What about Wool?

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Merino (fine wool)

Polypay (medium wool)

Lincoln (long wool)

Wool is a versatile, renewable resource that is environmentally friendly. Historically, wool revenue has contributed from 10 to 30% of the total gross income of U.S. sheep enterprises. In recent years, however, a combination of low wool prices, relatively high lamb prices, and the influx of hair sheep into U.S. flocks has caused a downward trend in the proportion of farm income generated by wool sales. As a result, sheep producers generally exert less selection pressure towards improving wool quality and quantity versus improving meat production (number, weight, and quality of lambs).

Exceptions, where wool production is more likely to contribute to economic sustainability, do exist. For example, wool continues to be important under more extensive production systems in arid regions of the Western U.S. Lamb production in these environments may be limited by heat, cold, and drought while wool production may be less affected. Typically, more feed resources are required for producing a good lamb crop than for producing a good wool clip. In addition, the majority of sheep in these areas are wooled. As a result, some attention to fleece quantity and quality is important. Other exceptions include specialty flocks that produce high quality fiber for hand spinning and weaving within the hobby fiber sector of the market. Superior quality wools of these types, carefully marketed, command high prices and, therefore, should be emphasized in selection programs.

The goal of this article is to provide some insight regarding genetic improvement of wool production and its relationship to lamb (meat) production.

Breed Classification

Sheep breeds should be chosen for specific management situations based on their adaptability and overall potential for meeting specific production goals. In terms of wool production, breeds represent either a limit or an opportunity for genetic change by selection. **Table 1** categorizes various breeds according to type of wool produced (fine, medium, and coarse or long) and describes the characteristics of the wool they produce. **Fine** wool breeds produce a more desirable, finer-grading fleece that has greater uniformity than fleeces from other wool types. Wool production is the primary objective and lamb production is secondary. Wool from these breeds is used for the best quality, lightweight, worsted, and woolen garments. **Medium** wool breeds are appropriate for flocks in which wool production is important but secondary in terms of income to that of lamb production. Wool from **coarse** or **long** wool breeds is used mainly for carpets, although the finest wools in this category may be used for tweeds or flannels and are desirable for hand spinning or weaving.

Economically Important Wool Traits

Sheep producers who rely on wool as an important source of revenue must have specific production objectives for it as a commodity. Identifying and selecting those traits that contribute toward high quality fleeces is the first step toward meeting wool production goals. As luck would have it, of all the economically important traits in sheep, those related to wool are some of the easiest to improve.

Progress through selective breeding is directly related to accuracy of identifying individuals that are superior or inferior for desired traits. For selection purposes, objective measures are preferable to subjective ones. Traits that directly influence the value of wool, and can be objectively measured, are **fiber diameter** (or **grade**), **staple length**, and **fleece weight**.

Fiber diameter (grade, fineness) is the most important price-determining measure of wool. Fine wool fleeces ordinarily bring higher prices per pound than do coarse wool fleeces. The grade, or fiber diameter, of wool primarily depends on the breed of sheep (**Table 1**). Visual evaluation of diameter is often practiced on ewe fleeces while objective measures (micron determination) are limited to ram fleeces. The finer the fiber (in other words, the smaller the fiber diameter), the better. Uniformity of fiber diameter is also important; fleeces with a high degree of variation in grade are undesirable and have a lower monetary value. To detect such variation, fleeces of ewes and rams can be examined before shearing.

Staple length refers to the length of wool obtained by measuring the natural staple without stretching out or disturbing the crimp (natural waviness) of the fibers. It also has an important effect on the monetary value of a fleece. Ordinarily, this trait is highly correlated with pounds of wool produced. Heavier fleeces typically have a longer staple length. Uniformity of staple length over the entire fleece also affects its value.

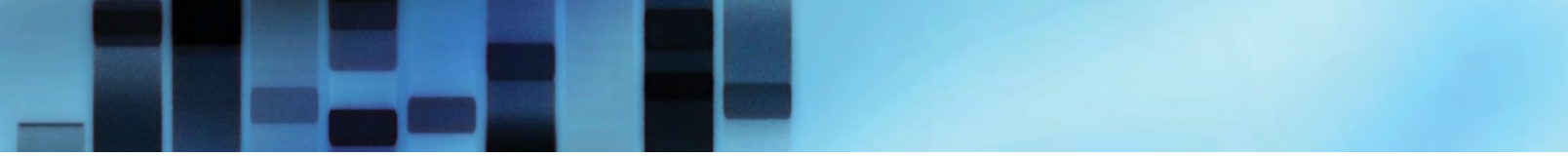

Table 1. Classification and Wool Characteristics of Various Breeds.

