CAN GUARD HAIR BE BRED OUT OF ALPACA SADDLE FLEECE?

(By Bob Kingwell, Monga Alpacas)

There are numerous articles explaining what guard hair is and why it is so undesirable, but very little seems to have been written on how to reduce guard hair in alpacas. Guard hair generally refers to primary fibres that are fully medullated, and in alpacas this seems to occur when fibres exceed about 40 microns in diameter. These fibres are generally longer and straighter than the rest of the fibres. The industry however regards fleece with more than 5% of fibres over 30 microns to be undesirable. The degree of medullation above this diameter is usually sufficient to make garments containing these fibres feel prickly and uncomfortable against the skin. The term "prickle factor", or "comfort factor" is used to express the percentage of fibres in a fleece sample that are less than or equal to 30 microns. Thus, when a sample has a comfort factor (CF) of 100%, no fibres have been measured over 30 microns in diameter. It is evident therefore that just eliminating guard hair is not sufficient. The industry goal should be the elimination of all saddle fibres that are over 30 microns. This article therefore assumes that 'guard hair' refers to these fibres.

So how can 'guard hair' be reduced? The obvious answer is 'by breeding alpacas that have saddle fleece with a CF of 100% for at least the first few fleeces' and with no more than 5% of fibres over 30 microns after that. To achieve this it is necessary to be able to measure the ongoing degree of success or otherwise of such a breeding program.

Before a stud male can be selected it is necessary to understand the fleece characteristics that determine the CF. An easy way to do this is to look at a fleece fibre diameter histogram. The histograms in Figures 1 and 2 are for two second fleece alpacas (usually 16 to 24 months old) and have been produced from mid side samples. The horizontal axis represents the range of fibre diameters and the vertical axis the percentage of fibres of each diameter. The histogram at Figure 1 is tall and narrow with a short base, whereas that at Figure 2 is shorter and broader with a longer

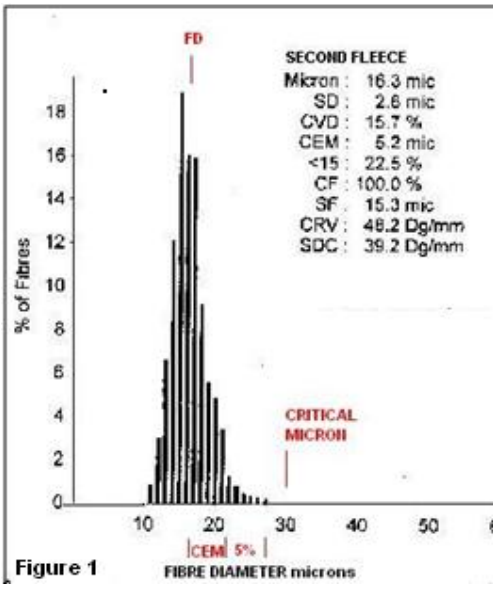

Figure 1

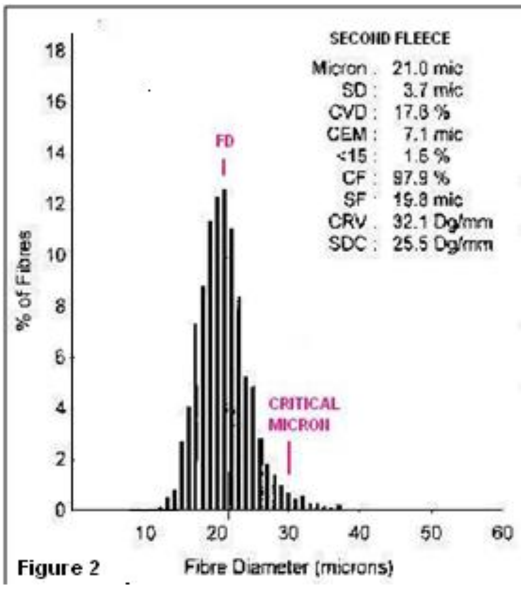

Figure 2

base. The position of the histogram along the horizontal axis is defined by the average fibre diameter (FD). The histogram is a visual representation of the variability of the fibre diameters in a fleece sample, and the standard deviation of fibre diameters (SD) which is a measure of this variability defines the shape of the histogram. The tail, which represents the coarsest fibres, is included in the coarse edge micron (CEM) measurement. Other measurable characteristics, that are not directly apparent from the histogram, are the average fibre diameter and standard deviation of fibre diameters of the secondary (sFD, sSD) and primary (pFD, pSD) fibres.

