IWG BULLETIN

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Understanding the Normal Distribution, Mean, Standard Deviation and Coefficient of Variation

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Introduction

An understanding of some basic principles of statistics is important for understanding and interpreting Objective Wool Measurements from individual sheep and for IWTO test certificates.

When comparing one sheep to another for mean fibre diameter (MFD (microns), standard deviation, co-efficient of variation, or for any other wool measurement, it is important that the sheep have run under the same environmental conditions since the last shearing (ie same paddock) and they are from the same age group.

The Normal Distribution

When interpreting data sets on any topic, be it rainfall, weaning weights in cattle, fleece weight or fibre diameter in sheep flocks, it is useful to understand not only the average or mean of this data, but to understand the range of the data, or the amount of variation that exists in the data set.

For many measurable animal traits such as fibre diameter in sheep, the frequency distributions among individuals are generally bell-shaped.

This means the number of individuals is greater at the intermediate values and gradually decreases toward the extremes. For example, if the mean fibre diameter (MFD) of a flock of sheep equals 19 microns. A large number of individuals in that flock will be close to that value (eg. 18 microns to 20 microns). There will only be a small number of animals that are distant from that value (eg. 14 microns, and 24 microns)

This is called the normal distribution and it is a mathematical curve that corresponds to bell-shaped distributions. See Figure 1 on page 2. The normal distribution has some interesting properties based on its mean and standard deviation, as shown in Figure 1. **68%** of individual values lie between the **Mean +/- 1 Standard Deviation**. And approximately **95%** of values lie between the **Mean +/- 2 Standard Deviations.**

For example, if the MFD of a flock of sheep equals 19 microns and the SD equals 1.4, then 68% of the sheep in the flock have a MFD that ranges from 17.6 microns to 20.4 microns.

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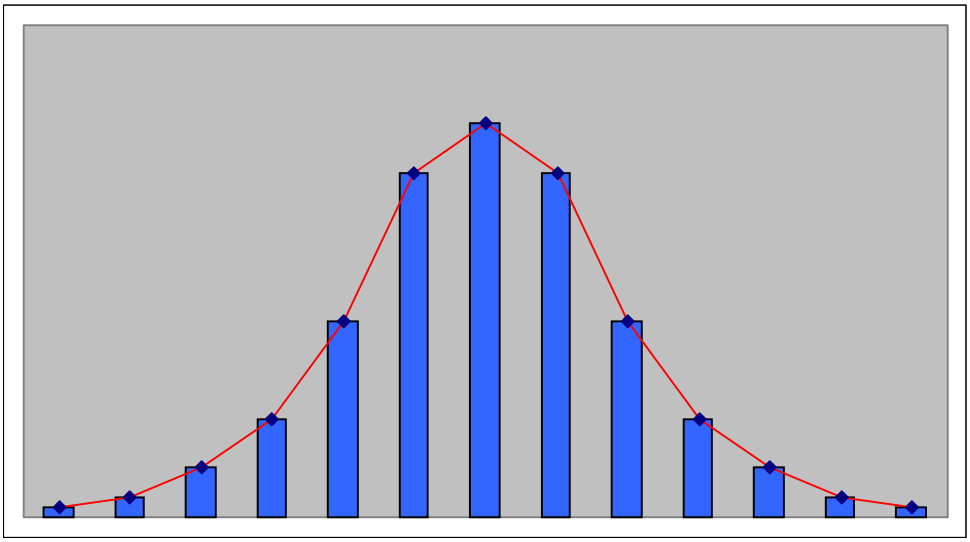
Figure 1. The Normal distribution



The MEAN is the arithmetic average, calculated by adding all of the individual measurements together, and dividing this sum by the number of measurements taken from the sample.

Mean Fibre Diameter

Mean Fibre Diameter (MFD) has the largest influence on the price of wool. It is also a trait that is highly heritable. This is why measurement of MFD has been introduced into sheep breeding programs as a selection tool for improving merino wool quality and production, and as a tool for improving clip preparation.

