed ASIP genotypes, only 11 were identified as blue black by their owners. (Their individual standards for what constitutes a blue black likely vary to some degree.) None of those animals carried an a3 allele, and we suspect this may be an important aspect of the blue black genotype. Eight of the 11 carried at least one a1 allele, and four were homozygous a1a1. And 9 of the 11 did not carry any MC1R dilution mutations.

Digging in a bit more, of the four animals in their own herds that these authors identified as blue black using the general criteria described above, all were of the EE a1a1 genotype, including the cria whose fleece is shown in the picture on page 9.

Thanks to the willingness of other breeders to combine their genotyping results with our own, we have collectively made great strides in understanding which ASIP and MC1R genotypes are most likely to produce alpacas with black base coats. But even with our improved understanding of the likely impact of the a3 mutation on coat colors, we still can't explain why 4% of the animals that have "EE aa" genotype and lack an a3 allele are not true black or silver grey but are instead rose grey or brown.

Other mutations, in ASIP or perhaps other genes, may provide an answer. We are optimistic that those answers will be forthcoming, too, because U.S. breeders' interest in and quick adoption of color genotyping has helped stimulate more research on this topic. We will continue to share what we learn — and what we are taught — about alpaca coat color genotypes in the months ahead. ◇

Specific ASIP And MC1R Genotypes

ASIP Genotype	ASIP_325-381del57_b	ASIP_C292T	ASIP_G353A
AA	T	C	G
Aa1	GT	C	G
Aa2	T	TC	G
Aa3	T	C	GA
a1a1	G	C	G
a1a2	GT	TC	G
a1a3	GT	C	A
a2a2	T	T	G
a2a3	T	TC	GA
a3a3	T	C	A

ASIP Genotype	ASIP_325-381del57_b	ASIP_C292T	ASIP_G353A
EE	A	C	ACCT
Ee	GA	CT	ACCT
Ee	A	C	DEL.ACCT
ee	G	T	ACCT
ee	GA	CT	DEL.ACCT

The Case For Breeding For More Staple Length

We'll get straight to the point: To help preserve the perception of alpaca as a luxury fiber in the North American Huacaya, breeders need to increase their focus on producing animals that retain significant staple length throughout their lives. Alpaca fiber's most highly valued characteristics, namely its soft hand and visual brightness, are best expressed in worsted or semi-worsted yarns which require longer staple lengths for spinning. And yet, in part because breeders and occasionally even show judges have difficulty assessing younger animals with long fleeces, the U.S. industry has trended towards producing young animals with shorter staple lengths. Unfortunately, those shorter-stapled young animals often become mature adults with fiber too short for worsted processing. And not only is their fleece less valuable per pound as a result, but they produce fewer pounds of it. Less quality and less fiber both put the market for alpaca fiber at risk.

In this article we consider alpaca fleece growth as a function of age to determine what staple length is necessary on a young animal to give a breeder confidence that it will continue to produce worsted length fiber as an a mature one, and advocate for some thoughtful change in how we evaluate young animals on that basis. We also examine the implied genetic relationships between fleece growth rates and other traits of value. Finally, we discuss ways to address herd-specific selection challenges and their business implications.

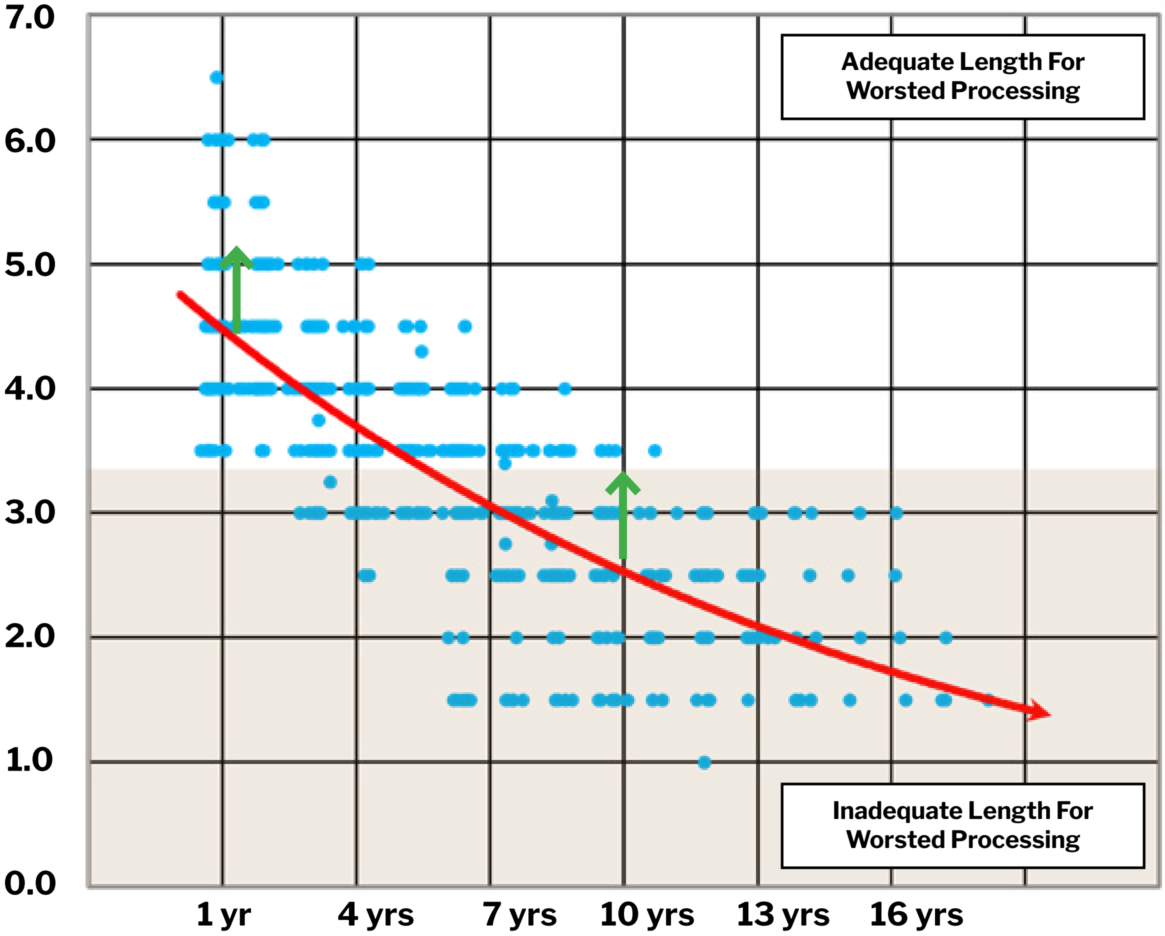
Alpaca Fleece Growth

As is the case with sheep and other fiber producing species, as well as for mammals more generally, alpacas' rate of hair growth slows as they age. Figure 1 on page 14 shows the stretched staple lengths of over 700 of our white females displayed as a function of the ages of the animals, recorded at our 2021 shearing. The red dashed line on the graph portrays the typical relationship between age and fiber growth rates within this large and genetically diverse group. Some animals will likely have genotypes which allow them to outperform this curve somewhat over time, while others will underperform it. But in general, it is safe to say that the growth rate of alpacas' fiber diminishes substantially as they get older.

The shaded bottom portion of the graph shows where staple length is insufficient for worsted processing (we assume this is approximately 3.5 inches at mid-side, corresponding to somewhat shorter lengths along the topline and hip. Three inches is considered the minimum stretched length for worsted and semi-worsted spinning systems.) As you can see, most of our females older than around six years produce annual fiber growth that is less than required for worsted processing, as do a worrisomely large proportion of our four- and five-year-old females. While it is true that most are pregnant and the demands of pregnancy likely slow their fiber growth rates (while we are unaware of any specific studies of alpacas in this regard, this has been demonstrated to be the case in sheep), these production-age females make up the greatest proportion

Why Staple Length Matters

**Stretched Staple Lengths for 704
White And Light Adult Females By Age**



Because their fiber growth rate slows as they age, we need to breed to increase the staple lengths of our females for them to maintain worsted processing lengths in mid-life and beyond.

of our herd and thus are the most important source of fiber produced by it. As a group they are underperforming relative to our goals.

It is unlikely that we will be able to dramatically change the impact of age itself on fiber growth with selective breeding. But we can readily select between genotypes that produce consistently more or less growth at any age, which can be visually understood as shifting the graph's red line up or down. So, for instance, if we wanted our typical female to produce worsted length fiber until around age of 10, we will need to breed so that our females produce yearling fleeces of at least five inches, as roughly indicated by the green arrows. Our light yearling females' fleeces averaged stretched lengths of 4.6 inches last year, with only one-third of them meeting a target length of five inches or greater. With the remaining two-thirds, we have work to do in the next generation.