AVERAGE FIBRE DIAMETER (FD)

The FD defines the position of the histogram along the horizontal axis. It is clear from the fleece histograms at Figures 1 and 2 that a low FD will move the histogram further away from the critical 30 micron cut off point for a CF of 100% than will a high FD. Because the FD will generally increase as an alpaca ages, it is necessary for the second fleece FD to be as low as possible if the first few fleeces are to have no 'guard hair'.

The first fleece is not always a reliable indicator because it can sometimes have a higher FD than the second fleece. There are several reasons for this. Although the fibre follicles have fully developed by the time the cria is born, not all the follicles will have produced fibres. It can commonly take up to 4 months for the cria fleece to fully develop so that fibres in this fleece will have varying lengths. The primary fibres, which are the first to develop in the unborn cria, will usually be the longest and they create the halo effect seen on some fleeces. This halo occurs when these fibres are standing straight out from the skin and is therefore not visible when the fleece is floppy. The secondary fibres are the next to develop and will not usually be as long as the primaries by first shearing. The secondary derived fibres largely develop after the cria is born and will therefore be the shortest at shearing. These are the very fine, almost fluffy, fibres seen in a cria fleece. Because the primary fibres tend to be longer, straighter and stiffer than the other fibres, the tips are more easily broken when an alpaca rolls or rubs against objects. This can give the impression that some alpacas have a better fleece than they really do. It is also one of the reasons why the tip of the fleece on the micron profile graph does not usually start at the same diameter as the cut end of the previous year's sample. The FD is obtained from measured diameters taken at increments along each fibre in the sample. Therefore when the fibres are of varying lengths they will have disproportionate effects on the FD. First fleeces are also influenced by varying nutritional intakes. These include the quality of and length of access to mother's milk and access to supplementary feeding that is primarily intended for lactating pregnant females. Males are a better indication of the success of a breeding program because they are not as exposed to these nutritional factors. Young males are often weaned earlier than females and they are not returned to the breeding herd afterwards.

STANDARD DEVIATION OF FIBRE DIAMETERS (SD)

The SD defines the shape of the histogram. It is a measure of the absolute variability of fibre diameters of a sample and is independent of the FD. From the histograms at Figures 1 and 2 it can be seen that when the SD is low the histogram is tall and narrow and when it is high the histogram is short and wide. A histogram for a second fleece with a low SD will generally have a lower FD and a shorter tail than a histogram with a high SD. This means that the tail of the low SD histogram will be further away from the critical 30 micron cut off point than that of the high SD histogram which in Figure 2 extends beyond 30 microns. The graph at Figure 3 is a plot of FD against SD and shows that there is a good correlation (0.76) between the two. The data was obtained from a herd of 67 alpacas with ages ranging from first to sixteenth fleece. Some alpacas will maintain a relatively stable SD for most of their lives and therefore a relatively stable FD. If these alpacas can be identified at an early age then a breeding program using these alpacas will progress faster than the current rate.

The standard deviation for changes in fibre diameters along the length of fibres has always been available from the micron profile graph supplied with histogram results. This standard deviation is a measure of the variability in diameter due to environmental influences. It is now possible to obtain the standard deviation for changes in fibre diameters between the fibres in a sample. This standard deviation is a measure of the variability in diameter due to genetic influences and is therefore a more realistic measure of what an alpaca is capable of passing on to its progeny. This genetic standard deviation will always be less than the SD however the closer they are to being the same, the less environmental influences there will have been on the fleece and the lower will be the along fibre standard deviation. The genetic test is worth considering if the micron profile standard deviation is high.