Wool Class	Wool Characteristics within Class		Breeds within Class	
Fine Wool	Blood grade: Spinning count: Grease fleece weight: Average fiber diameter: Staple length:	Fine 80 to 64 9 to 18 lb/ewe 26 to 17 microns 2.5 to 3 inches	Merino Cormo Debouillet Rambouillet Targhee	
Medium Wool	Blood grade: Spinning count: Grease fleece weight: Average fiber diameter: Staple length:	½ to ¼ Blood 62 to 50 4 to 14 lb/ewe 33 to 21 microns 2.5 to 5 inches	Cheviot Columbia Corriedale Dorset Finn Hampshire[a] Montadale	Polypay Shropshire Southdown Suffolk[a] Texel Tunis
Coarse or Long Wool	Blood grade: Spinning count: Grease fleece weight: Average fiber diameter: Staple length:	Low ¼ to Common 48 to 36 8 to 12 lb/ewe 41 to 31 microns 3 to 15 inches	Border Leicester Coopworth Cotswold Lincoln Romney	
Colored Wool			Black Welsh Mountain Icelandic Jacob Navajo-Churro Shetland	

[a]Frequently contaminated with black fibers.

Fleece weight, in particular **clean** fleece weight, combines effects of staple length and fiber diameter. Within a particular wool grade, clean fleece weight is the best quantitative measure of fleece value. However, scouring individual fleece samples is expensive and its cost cannot be justified, especially for ewes.

Grease fleece weight, the actual weight of the fleece when shorn, is the most practical quantitative measure of wool production. Within breeds, there is a high, positive correlation, or association, between grease and clean fleece weight. Thus, simple and inexpensive measurement of grease fleece weight, and selection for it, can be expected to increase clean fleece weight.

Objective measures of fiber diameter, staple length, and fleece weight of all ewes in the flock may not be cost effective. However, cost of evaluating potential sires can be justified, particularly in purebred flocks of wool breeds. Both purebred and commercial producers should insist on objective evaluation of grade and either clean or grease fleece weights when selecting rams.

Many producers combine subjective with objective measures in their selection programs. For example, the average fiber diameter of ewe fleeces can be estimated visually and their fleeces weighed individually at shearing. Although grease fleece weight is not as good a measure of wool production as clean weight, it is objective, low cost, and rapid. At the same time, rams can be evaluated objectively for these traits.

Other fleece traits include fiber density, color, softness of handle, and freedom from defects. Fiber density, the closeness or compactness of the fibers in a fleece is important, but a practical objective measure has not been developed. Experienced producers may be able to assess fiber density subjectively through a "touch method."

Colored or white fleeces contaminated with brown or black fibers are less valuable to large textile manufacturers than are pure, creamy white fleeces. Thus, color is generally considered a wool defect and sheep with a lot of black fiber, hair, or kemp should be culled. However, in specialty flocks that produce high quality fiber for hand spinning and weaving, the top priority may be producing wools of many shades of black, brown, and gray.

Genetic Parameters

Selection programs require estimates of **heritabilities** and **genetic correlations**.

Heritability refers to the proportion of differences among animals for performance traits that are due to differences in the additive effects of the genes they possess. In other words, heritability measures the likelihood of those differences being transmitted from parents to offspring. The higher the heritability for a trait, the faster the genetic change through selection. Wool traits are moderately to highly heritable (**Table 2**). This means producers can

Table 2. Heritabilities of Fleece Traits.

Trait	Percent
Grease fleece weight	35
Clean fleece weight	25
Yield, %	40
Staple length	55
Fiber diameter	40
Crimp	45
Color	45

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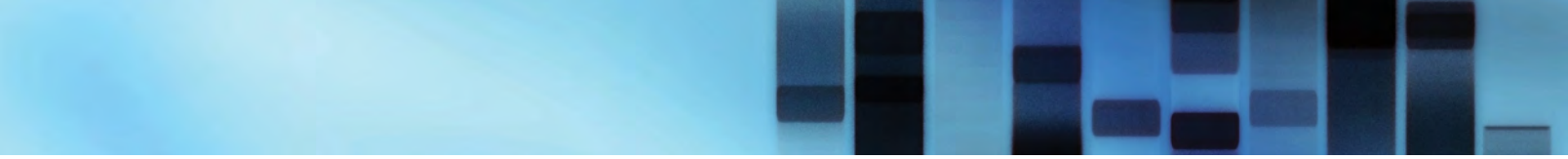


make rapid improvement in wool quality and pounds of production using selection programs.

Genetic correlations indicate the relative change in one trait associated with selection for another trait. As shown in **Table 3**, genetic correlations of wool traits with each other are generally positive. A positive correlation means that some of the same genes affect both traits and that a genetic increase in one trait results in a predictable genetic increase in the other trait. Positive correlations are not necessarily favorable. On the average, a heavier fleece weight is associated with a larger fiber diameter. The two traits increase together, but only the increase in fleece weight is favorable. An increase in fiber diameter is unfavorable. Thus, genetic correlations should be considered when selection programs are developed.

Other important production traits, such as reproductive efficiency, lamb growth rate, and desirable carcass characteristics, are negatively correlated with most wool traits. Fortunately, most of these correlations are relatively small. Thus, improvement in wool production is not likely to be associated with large undesirable effects on other production traits.