Figure 1: Stretched staple lengths by age for white Huacaya females in our herd.

Breeding Selection For Staple Growth Rate

The graph in Figure 1 is helpful for understanding whether an animal has faster- or slower-growing fleece for its age. But it does not help adjust for other factors that influence the rate at which fleece grows. For instance, as we previously noted, pregnancy likely affects the fiber growth rate of female alpacas. Many of you will have also observed slower fleece growth rates as a result of illness. More broadly, environmental differences ranging from the quality and nutritional balance of the feed provided to the length of daylight may affect the rate of hair growth. How do we compare the genetic potential for fleece growth of animals that come from environments and husbandry regimes that are different from those of our own farm, as we must do when we consider purchasing animals for a breeding program?

The answer is EPDs, though to use them most effectively we will suggest a small adaptation. Even as they are, though, they are quite useful for looking through the effects of environment and age on staple growth to discern which animals have the genotypes for the fastest rate of fleece growth in their offspring. Because they are adjusted for environmental differences, you can use the discussion about results at our farm below to benchmark your evaluations at others'.

Figure 2 on page 17 shows the relationship between stretched staple length and age for the herdsires we used on the farm in 2021. It further indicates the EPD rankings of the males using color. The graph makes it clear males that are producing worsted length fiber in their mature years typically have EPDs for Mean Staple Length (MSL) in the top 25% of the rankings. The young sires in our herd with top 25% EPDs have stretched staple lengths of 5 inches or greater for their second fleeces and quite frequently their third as well.

As for the males that will stop producing worsted-length fiber by the time they are just five or six years old? Their second fleeces are often not alarmingly short, as you can see. They manage at least four inches of growth, and sometimes a bit more. However, that length at that age, and the lower-tier EPDs associated with them, indicates that these males' fleeces will often be too short for the highest value processing starting around age five or six.

Because we don't use many older males for breeding, Figure 2 has few examples of the stretched staple length of older sires. The ones that are there, though, are almost exclusively ones with longer staple lengths and EPDs to produce the same. Why is this? We think it is in part because we have a hard time mentally getting past the lack of length in the shorter fleeced older males at shearing, when we make typically the coming season's breeding decisions, and as a result stop using them at a younger age. This obviously doesn't make a lot of sense, given that we can predict which males are going to be short-fleeced long before they are — if we don't want to use them when they are older, why use them when they are younger? In part this is because we are still failing to recognize what a problematic length of growth is in a young animal, since that length still seems adequate in an absolute sense.

But there is another reason also. The shorter-stapled males are disproportionately the ones who create animals that can win in the show ring. This is an issue we will address shortly.

Figure 2: Stretched staple lengths and EPD rankings for our sires by age.

The relationship between stretched staple lengths and EPD rankings shown in Figure 2 does not correspond perfectly, and there are animals that produce faster hair growth than their EPDs for MSL would suggest. This is usually because their fleeces are of very high curvature. The curvature of the fiber affects the difference between the relaxed staple length used for the EPD calculations and the stretched staple length that both better measures the true length of the hair and is relevant for spinning yarns. The higher the curvature of the fleece, the shorter a relaxed staple will be relative to its stretched version because the crimp makes the hair shorter in its relaxed state. As a result, animals with high curvature fleeces will have EPDs for MSL that understate fiber growth rates compared to those with low curvature fleeces.

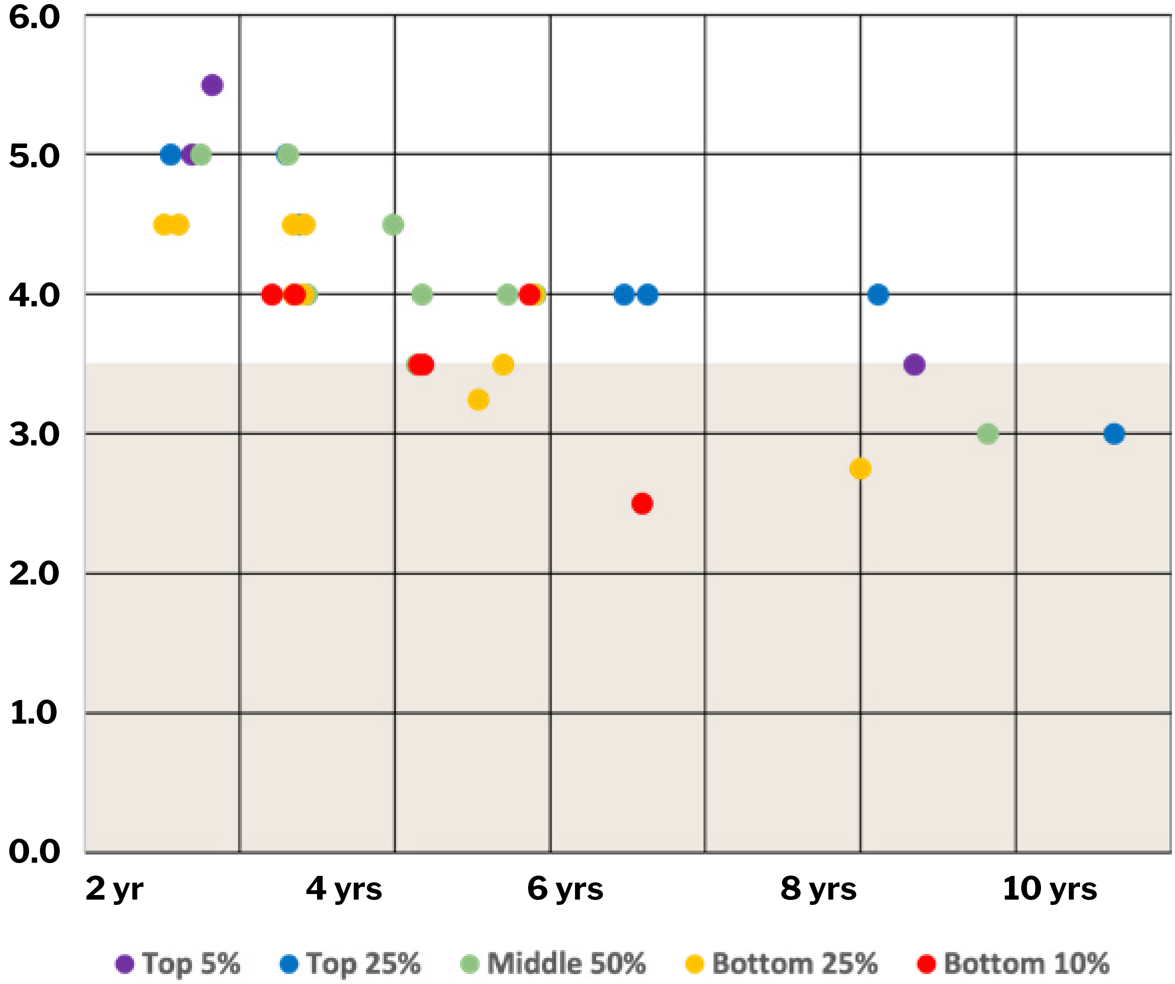
At the skirting table, we measure and record our animals' stretched staple lengths to put all fleeces on the same footing to evaluate staple growth. When we use EPDs, we adjust the MSL measure by the EPD for curvature to get a better sense of their genotypes for that trait. For our own purposes, we do this with statistical tools and provide in the Snowmass Community Database an imputed EPD for staple growth rates, which we refer to as "MCASL," short for micron and curvature adjusted staple length. However, you can make a rough mental adjustment to the EPD for MSL by looking at the EPD for curvature. Animals with the genotypes for high curvature fleeces will have better genotypes for staple growth rate than what is implied by their EPDs for MSL. The reverse is true for animals with the genotypes for particularly low curvature fleeces.

EPDs can also tell us whether the genotypes that produce faster fleece growth rates are related to those responsible for other fleece traits of interest. Where they exist, those relationships can make it challenging to manage fleece traits independently, which sometimes makes it hard to make progress in one fleece trait without losing ground in another. We reviewed the EPDs of several thousand animals to look for those relationships. We were happy to find that, aside from an expected positive correlation with fleece weight, there was no meaningful relationship between the imputed EPD for staple growth rates, MSCASL, and those for fineness, micron uniformity, medullation, or curvature. This means that breeders have an opportunity to select to improve staple growth rates in alpacas without compromising the quality of other fleece traits.