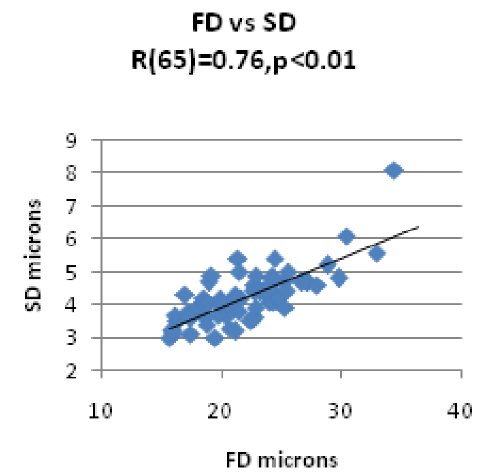

Figure 3

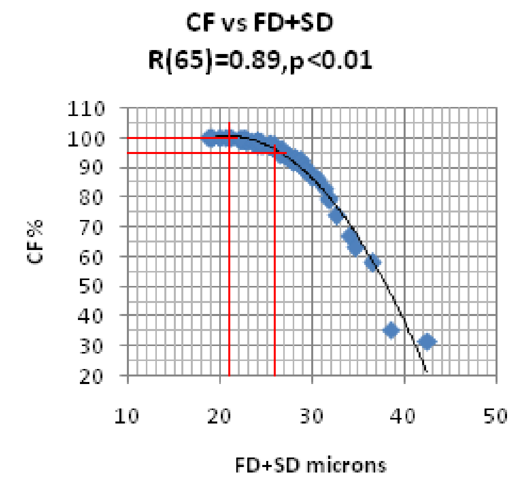

Figure 4

COMFORT FACTOR vs FIBRE DIAMETER + STANDARD DEVIATION

It has been shown that a low FD and SD are necessary if 'guard hair' is to be eliminated, but how low should these values be? Can one value be a bit higher and the other a bit lower and yet still achieve the same result? As it turns out it is the sum of the FD and SD that is important. There is a strong correlation (0.89) between the CF and FD+SD. This can be seen in the graph at Figure 4 which was compiled from the same herd of 67 alpacas mentioned above and whose CF's varied from 100% to 31.5%. It is evident from the graph that when FD+SD is less than 26 microns, the CF will be greater than 95% and when it is less than 21 microns, the CF will be 100%. The graph confirms the strength of FD+SD for selecting alpacas with little or no 'guard hair'.

COEFFICIENT OF VARIATION OF FIBRE DIAMETER (CV)

Although not mentioned above, this article would not be complete without a discussion of CV. The CV is obtained by dividing the standard deviation by the average fibre diameter and expressing the result as a percentage ((SD/FD)x100). It is an expression of the relative variability of a fibre sample to the FD and, as can be seen from the formula, is inversely related to the FD. The CV is therefore only useful when comparing alpacas with a similar FD. When two alpacas have the same CV but very different FD's then, although the CV's are the same, the variability or range of diameters for the lower FD will be smaller than that of the higher FD. Unlike the FD and SD which are independent variables, the CV is a dependent variable which will increase as the SD increases when the FD remains constant, but will decrease as the FD increases when the SD remains constant. This creates a problem if alpacas are being selected for stable SD's since, as the FD increases, the CV will become smaller. This gives the illusion that the breeding program is working when clearly it is not. Therefore, because of this inverse relationship with FD, breeding for low CV's will not necessarily reduce 'guard hair'.

COARSE EDGE MICRON (CEM)

The CEM is the number of microns separating FD on the histogram from the coarsest 5% of fibres in the sample and therefore defines the position of the histogram tail (see Figure 1). A low CEM, together with a low FD, results in fewer fibres being over 30 microns. When FD+CEM is equal to 30 microns then no more than 5% of fibres will be over 30 microns and the CF will be 95%. The CEM can therefore be used as another way of expressing the critical 95% CF (For the CF to be equal to or greater than 95%, FD+CEM needs to be less than or equal to 30 microns). There is also a very strong correlation (0.96) between SD and CEM as can be seen from the graph at Figure 5. This confirms that the SD defines the whole shape of the histogram including the tail. The slope of the line of best fit results in the CEM being equal to approximately twice the SD. Therefore if fleece test results do not include CEM, then SDx2 can be used as a reasonable estimate instead. Often when alpacas are being advertised the CF is not mentioned. However as long as FD+2SD is less than 30 microns then the CF will usually be at least 95%.