- To measure MFD on an individual animal, an appropriate sample of the fleece needs to be collected. A large number of fibres (usually a 1000 or more) from this sample are then measured by a wool testing instrument (eg. OFDA2000). The MFD for this animal is calculated by adding together the measurements taken on the individual fibres, and dividing by the number of measurements taken.
- To measure MFD of a flock of sheep, add together the MFD for the individuals in the flock, and divide by the number of sheep.
- To measure MFD of a lot of wool (eg.10 bales of wool), a standard number of core samples is taken from these bales. The core sample is further sub-sampled then individual fibres within the sub-samples are measured to calculate a mean that is relevant to the lot of wool.

The STANDARD DEVIATION (SD) is a measure of the spread of data either side of the mean. The formulae for calculating SD is quite complex, however, it is simple to calculate on a computer.

In Merinos, the lower the SD the more uniform the wool (it usually shows better style and character). There is evidence that lower SD values for a given MFD give better spinning results. This is usually expressed in terms of the Co-efficient of Variation of Diameter %. For example: A wool with an average diameter of 21 microns and a CVD of 20% as been found to produce yarns with properties similar to 20 micron wool with a CVD of 25%. This equation was developed by Martindale in 1949 and the result is referred to as “spin fine”.

There is also generally less fleece rot and a probability of higher staple strengths in wools with low SD.

IWG would like to acknowledge Julia Harris of Innovative Wool Services, Longreach for the compilation of this IWG Bulletin

It is possible to calculate an SD value for fibre diameter (microns) of an individual sheep, for a flock of sheep or for bales of wool. The standard deviation for fibre diameter for a flock of medium wool merinos is quite consistent at about 1.4.

The SD values for individual sheep tend to be higher than for flocks (range usually 2.5 – 6.2). This is because there is more fibre diameter variation in one staple in a single fleece, than fibre diameter variation across the fleece, or within a mob.

Since SD increases with MFD making comparisons between individuals or flocks with different MFD is difficult. Therefore, it is also important to understand the coefficient of variation of diameter (CVD%).

The CO–EFFICIENT OF VARIATION % (CVD) equals the SD multiplied by 100 and divided by the MFD (micron). CVD is also a measure of variation.

Within the normal range of Merino wools that are fleece tested, Co-efficient of Variation of Fibre Diameter (CVD) usually falls in the range of 15 - 30%. A fleece with a low CVD of 15% is very uniform, whereas a fleece with a high CVD of 30% is very uneven (usually of poor character and style). High CVD Merino wools tend to be more subject to fleece rot and therefore fly strike.

SD and CVD% for fibre diameter is affected by the environment. For sheep of the same bloodline and age the CVD% average will vary from year to year. Therefore, if you are using SD or CVD% as culling criteria in a breeding program, the cut off values may need to be varied from year to year.

In a breeding program CVD% can be a cost effective indirect selection criteria for staple strength.

Not all distributions for fibre diameter (microns) are symmetrical. Some maybe skewed to the left or the right of the mean. A skew to the left hand side of a histogram is generally referred to as a fine edge, whilst a skew to the right hand side of a histogram is generally referred to as a course edge.

The SD and CVD% of sale lots will be higher than for individual fleece results, because sale lots are combinations of many fleeces together (increasing the variation). The average CVD% of all Australian farm lots is very close to 21%, irrespective of the mean fibre diameter (microns).

CVD% can be an indicator of skin comfort of the wool. In general terms wools that are finer than 19 microns will not present a comfort problem unless CVD% is very high. Therefore, as fibre diameter decreases, SD and CVD% have less influence on the 'softness' or comfort of the wool. When breeding sheep to improve 'softness' or skin comfort, it is easier to lower fibre diameter than to reduce CVD%, as fibre diameter has a higher heritability.

Comfort factor (CF) is the % of fibres equal to or less than 30 microns.

Comfort factor is a measurement that has been developed on the assumption than it is the fibres 30 microns and greater that cause skin discomfort although it has been demonstrated that this varies between individuals.

Comfort factor is micron dependent, and can be taken into account if using SD or CVD% to cull for 'softness' or skin comfort. NB: when MFD is 17 or finer, CF is generally always 100%.

References:

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AWTA Ltd. Information Sheets – SD and CVD – measures of micron variability

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