Why don't we see more breeders focusing on producing longer-stapled animals? We think it is because our evaluations of the fleeces of young animals are sometimes confused by length. We'll explain how and why.

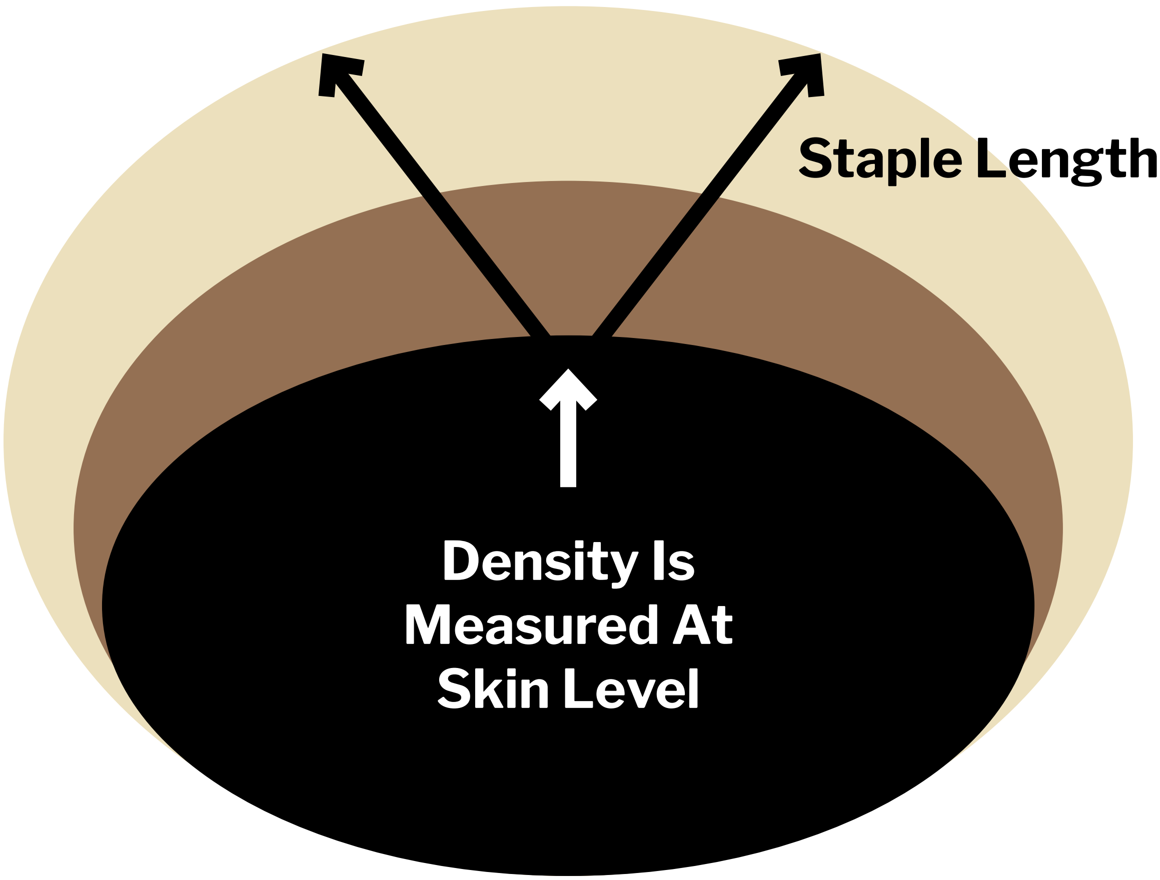
Breeding For Luxury For Life

Stretched Staple Lengths Of Our 2021 Sires By Age, With Their EPD Rankings Indicated By Color



Choose animals with EPDs for staple length in the top 25%, or at least 5 inches of stretched staple length as young adults.

Long-Stapled Animals Appear Less Dense From The Outside — But That Is Not Where Density Is Measured



History Of "The Look"

There was a time when sheep breeders relied on crimp frequency as a useful indictor of the fineness of a fleece, so closely were these two attributes related. With advances in breeding this became much less useful within individual breeds. In alpacas, too, it is a poor proxy for fineness: While it is not possible for a coarse fleece to exhibit a very high frequency crimp style because the composition of the coarser hair impedes it, it is very possible for a finer one to exhibit a broader crimp style if the animal's fleece is growing very quickly. This is because the distance between the individual peaks in the crimp of animals of comparable fineness are determined in part by how fast the fleece is growing. Faster-growing fleece tends to have a longer distance between the peaks, which is to say a lower frequency style. That has not stopped us from sometimes confusing "lower frequency" with "higher micron." This is not always the case.

We also hear breeders sometimes referring to the "developing style" of a young animal and sometimes use the same phrase ourselves to refer to an animal that is showing a tighter crimp style at the base of a juvenile fleece as opposed to the tip. Recognize that part of what we are all referring to as a development of style actually reflects the fact that the rapid fleece growth of the very young animal is slowing, which results in an increase in crimp frequency. There are other things going on in a young fleece, including the activation of secondary follicles, that contribute to our impressions as well. But the tighter crimp style does not "develop" so much as appear as a function of slowing fleece growth. Slowing growth has no independent value. The animal that manifests a tight crimp style at a young age is likely to be a very short-stapled adult.

We have also heard some industry experts refer to a link between faster staple growth rates and reduced micron uniformity. Interestingly, a small unfavorable correlation between staple growth rates and SDs is evident in our EPD data. But it is very small — too small to make staple length any kind of a useful proxy for distinctions in micron uniformity.

This leaves us with the most difficult evaluative challenge, which is assessing the density of the longer stapled animal. This challenge is illustrated by the picture at left. The longer a Huacaya's fleece grows, the greater the volume of space it fills. As a result, the long-stapled alpaca usually looks more open-fleeced from the outside than its shorter-stapled peers and may be more cross-fibered at its outer edges. In addition. the very weight of the longer staple can draw out the style across its length.

As a result, even sophisticated observers can have difficulty assessing the density and organization of these fleeces. These can only be evaluated by close assessment at the skin level, which is something most of us haven't practiced.

With respect to our own animals we have ways of correcting our subjective assessments: When we look at fleece weights we collect at shearing each year and adjust them for differences in micron and staple length we discover when we've made poor subjective assessments of density. That has helped teach us that we ourselves tend to underestimate the density of long-stapled animals. With that in mind, the following examples from within our own herd may help calibrate your judgment of the long-stapling fleece when it is on the animal, as they have ours.

The Long And Short Of It

The image of fleece samples shown here helps illustrate the challenges associated with evaluating fleeces of different lengths. The fleece samples shown are from second fleeces of some of our best white sires. The samples had AFDs that ranged between 16 and 18 microns and mean curvatures between 43 and 53 d/mm — not a lot of variation, in other words. With the ruler for context you can see that the relaxed samples vary considerably in length, as they do when stretched. Relaxed crimp frequency ranges from a deep-amplitude 6 crimps per inch for the left-most sample to 10 for the one at far right. When these fleeces are on the animal rather than on a table, the crimp frequency appears to be less, especially for the longest-stapled ones. The animal whose fleece is shown at the far left has a style that appears particularly bold when he is in full fleece.

But there are other things we would like you to observe in this photo as well. Notice that all the fleece samples look quite well organized at their base, as indeed they are — these are some of our best sires. But at their ends the longer samples look more open and disorganized than the short sample does, with more fuzziness from cross-fibering which propagates down the staple. This is the result of the staple opening and expanding in volume as it grows away from the skin. By contrast the shorter stapled example looks organized and dense right to the tip. Does this reflect higher density for the shorter fleece? We think not, as the average shearing weight of the longer stapled animals in this group was 70% greater — that's right, almost twice as much — as that of the shortest stapled one even though there is comparable fineness within the group. It's just that short-stapled fiber hasn't grown as far from the skin and is filling less volume, with the result that it appears denser and more organized from the outside.

Show judges will sometimes caveat their descriptions of the density of an unusually small juvenile or yearling animal by noting that the animal's small size is contributing to that phenotypic density because its hair follicles are being distributed across a smaller skin area. If the animal was well-grown, it would appear less dense. We need to build the same type of understanding and articulation into our evaluations of the density and organization of animals of varying staple length.