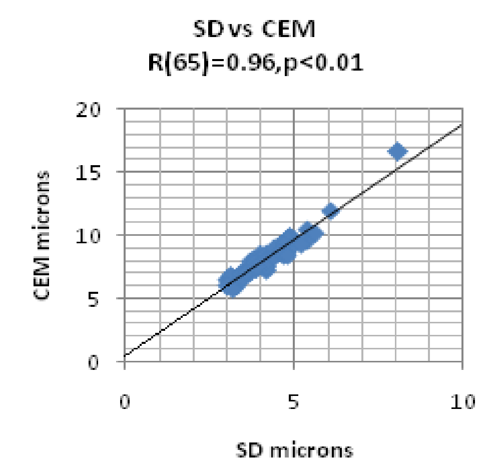

Figure 5

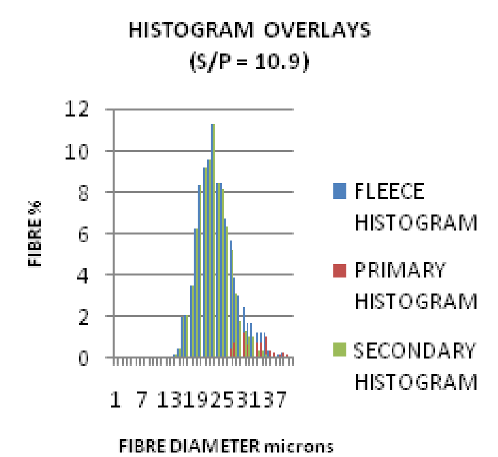

Figure 6

SECONDARY AND PRIMARY FD AND SD

The secondary and primary fibres together make up the fleece sample therefore the sum of their separate fibre diameters produce the fleece sample FD and SD. This is illustrated in the composite histogram at Figure 6 where the three separate histograms have been overlaid. The S/P ratio for this fleece sample is 10.9. This means that the primary histogram represents 8.4% of the fibres tested ((1/(10.9+1))x100). The histogram shows that although the primary fibres are largely responsible for the tail on a fleece histogram, some of the secondary fibres may also be involved. It is important therefore that both the primary and secondary fibre diameters and standard deviations be as low as possible. The aim should ultimately be to reduce the pFD to that of the sFD.

MARKERS FOR PREDICTING FUTURE INCREASES IN FD AND SD

It has been shown that if 'guard hair' is to be reduced to acceptable levels then it is necessary to breed alpacas whose FD+SD remains less than 26 microns, but how can this be predicted for a second fleece male? This can only be achieved by finding a stable marker for second year fleeces that is strongly correlated to FD, SD or preferably FD+SD and that is not age dependent. If the marker is correlated across a range of ages then it will not be stable since it will vary as the FD or SD varies with age. There are a number of possibilities including curvature, follicle density, S/P ratio, and FD+SD. There are others such as handle and lustre but, because they can only be measured subjectively, they have not been considered here.

CURVATURE (CRV): Curvature is a measure of crimp formation, and Cameron Holt in his article for Alpacas Australia, Issues 50 and 51, has indicated that there is a good correlation of -0.79 between CRV and FD. This result is based on measurements taken from 261 alpacas of varying ages. The correlation increased to -0.81 when he selected the best 97 alpacas for good crimp formation. He concluded that "micron is a strong influence on curvature". It is evident therefore that generally the higher the curvature, the lower will be the average fibre diameter. This however does not necessarily mean that CRV is a marker for stability. The graph at Figure 7 is a plot of the increase in FD+SD between 2nd and 5th fleece against 2nd fleece CRV. No significant correlation was found. Curvature is therefore not considered a useful marker for predicting stability of FD+SD.