When the fleeces are on the skirting table it's obvious which young sires are producing more valuable fleeces, but experience has taught us that it is much less obvious which type of fleece breeders and even judges will find exciting when they see animals in full fleece. In fact we rarely bother to show animals like the one that produced the fleece on the far left in the image, for instance, so much is the bolder, high amplitude crimp style fleece out of fashion in the ring. Most of you who show probably leave this type home as well, which is ultimately problematic in our minds. These are the type of animals that we need to both see and use more in our industry, not less. ◇

Heat Stress and Nutrition

The warming climate is creating both threats and opportunities for livestock breeding operations, and this is driving research, experimentation, and ultimately significant change in how animals and farms or ranches are managed around the world. For alpaca breeders these changes can be easy to miss because the research and support for adaptive changes focuses on the management of species with far greater aggregate economic value. Much of what is learned about the impact of a warming climate on the health of other ruminants is likely to apply to alpacas as well, however, and will affect the bottom line of an alpaca breeding business in similar ways.

In this article we discuss studies of cattle, sheep and goats that have clarified the value and cost effectiveness of alleviating heat stress and its consequences by supplementing nutrition before and during periods of heat stress. Alpaca and alpaca breeding businesses seem likely to find benefit from similar approaches. The cost and risk associated with improving nutrition is low too, which makes it compelling for growers to try these approaches even before the benefits to alpacas have been quantified.

More broadly, it is valuable for all of us to have a very basic understanding of the impact of heat stress on our animals. Not only does it have a profound and wide-reaching effect on how their bodies function but its effects can be long-lasting, even permanent. This article contains references to excellent sources with fuller explanations for those interested in learning more.[1]

Heat Stress and Its Consequences

Animals' bodies gain heat in two ways: Their bodily functions produce it, and when the weather is hot they can also gain it from the environment. Likewise, they have two ways of dissipating excess heat, through both radiant and evaporative cooling. Alpaca growers can directly observe some of the ways alpacas increase the rate at which they dissipate excess heat: They sweat more, for instance, and cluster in the shade or under fans. More difficult to directly observe are the ways that other physiological functions change to reduce the amount of heat produced by the body in the attempt to maintain a normal body temperature. Heat stress presents an immediate and potentially mortal threat, and alpacas and other mammals have evolved to sacrifice growth, reproduction and even long-term health in the battle to stave off death from heat.

One of the ways that mammals reduce the amount of heat their bodies are producing is to reduce the amount of food they eat. Digestion is a metabolically

[1] This book chapter provides an excellent summary discussion with an extensive list of links to research: Dunshea F.R. et al. (2017) Nutritional Strategies to Alleviate Heat Stress in Sheep. In: Sejian V., Bhatta R., Gaughan J., Malik P., Naqvi S., Lal R. (eds) Sheep Production Adapting to Climate Change. Springer, Singapore. https://doi.org/10.1007/978-981-10-4714-5_18

intensive process: Even your own body temperature rises slightly after a meal. Ruminants have been shown to produce about 8% of their body heat from the fermentation of their feed in their stomachs, an amount which varies depending on the characteristics of the food they are consuming. Eating less thus helps them stay cooler.

However, this response to heat stress creates significant issues. Not only are animals operating at an energy deficit, utilizing more calories than they are consuming, but they are also depleting internal stores of vitamins and minerals. Because heat stress also produces incremental oxidative damage, this is particularly true of antioxidants like vitamin E and selenium. To make matters worse, heat stress also slows their digestion and reduces the efficiency of nutrient extraction in their guts. Malnourishment can thus be an important consequence of heat stress, and one that is difficult to observe directly.

Mammals' immune systems are also affected by heat stress in myriad and complex ways that this unlearned author will describe simply as "mostly bad." Animals experiencing heat stress are more prone to inflammation and less able to fight off infections. These immune system effects can considerably outlast the period of active heat stress, and in fact some of the challenges an alpaca grower faces with her herd's health in the fall and even winter may have their source in the previous summer's heat. The duration of impact can extend even further. For example, research in cattle has shown that the immune systems of calves born to cows that experienced heat stress during the pregnancy are permanently altered in ways that make those calves less robust. Those same cows produce less milk following not just the pregnancy during which they experienced heat stress but after subsequent pregnancies as well.

Reproductive functions are also compromised by heat stress. Males' sperm quality declines, ovarian functions are affected, conception rates drop and miscarriage and premature birth rates increase. At our farm we have also documented a statistically significant increase in the sex ratio (that is, the number of male offspring born compared to the number of females) of crias born to dams who conceived when they were heat stressed. Other research has revealed a comparable sex ratio shift in the offspring of heat stressed cattle. These issues represent fundamental challenges to the financial bases of breeding businesses.

Finally, animals exposed to heat stress grow more slowly. This is true even in utero, where the fetuses of heat-stressed mothers grow more slowly on average than they otherwise would. They also finish smaller: For example, alpaca breeders in the southern U.S. have long observed that their animals seem to end up smaller on average than those raised in the cooler north. It is a challenge for researchers to parse the results to determine relative contribution of the myriad challenges to growth that heat-stressed animals face to determine how much of the growth differential is due to reduced consumption of food, impaired digestive function, an increase in other health issues, or because their bodies have down-regulated growth to reduce the internal production of heat. As you would guess, the magnitude and duration of the heat stress endured by the animals also matters.

Fiber growth rates are also affected: Studies of merino sheep have shown that the wool of animals exposed to chronic heat stress grows more slowly,

Pelleted Alpaca Feed Nutritional Analyses

	Mazuri Alpaca & Llama Maintenance	Poulin Alpaca & Llama Maintenance	Blue Seal Llama-Alpaca Pellets	Nutrena Country Feeds Llama & Alpaca Feed	Bluebonnet Feeds Supreme Alpaca Llama Food	Cotton Creek Farms Alpaca Pellet
Crude Protein, Min.	12.0%	15.0%	14.0%	14.0%	15.0%	14.0%
Crude Fat, Min.	2.0%	2.5%	3.5%	3.5%	5.0%	2.0%
Crude Fiber, Max	18.5%	15.0%	14.0%	16.0%	14.0%	17.0%
Calcium, Min.	1.05%	1.3%	1.25%	1.5%	1.7%	1.3%
Calcium, Max	1.55%	1.8%	1.75%	1.9%		1.8%
Phosphorus, Min.	0.75%	1.0%	0.8%	0.8%	1.1%	1.0%
Salt, Min.	1.0%	1.0%	0.75%	1.25%		.7%
Salt, Max	1.5%	1.5%	1.25%	1.75%		1.2%
Copper, Min.					18 ppm	
Selenium, Min.	1.3 ppm	1.25 ppm	0.4 ppm	1.0 ppm	2.2 ppm	3.1 ppm
Zinc, Min.		800 ppm	200 ppm		1000 ppm	600 ppm
Vitamin A, Min.		18,750 ppm	8,500 IU/lb	20,000 IU/lb	25,000 IU/lb	20,000 IU/lb
Vitamin D, Min.		7500 ppm			13,000 IU/lb	5,000 IU/lb
Vitamin E, Min.		1400 IU/lb	150 IU/lb		400 IU/lb	500 IU/lb
Vitamin B12, Min.					104 IU/lb	
Biotin, Min.		15 mg/lb				6 mg/lb

Figure 1: Pelleted alpaca feed nutritional analyses as provided by manufacturers.

with reduced nutrition identified as a likely cause.[2] Fiber quality is also likely diminished because of reduced nutrition. This illuminates another challenge for breeders, which is to differentiate these environmental influences from genetic ones when making breeding decisions based on phenotypes (yes, we are going to remind you about the value of EPDs again – there it was.)

Most alpaca breeders need no convincing that heat stress is bad for their animals. What they do need is cost-effective ways of reducing this stress and/or its consequences. There are three basic approaches that a livestock grower can take to meet this challenge: They can cool the environment their animals live in; improve their animals' nutrition; and breed for resilience to heat. Over the long-term, many growers will need to include all three approaches in their management plan to maintain their animals' health and performance in a hotter climate. But of the three, changing nutrition will likely be the least expensive and, assuming it works for alpacas as it does for other ruminants, provide some of the quickest benefits.

Improved Nutrition

If research into the diets of cattle, sheep and goats provide representative guidance for alpaca care, there are nutritional strategies that can help reduce the level of heat stress alpacas experience as well as compensate for its negative effects. There are two key steps to managing nutrition in the face of heat stress. The first is to make sure that alpacas have access to food and supplements that help them establish internal reserves of vitamins and minerals, and particularly of antioxidants, well prior to an anticipated period of heat stress. The second is to feed higher nutrition, lower-fiber feed during times of active heat stress than you might during other times.

Vitamin E and selenium are both potent antioxidants, and dietary supplementation with either or both in combination have been shown to reduce both rectal temperatures and respiration rates of heat-stressed sheep.[3] Of the two, vitamin E supplementation had the greater effect, reducing rectal temperature increases in heat-stressed sheep by 39% and 42% in two separate studies. Several minerals, including chromium and zinc, are known to increase blood flow to the skin and lungs which can help increase radiant heat loss.

More broadly, animals that are eating less are at risk of ingesting insufficient levels of all vitamins and minerals, and so breeders must consider the possibility that alpacas are dealing with the consequences of other nutritional deficiencies as well. Unfortunately research regarding appropriate levels of vitamin and mineral supplementation for alpacas is very limited, and mostly derived from studies of cattle, goats, and sheep.[4] The need for supplementation will also vary according to other environmental conditions on individual farms. For instance, animals that graze on green pasture will ingest greater

[2] Thwaites, CJ. Heat stress and wool growth in sheep. Proc. Aust. Soc. Anim. Prod. (1968) 7:259-263.
[3] See, for instance, Chauhan SS, Celi P, Leury BJ, Clarke IJ, Dunshea FR (2014) Dietary antioxidants at supranutritional doses improve oxidative status and reduce the negative effects of heat stress in sheep. J Anim Sci 92:3364-3374.
[4] We recommend reviewing the research of Dr. Robert Van Saun of the Department of Veterinary & Biomedical Sciences at Pennsylvania State University to learn more.

amounts of vitamin E than dry-lotted animals consuming grass hay that, as the result of drying and storage, has lost much of the vitamin E it contained when fresh.

The switch to a heat stress protective nutritional program should start a couple of months prior to the hot season on the farm to be most effective.[5] The goal is not to fatten the animals but to make sure they have more than adequate internal reserves of vitamins and minerals (where that is possible) in advance of a time of year when they will both ingest less and need more of these critical substances.

Feed choices can also help reduce the amount of heat stressed experienced by alpacas. Fermentation in the stomach generates heat, and poor quality, higher fiber hay and forage takes more fermentation to digest. Better quality hay and grass can help reduce heat stress by limiting the amount of fermentation required, and also provides more nutritional value relative to the quantity consumed which is important when the animals are eating less in the heat. Alfalfa hay in particular is both rich in calories and nutrients, including vitamin E, and typically lower in fiber than straight grass hay. Growers who have historically saved their richest hay or those extra bags of fortified pellets for when their alpacas are huddled in the barn in mid-winter may wish to feed this in the summer's heat instead, or as well.

Figure 2: Mineral salt nutritional analyses as provided by manufacturers.

Comparing Feed Supplements

We compared the nutritional value of six pelleted alpaca feeds as well as five types of mineral salt. This information is presented in Figures 1 and 2. While we cannot tell you what feed is optimal for your farm and animals, or even if it is incrementally useful at all, we thought this side-by-side presentation would still be helpful.

All of the alpaca pelleted feeds shown in Figure 1 have wheat middlings as their primary ingredient. Wheat middlings are the parts of wheat that are left over from the flour-making process, and include the wheat germ, the bran, and other leftover materials. While the absolute quality of wheat middlings varies, in general this feed source is lower in fiber than legume and grass hay, which reduces the metabolic effort required to digest it. It is often higher in protein as well and contains other useful nutrients, including zinc and selenium. Wheat fiber is also readily digested by ruminants. Pelleted feed is thus an attractive addition to the diet of alpacas facing heat stress — at least before considering its relative cost.

That said, feed producers have chosen to enhance their pelleted product with different amounts of vitamin and minerals. We have shown the guaranteed content analyses for each brand in the table and highlighted the vitamins and minerals that have been shown to help animals cope with heat stress. There are meaningful differences between the products. Again, while we don't know the "right" amount of vitamin E, selenium or zinc for animals on your farm, we do know that these feeds are being safely fed to alpacas across the country, and that superior nutrition is likely to be especially valuable during times of heat stress.

[5] Alhidary IA, Shini S, Al Jassim RA, Abudabos AM, Gaughan JB. Effects of selenium and vitamin E on performance, physiological response, and selenium balance in heat-stressed sheep. J Anim Sci. 2015 Feb;93(2):576-88. doi: 10.2527/jas.2014-8419. PMID: 26020746.

Mineral Salt Nutritional Analyses

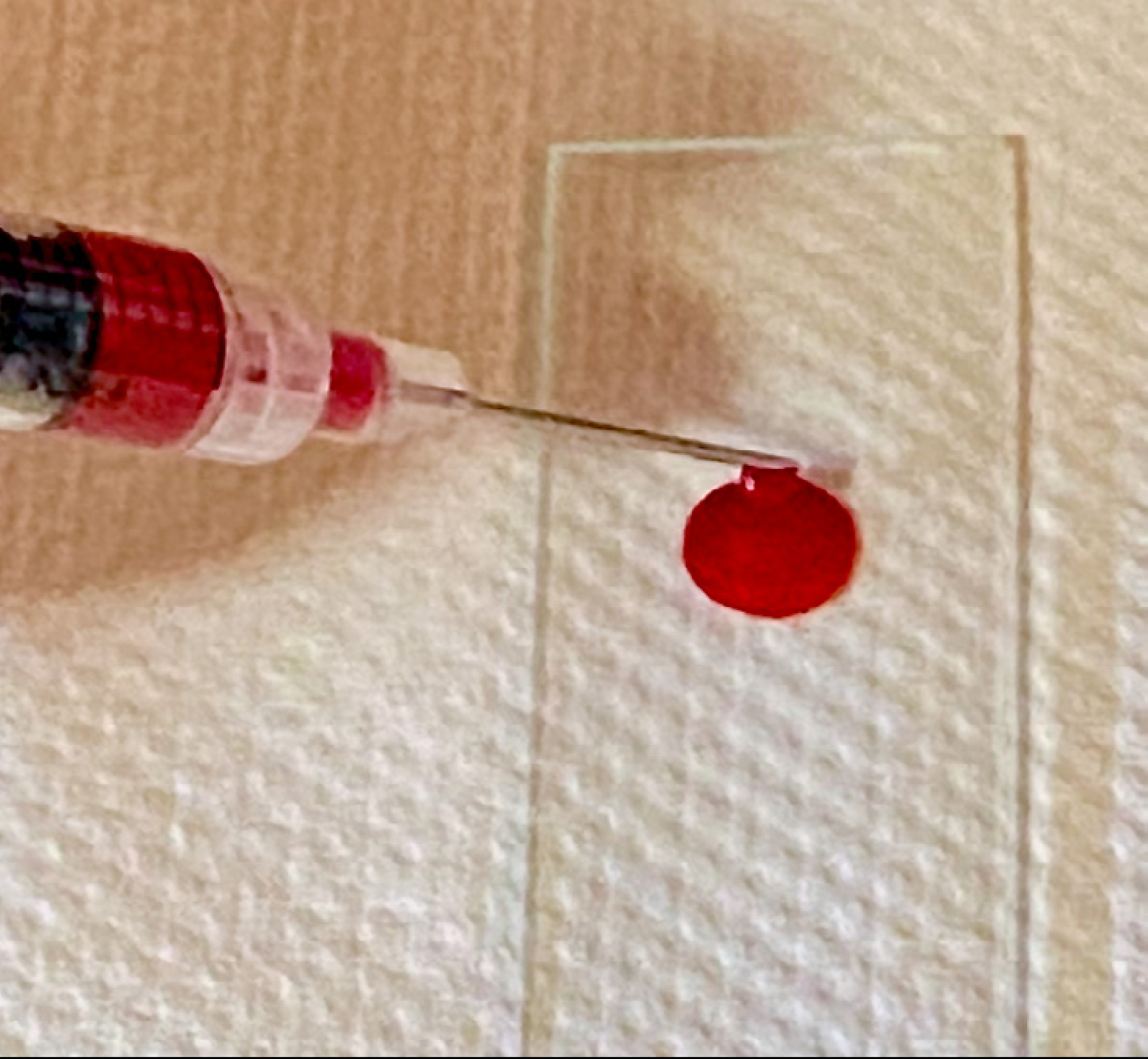
	Stillwater Minerals Formula 104	Evans Vitamin-Mineral Blend E (also sold as Mazuri Minerals Blend E)	Poulin Northeast Alpaca and Llama Free Choice Mineral	Masterplan Llama Minerals	Purina Sheep Mineral
Salt	19%/21%	21.5/25.8%	21.96%/26.35%	6.0%-7.3%	11.25%/13.5%
Calcium	7.5%/8.5%	6.0%/7.2%	5.45-6.48%	13.0%-15.6%	14.85%/17.82%
Phosphorus	6.5%	4.0%	2.95%		6.0%
Vitamin A	250,000 IU/lb	200,000 IU/lb	202,500 IU/lb	190,000 IU/lb	100,000 IU/lb
Vitamin D	30,000 IU/lb	75,000 IU/lb	105,000 IU/lb	25,000 IU/lb	10,000 IU/lb
Vitamin E	7,000 IU/lb	9,000 IU/lb	25,000 IU/lb	1000 IU/lb	200 IU/lb
Iron	5000 ppm			2000 ppm	
Manganese	1500 ppm			1500 ppm	500 ppm
Zinc	9000 ppm	9000 ppm	0.47%	9000 ppm	1250 ppm
Iodine	30 ppm			300 ppm	30 ppm
Cobalt	20 ppm			15 ppm	3 ppm
Selenium	70 ppm	70 ppm	90 ppm	5 ppm	11.5/13.8 ppm
Copper	200 ppm	250 ppm	30 ppm	90 ppm	
Potassium	2.8%			2.0%	
Magnesium	0.6%		4.65%	1.0%	2.0%
Vitamin B12	300 mcg/lb				
Vitamin B1	32.25 mg/lb				
Vitamin B2	50.0 mg/lb				
Vitamin B3	241 mg/lb				
Biotin	1.6 mg/lb			6 mg/lb	
Thiamine				39 mg/lb	