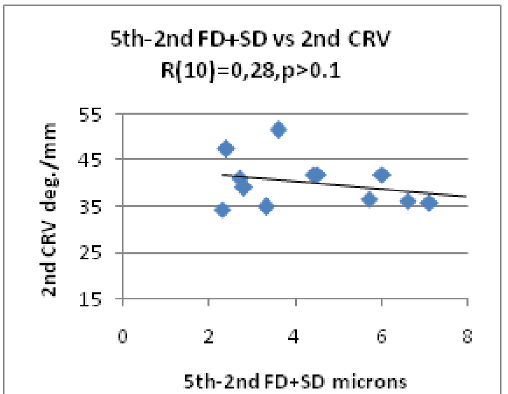

Figure 7

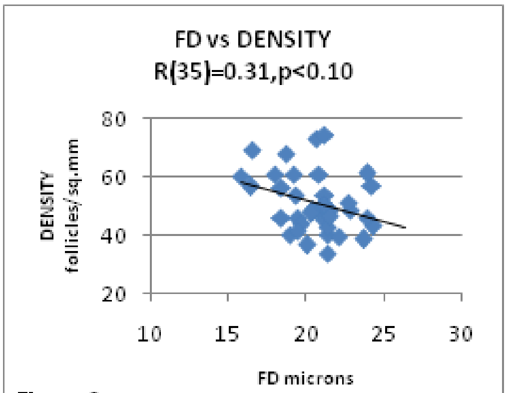

Figure 8

FOLLICLE DENSITY: An alpaca has the greatest follicle density when it is born and this density gradually decreases as the skin area increases until it is fully grown. If it is assumed that body volume is proportional to body weight and that a 12 month old alpaca maintains the same body proportions and body score as it grows then density is weight dependent rather than age dependent. It has therefore been considered as a possible marker. Although follicle density is not stable, it does decrease at a predictable rate which allows alpacas of different weights to be compared. As a rough guide the follicle density will decrease by about 6% for every 10% increase in body weight. The graph at Figure 8 is a plot of FD against follicle density and the data was obtained from published skin test results for 37 alpacas. Unfortunately body weights were not available and the data could therefore not be adjusted for the different body weights at the time of testing. It is also probable that not all the alpacas would have had the same body score. Despite this the graph indicates that there is only a weak negative correlation (-0.31) between FD and follicle density. This result suggests that density is not a useful marker and that breeding for density will not necessarily produce finer fleeces and therefore will not necessarily reduce ‘guard hair’.

SECONDARY TO PRIMARY FOLLICLE RATIO (S/P ratio): The secondary to primary follicle ratio is the ratio of the number of secondary (including derived secondary) to primary follicles in a sample and remains stable for the life of the alpaca. This ratio is not available from the usual fleece sample test. It is obtained by counting, under a microscope, the number of secondary follicles to each primary follicle within a number of follicle clusters on a skin sample and dividing by the number of clusters. Most primary fibres are coarser than most secondary fibres and the primary fibres are largely responsible for the tail on the histogram. It could therefore be assumed that as the S/P ratio increases then the FD would decrease. The graph at Figure 9 however produced no correlation between the S/P ratio and FD. This result suggests that breeding for a high S/P ratio will not necessarily reduce ‘guard hair’.

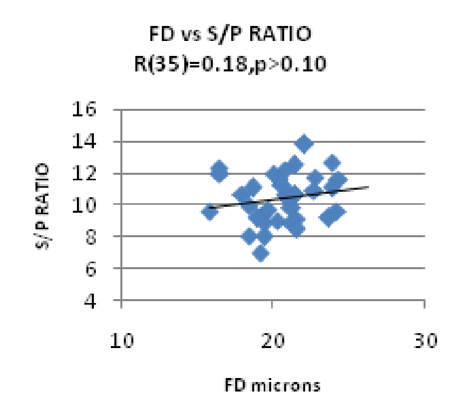

Figure 9

FIBRE DIAMETER + STANDARD DEVIATION (FD+SD): The strong correlation between FD + SD and CF suggests that it is worth looking at the changes in FD+SD over time. No correlation was found between 2nd fleece FD+SD and the increase from 2nd to 5th fleece FD+SD. If however a low value is more stable than a high value then FD+SD would be a useful marker. The graph at Figure 10 is a plot of 2nd fleece FD+SD against 5th fleece FD+SD for 13 alpacas from the herd of 67 alpacas referred to above. Although a strong correlation of 0.85 was found, the slope of the line of best fit indicates that FD+SD is not stable over time for this particular herd. Since the line has a slope of 1:1 it would need to pass through the 15 micron intersection for the values to be stable. From the graph it can be seen that the increase averaged about 4 microns over the 3 years. The graph however is still useful because it can be used to select the better alpacas and to measure the success of a breeding program. None of the alpacas achieved 5th fleece values of less than 21 microns however 4 were less than the critical 26 microns for a CF greater than 95%. The disadvantage of this over a marker is of course the need to wait another 3 years before the better alpacas can be identified. The graph however does suggest that lower FD+SD alpacas will generally be more stable. The alpacas falling below the line of best fit are more stable than those above the line and if the slope for next year’s graph intersects the vertical axis closer to 15 microns than this year’s 19 microns then, because the rate of increase will have reduced, the program will be working. This result indicates that ‘guard hair’ can be reduced by breeding for a low rate of change in FD+SD.