Your choice of supplement, or whether you provide one at all, will also be a function of cost and the degree to which you need or perhaps prefer to use pelleted feed for caloric support in addition to using it as a nutritional supplement. Because in our experience alpacas are happy to eat as much pelleted feed as is provided, you might find it useful to calculate an effective cost per unit of vitamin supplement provided. A feed with lower levels of nutritional supplementation might even be preferable if the cost difference between it and one that has higher levels allows you to feed more of it.

The nutritional content of mineral salts varies even more widely. Because animals consume the mineral salt because of its salt content, the percentage of salt itself also matters: Animals will need to consume more of a lower-salt mineral salt mix to obtain the same absolute amount of salt as they would consume from mineral salts with a higher percentage of salt. For this reason the vitamin and mineral content should be scaled by the percentage of salt in the blend when comparing brands.

Unlike pelleted feed, alpacas will not increase their salt consumption as a function of how much you provide, unless you are currently providing less than they need. In the absence of more detailed information regarding the specific vitamin and mineral requirements of alpacas, it probably makes sense to offer them a mineral salt made specifically for them or for another small ruminant species.

Going forward we encourage you to keep an eye on research developments regarding the management of ruminants in a warming climate. While research on alpacas specifically is likely to remain sparse, as this discussion suggests there is great deal of effort being made to understand how to best manage other more economically important livestock species in a warming climate, and with an eye to agricultural businesses' bottom lines. This will produce useful guidance for those of us raising alpacas also. ◇



Two Instruments That Save Lives

Among the most important tools on our farm? A hematocrit centrifuge and a refractometer. This pair of instruments has helped us improve our animals' health and save not a few of their lives while simultaneously helping limit the use of unnecessary medication and reducing the need for veterinarian visits. We believe they have even helped us reduce our animals' miscarriage and premature birth rates. Even better, we have achieved these major long-run improvements to the economic profile of our business at a cost of just a few hundred dollars.

By analyzing a very small amount of blood, a hematocrit centrifuge and a refractometer allow us to discover whether an animal is anemic, as well as — and this is important — narrow down the likely causes without needing to call our vet and wait for the results of a laboratory produced blood panel or take the animal to a hospital when a veterinary visit is not possible. Both of these options can be slow relative to the pace of a health crisis, and in the case of a hospital can also be quite expensive.

In fact it was her own frustration with these challenges that some years ago led our farm's veterinarian to suggest that we learn to run these two simple blood tests on the farm. She taught us how to do the tests and how to interpret the results so that we could provide better and more timely care to our animals. If after reading this article you decide you would like to do the same tests on your farm, we strongly recommend you also work with your own veterinarian, who not only has a medical degree that we lack but is also more familiar with the environment on your farm, to understand how to interpret your test results.

PCVs and Protein Levels

A hematocrit centrifuge spins a tiny capillary tube with a few drops of blood in it to separate the blood by the weight of the components. The heavy red blood cells concentrate at the bottom of the tiny tube and the tube is then held to a measuring card to determine the packed cell volume percentage, or PCV. A PCV that is lower than the normal range indicates that the animal is anemic — that is, deficient in red blood cells. At our farm, PCVs from 28% to 32% are normal in appropriately hydrated animals, while PCVs in the mid-twenties indicate the animal is suffering from mild to moderate anemia. We get very busy supporting animals with PCVs in the low 20s and high teens and consider it a medical emergency if we find an animal with a PCV in the mid-teens or below.

What we do from there depends in part on the results of the refractometry. Brix refractometers like those used in home brewing are inexpensive and provide us with what is referred to as a plasma total solids reading, which is a very good proxy for the total plasma protein level provide by a blood panel report from a laboratory. To use it, a drop of the animal's plasma is placed on the viewing screen, the refractometer is pointed towards a light source and the result is read. At our farm a total protein level of 7.0 or greater is considered normal; readings below 6.5 get us busy and readings below 6.0 put us on high alert.

To obtain the plasma necessary for the test, we either retrieve a drop from the opposite end of the capillary tube from the packed red blood cells or spin a small amount in a test tube long enough for the plasma to rise to the top and then draw a drop from there. If the centrifuging of both the hematocrit sample and the plasma sample are done immediately (really) after drawing the blood, there is no need to mix the sample with an anticoagulant — and if drawing blood from a vein is intimidating you can even learn to draw a few drops from a tiny nick to the ear directly into a capillary tube. However, if you are drawing blood as you go about farm chores and are a bit delayed getting to your lab, you will want to draw a few ccs and dispense them into a "purple top" blood collection tube with an anticoagulant in it. We order the K2 EDTA 7.2 mg tubes online.

Here's how we use these results: If the animal has both a low PCV *and* a low protein result, we assume that the animal is losing blood. This is typically from either an intestinal parasite infection or stomach ulcers. If, however, the animal has a low PCV with a *normal* protein result, we suspect an active mycoplasma haemolamae infection, because that very common bacteria destroys red blood cells while leaving other blood components untouched.

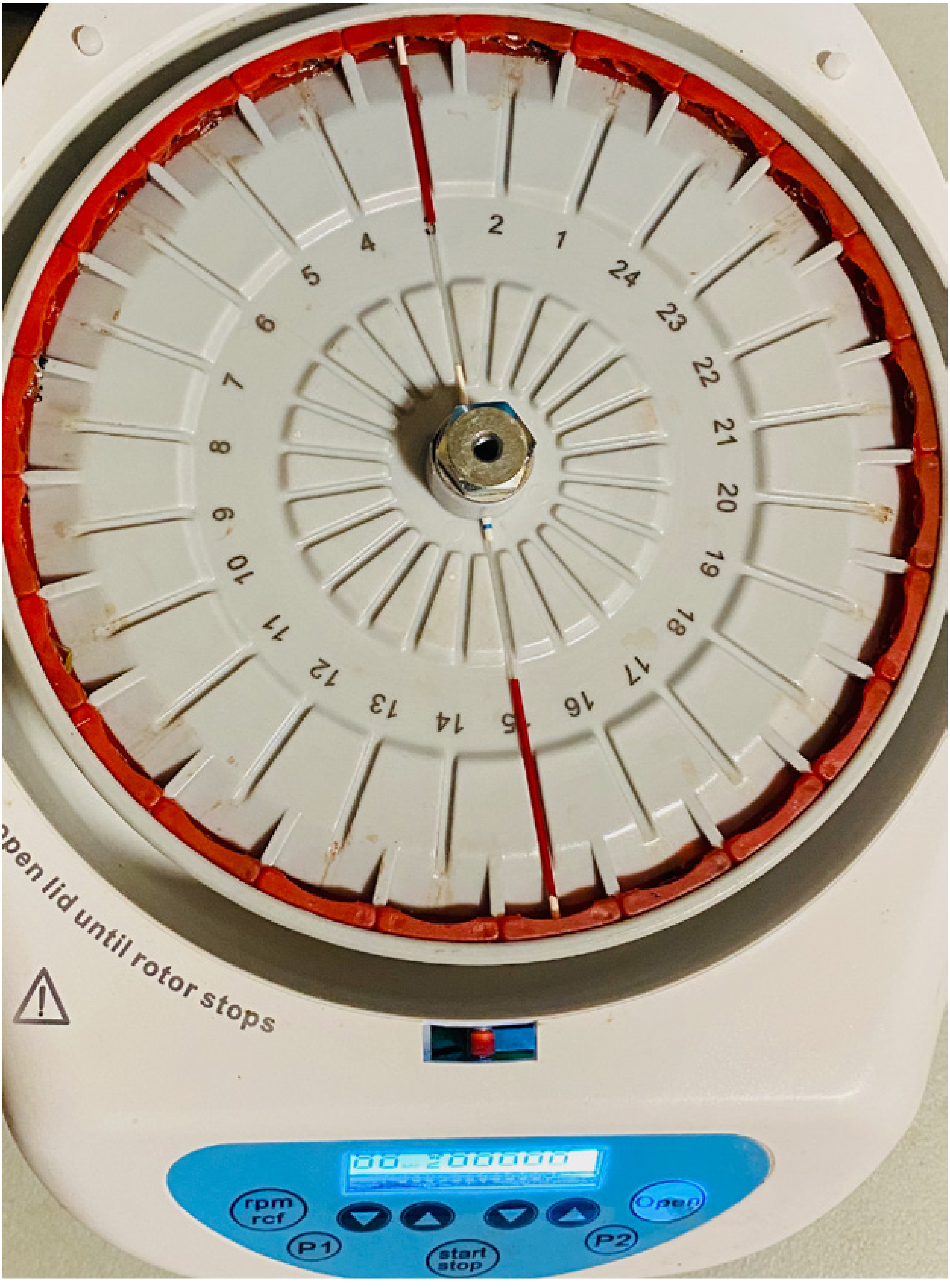
The next thing we will do is consider the absolute levels of the PCV and protein measure to determine next steps. For instance, if the results indicate that an animal has only slightly lower than normal PCV and total plasma solids levels, our next step will be a fecal exam, to see what parasites are present and get a sense of their relative prevalence. On the other hand, we will treat a more significantly anemic/low protein animal to eliminate a potential haemonchus contortus infection right away, even if the fecal looks clean or relatively so, because a heavy enough load of this parasite can kill an animal even before the worms have matured enough to start producing eggs.

At our farm we routinely include ulcer medication in the treatment plan for a moderately to severely anemic animal whom we believe has been brought down by parasites or ulcers. We also provide a period of iron supplementation to all animals overcoming more significant anemia, as well as other nutritional supplements including increased pelleted feed. Of course, if the animal's test profile suggests it has an active case of mycoplasma haemolamae, we treat with antibiotics per our veterinarian's recommendation. We will sometimes also look for evidence of the infection by using a microscope to examine a bit of blood stained with a rapid differential stain to see if we can see the mycoplasma on the slide. Sometimes we can, which is interesting.

We have found that retesting our animals during their recovery is also important. It can take an animal a long time to fully recover from moderate to severe anemia, during which time they remain vulnerable to other challenges — not that you would know it from looking at them, as frequently they quickly return to contentedly grazing with the herd like nothing is wrong. Older animals can be especially slow to bounce back. Retesting helps us keep our husbandry support for them at appropriate levels.

The Cost

You can purchase a simple brix refractometer online for less than $20 and read it by holding it up to the light (that is what we do) or you can buy a little more expensive one with a digital readout if you are feeling fancy. You won't need a separate hematocrit centrifuge if a capillary tube plate attachment is offered for the type of centrifuge you use to for your fecal analyses, but if this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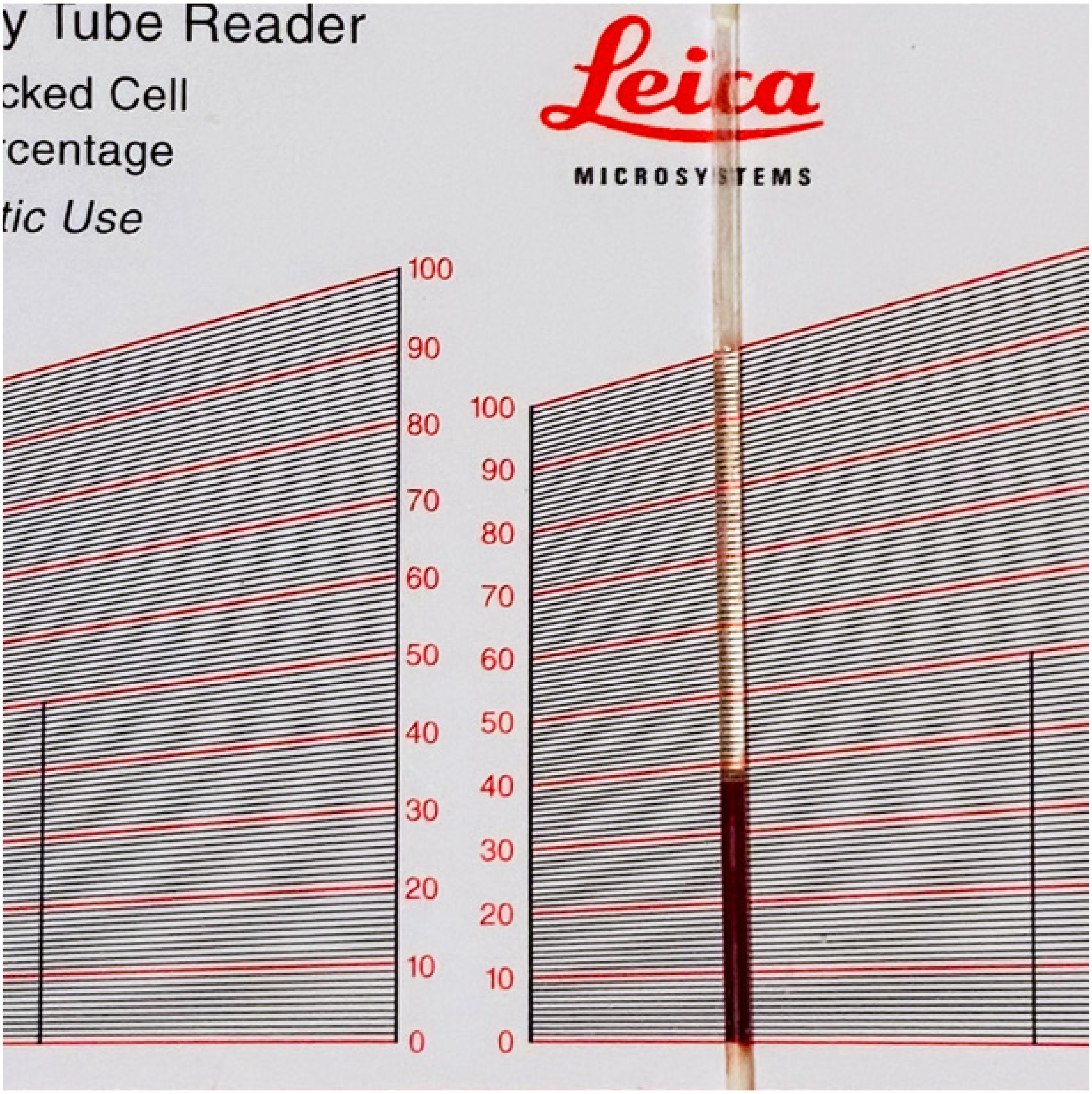
is not the case you will need to purchase one, and it will probably cost you between $100 and $500 depending on the type you choose. We acquired our first hematocrit centrifuge on Ebay — it looked like it belonged in a 50's sci-fi television show, cost $100 and worked really well for years. We have a newer, fancier one now that does the same job at a higher cost.

We pay $48 for a box of 1000 capillary tubes, but you can also buy a tube of 200 for under $12 from Amazon. Don't forget to order a little tray of capillary tube sealant and add a reusable capillary tube pipette if you want to use the plasma separated during your hematocrit run to do the refractometry analysis (which may save you a bigger blood draw). Finally, if you need blood tubes with an anticoagulant in them, this will add a bit to the cost of the analyses, but not much – we pay $27 per box of 100.

One you get your new equipment set up, do a few practice runs of both types of tests. We strongly recommend calibrating your results against the lab your veterinarian has used in the past, by sending part of each sample you draw in for laboratory analysis even as you do your own analysis on the remainders. You may tie out very closely (we did) or find there is a small systematic bias for which you can adjust your interpretation and comparison of results. If your results vary in an unpredictable way from those reported by the lab, you will want to review your process to find out why. It will likely be a quick fix because these are not difficult skills to learn.