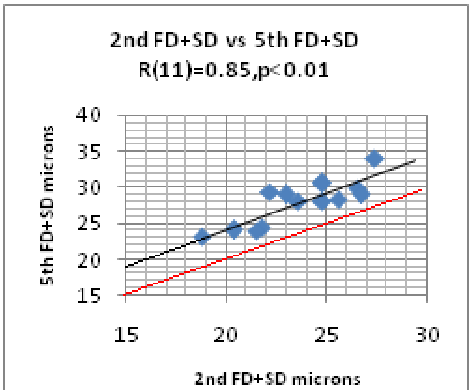

Figure 10

SUMMARY

There are many fleece characteristics that influence the comfort factor. However there are only two that are independent of the others. These are FD and SD. The others are useful because they help to explain why FD and SD are so important. The strong correlation between CEM and SD indicates that SD defines the tail of the histogram. The sFD, pFD, sSD and pSD are embedded within FD and SD, and together make up the FD and SD of the fleece histogram. The height and base which help to describe the shape of the histogram are defined by the SD and the position of the histogram along the horizontal axis is defined by the FD. The FD and SD together define the fleece histogram. The sum of FD and SD was found to be strongly correlated to CF and indicates that the value of FD+SD identifies the extent of 'guard hair' in a fleece sample. This strong correlation between FD+SD and CF is not surprising since the FD and SD define the position and shape of the histogram. Most breeders are breeding for low FD and an increasing number are also breeding for low SD, however it is the sum of the two that is important in reducing 'guard hair'. Several possible markers that might identify 2 year old alpacas likely to maintain a stable FD+SD as they age have been evaluated. These include curvature, follicle density, S/P ratio and FD+SD itself. Follicle density was the only one found to have a significant correlation. It was weakly correlated to FD, however this result may have been influenced by the lack of weight information required to adjust the follicle densities for varying body weights. Although no markers were found that would predict which 2 year old alpacas would maintain a stable FD+SD, a method was found that would help to select the more stable 5 year olds and to measure progress in a breeding program. The strong correlation between 2^{nd} and 5^{th} fleece FD+SD shows that progress can be made in reducing 'guard hair' by breeding for low FD+SD.

DISCUSSION

The lack of correlation between FD and S/P ratio was surprising, as was the weak correlation between FD and follicle density. In an effort to understand these unexpected results, the correlations between follicle density and S/P ratio and between follicle density and the number of follicle clusters per sq.mm were calculated. It has been assumed that a follicle cluster contains one primary follicle surrounded by a number of secondary follicles and that three clusters form a follicle group which therefore contains three primary follicles. The number of clusters can be determined by dividing the follicle density by the S/P ratio+1. No correlation was found between follicle density and the S/P ratio however a good correlation of 0.80 was found between follicle density and the number of follicle clusters ($R(35)=0.80, p<0.01$). This suggests that, since each cluster contains one primary follicle, fleece density is determined by the number of primary fibres. If greater density means more primaries then this reinforces the need to decrease their diameter and therefore the FD and SD. The results also suggest that, contrary to expectations, it is not the S/P ratio within a cluster that mirrors density but rather the extent of the empty spaces between the clusters. These empty spaces and therefore the number of clusters appear to have a far greater impact on density than the number of fibres within each cluster. If this is correct and the number of clusters can be increased while maintaining the same S/P ratio then obviously the density will also increase. Of course if the S/P ratio can also be increased then the fleece will be very dense indeed and it remains to be seen what might happen to the FD+SD.