Finally, remember it is important to speak with your veterinarian about how she or he recommends interpreting the results. Your vet may also find it useful if you provide current and/or historical PCVs and protein levels when they are making a farm visit to assess an ill animal or animals. You may quickly find yourself tempted to take another useful step as well: Namely, to keep blood collection and transfusion supplies at your farm, for emergencies involving your animals or others in the region. This too, can be inexpensive life-saving equipment to have on hand, especially if your vet does not maintain a regular inventory. ◇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Notes From Our Breeding Program

We finalized this issue of *The American Alpaca Journal* less than two weeks after we finished shearing 1487 animals during an eleven-day shearing marathon that, truth be told, we all dreaded for weeks beforehand. There is an office rule that the whining cannot start until the shearing does, but it is typically honored in the breach. By contrast, after shearing we are all on a bit of a high, and not just because it is over: We collect a treasure trove of valuable data during the process that we immediately put to work, using it to guide breeding decisions, improve husbandry practices and, importantly, inform our conversations with other breeders about our animals and genetics.

The most important locus of data collection at shearing is the grading table. If we had to pick between evaluating an animal's fleece while it was on the animal or on the grading table, we'd pick the table. Histograms, even the grid histograms we produce, are useful but not an adequate substitute for grading the shorn fleece. The key to making the fleece evaluation process yield as much useful information as possible is to develop a consistent, program-driven method of assessing each fleece and recording the results. By "program-driven" we mean focused on the specific goals of the breeding effort.

On page 41 we show our own evaluation sheet for grading our fleeces. Many of you have seen this before or heard us cite what we recorded when you evaluated one of our animals for purchase. You can see that the aspects of the fleece we assess are relatively few in number. Taken together, though, they tell us nearly everything we need to know. And because the spreadsheet in which this information is recorded also includes the animal's name, birthdate, color, sire and dam, we can sort our data to discover important patterns, like which sire's offspring have the brightest fleeces on average or (as we discussed in an earlier article in this journal) at what age do our animals' stretched staple lengths tend to fall under the length required for worsted processing?

As the sheet indicates, we assign a fineness grade to each fleece. This grade is based on what we think the right processing designation for a fleece is: The objective of grading is to create uniform lots of fiber for processing. So, for instance, a fleece with 14 micron secondaries but many strong primaries may be recorded as a grade 2 fleece rather than a grade 1 fleece, with the "Notes" section typically explaining this decision. We measure crimp frequency so we understand the style that the fleece carried.

We score luster, or brightness, on a relative scale from 1.0 to 2.0. This subjective ranking is one of the most important results of the grading exercise at Snowmass as it correlates with many of our breeding objectives. We also take a staple from the mid-side of the fleece and measure its stretched staple length against a ruler. Finally, we make a subjective overall assessment of uniformity, considering two particular aspects of the fleece: 1) consistently of micron and style across the entire reach of the blanket; and 2) variation of micron within the staple. This extremely important measure subsequently helps us differentiate between animals with above average, average and below average uniformity at the farm and we have found it to be superior to even the grid histograms that we produce as a guide for understanding the animals' fleece uniformity.

Fleece weights are very important to know and can only be measured when the fleece is off the animal. We record both total shearing weights and skirted blanket weights and use them in combination. Skirted weights can sometimes be misleading if we have to skirt extensively for vegetable contamination, so in those cases we will look more to total fleece weights to understand the production characteristics of the animal. When considered along with stretched staple lengths, they also provide a really good sense of density, more accurate than what we often feel we can achieve with on-the-animal assessments.

Finally, we record individual comments for most of our fleeces, explaining our grading decisions and/or noting other impressions. These notes are often very useful because they tend to summarize an impression. They are often the first thing we review when considering an animal for a client. You may look at this scorecard for grading fleeces and love it or see an even better way of collecting information for your own program. Either way, we strongly recommend this approach to assessment.

We identify the young males we will elevate to herdsire status each year during shearing. These males are typically those which will turn two years old during the coming breeding season, so most of the males we were evaluating were born in the summer or fall of 2020. We evaluated about 50 of these males between Snowmass and Accoyo America. This male age cohort had already been reduced by almost three-quarters by two rounds of culling animals for fiber farm use, and the roughly one quarter of the original group that remained were all somewhere between good and amazing. Of the approximately 50 we evaluated at shearing, 20 made the cut for use as sires, which represents just over 10% of the number of males of this age born on the farm in 2020.

These are our rising stars. Ours and yours, because this is also the group of males from which we will sell sires to other farms. We made the decision a few years ago not to sell any male for breeding that we would not also use ourselves. A less stringent rule would not help the American alpaca industry progress as quickly as we all would wish. We keep a weather eye on genetic diversity and make sure to make breeding decisions that allow us to continue to use males from the widest possible range of bloodlines, but all must exceed the same threshold of quality.

This year we have decided to offer for sale a group of these males in a broader and more formal way: Watch for our Rising Stars Review. We will distribute information about each male to allow for comparisons both within the group and among other males available from other breeding programs. This will hopefully increase transparency and context in a way that makes decision-making easier for breeders acquiring new genetics. Along with our color genotyping results, it may also prompt some breeders to think a bit differently about color. In the past, the inquiries we have received from breeders looking to purchase a male have typically specified a desired phenotypic color for that male. But with color genotyping results as well as an easier way to compare multiple males at the same time, breeders may find new ways of framing their search, for instance by the desire for certain fleece traits in combination with a specific ASIP allele or alleles, rather than for animals of a particular color.

We were particularly excited about one other finding at shearing, which was the dramatic increase in staple lengths that we have managed to produce in

Markings (S) Solid (SP) Spot (ID) Grey Where?	GRADE	CRIMP FREQUENCY # / INCH	LUSTER 1.0-2.0	STAPLE LENGTH	UNIFORMITY 1.0-3.0	S Blanket WEIGHT	TOTAL FLEECE WEIGHT	NOTES
	1	8	1.1	3.50	1.0	2.9	8.0	still looking excellent
	1	7	1.4	4.50	1.5	2.2	6.3	some strong primaries in blanket but not lots
	1	8	1.0	5.00	1.3	2.9	8.1	coarser at shoulder
	1	7	1.1	4.00	1.0	3.0		seems dense
	1	8	1.1	4.00	1.2	2.7	4.9	stunning look - amazing hand
	1	9	1.4	4.5	1.3	2.5	5.3	big fleece, even fleece throughout
	2	5	1.3	4.5	1.2	2.6	6.9	greasy, nice hand, Tender Tips - 2nds
2 FN	1	8	1.5	4	1	2.3	6	nice but for spots
	2	7	1.4	3.5	1.6	1.8	4.6	higher micron for age, open staple, needs to develop
	2	6	1.4	5.5	1.6	1.8	4.8	greasy, even character, strong primaries in blanket, cotted
	2	7	1.8	4.00	1.7	4.0	8.0	GR 2 for primaries - FIBER
pea / topline	1A	10	1.2	5	1.2	2.9	6	fawn spot, organized, fine, bright, yummy handle
	1	7	1.6	5.5	1.4	3.4	7.2	dryer handle, micron variation within staple, duller
	2	8	1.4	4	1.5	1.1	2.1	open in staple, micron variation throughout
1 FN	1	8	1.0	5.50	1.0	4.2	8.3	insanely good

the last couple of years. Animals with stretched staple lengths of five to six inches are now very common among our crias and yearlings, and shorn blanket weights have soared. Most of the yearling males we are elevating to herdsire status have stretched staple lengths of 5.5 inches or greater. We have some short-stapled males with excellent overall quality and important genetic diversity that we will also be using, and we can do this without sacrificing our goal of producing animals with the genotypes to produce worsted length processing their whole lives in part because we have increasing numbers of very long-stapled young females to which to breed them.

The eastern environment in which the Snowmass herd now lives is also playing a role in producing longer staple lengths and higher AFDs in Snowmass animals now versus when they lived in the very different environment of northern Idaho. As usual, this serves as a good reminder that husbandry plays a big role in the production of an animal's phenotype. Another reminder for us, visible at shearing each year, is the fact that many of our retired females are producing heavier, long-stapling fleeces in their sunset years than they were when they were younger and pregnant all the time. As we discussed earlier in the Journal, this is something to keep in mind with respect to maintaining the value of an animal's fleece production throughout the entirety of its life.

We hope you have a productive and enjoyable balance of the year and look forward to seeing you at educational events this summer and again at shows in the fall! ◇

Upcoming Snowmass Events

July 11:
Rising Stars Presentation

July 20:
Lynn's Scheduled Crisis
(Reason TBD. Don't be the reason)

August 3:
Reserved For Equipment Breakage

September 21-27:
Bred Maiden Virtual Pen Sale

Oct 8:
Susanne's Turn To Lose It
(which Lynn conveniently scheduled for a Saturday!)

Reach Us At
Lynn@lcfalpacas.com
Susanne@lcfalpacas.com

Snowmass Alpacas

Little Creek Farm
Accoyo America

www.snowmassalpacas.com
Lynn Edens
Susanne Bienenstock


1415

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Little Creek Farm
Accoyo America