Table 3. Correlated Response in One Fleece Trait Associated with Direct Selection for Another.

Direct Selection for:		Correlated Response Expected In:
↑ Clean fleece weight	→	↑ Staple length ↑ Fiber diameter ↓ Fiber density
↑ Staple length	→	↑ Fiber diameter ↓ Fiber density ↑ Clean fleece weight
↑ Fiber diameter	→	↓ Fiber density ↑ Clean fleece weight ↑ Staple length
↑ Fiber density	→	↓ Clean fleece weight ↓ Staple length ↓ Fiber diameter

Age at Selection

The best time to evaluate a fleece is when sheep are yearlings with a full 12-month fleece. At this time, maternal influences and effects of age tend to be reduced. In addition, wool traits are highly repeatable; therefore, measurements made at a year of age can be good indicators of future wool production.

At weaning: Initial evaluation of ewe lambs for replacement. Ignore wool traits except to remove sheep with defects, such as colored spots, extremely hairy britch, or belly wool that extends up the sides of the animal.

Yearling: Primary evaluation of replacement ewes and rams. If animals were not shorn as lambs, differences in age (fleece growth period) and type of birth or other preweaning variables may still be evident. Fleece weight, staple length, and fiber diameter should be considered. Most genetic progress is obtained through ram selection.

Mature animals: At maturity, culling should be based largely on age and soundness. Most selection should have occurred on yearlings. Evaluating aged ewe fleeces is difficult because of differences in physiological states of the animals. For example, barren ewes will have better fleeces than ewes that have raised one or more lambs. Culling of mature rams should largely depend on progeny performance.

Inheritance of Color

With the exception of specialty flocks that produce fiber for hand spinning and weaving, colored wool is considered to be undesirable and culling is recommended for sheep with pigmented fleeces. The inheritance of color is generally assumed to be qualitative in nature; that is, influenced by only one or a few pairs of genes. Most instances of black color in sheep fall into this category and are due to a single gene which allows pigmentation. This gene is recessive to the dominant gene for white wool. However, there is apparently more than one type of black color and more than one gene involved. Inheritance of brown and multicolored fleeces is more complicated and many pairs of genes may be involved.

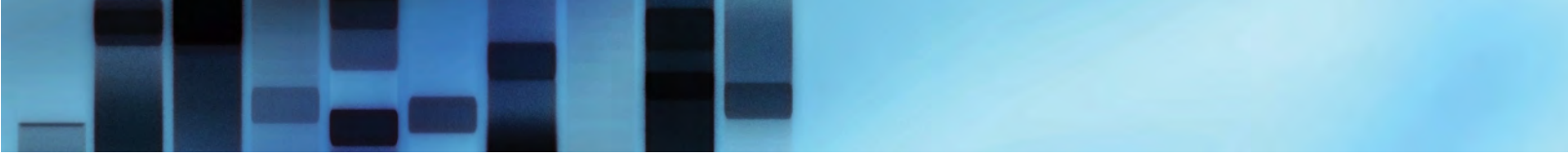
Selection Programs

Realistic plans for changing wool production traits by selection are not reached in many flocks. Problems may involve relationships among traits, age when selections are made, and animal identification. However, in most situations, lack of a well-designed selection program is the primary reason. Too often there is no plan or plans are changed so frequently they lose direction.

Selection programs can be based on **individual records**, **progeny performance,** or preferably, **Estimated Breeding Values** (EBVs).

When individual records are used, animals are selected solely on their own performance record or phenotype for the trait (for example, grease fleece weight). This type of selection can be used effectively for wool traits because they are moderately to highly heritable.

Selection based on progeny performance is typically limited to rams. Keep in mind that performance records will not be available on progeny until they are measured at approximately one year of age. As a result, genetic progress may be slowed because of the increased generation interval.



A more accurate method of selection, even for highly heritable traits, involves use of EBVs. The National Sheep Improvement Program (NSIP) generates EBVs for three economically important wool traits **(Table 4)** in western range breeds and maternal wool breeds, like the Polypay. EBVs are science-based, industry-tested data values that can be tracked and measured. They are proven to increase on-farm productivity and enhance selection decisions.

Table 4. Estimated Breeding Values (EBVs) Produced by NSIP for Various Fleece Traits.

EBV	Description
Fleece weight (%)	Based on grease fleece weight and estimates animal's genetic potential for wool production. Fleece weights are recorded in kg but are reported as percentages of the overall mean fleece weight.
Staple length (mm)	Estimates genetic potential for length of wool fiber. Positive selection emphasis is recommended in flocks that receive premiums for long-staple fleeces.
Fiber diameter (microns)	Estimates genetic merit for fleece quality. Animals with finer, more desirable fleeces have negative fiber diameter EBV, so negative EBVs are favored for this trait.

EBVs begin with on-farm production data but then convert it to actionable genetic information. Performance data (such as fiber diameters, staple lengths, and fleece weights) are adjusted for variables that are not related to genetics, such as age at measurement, sex of the individual, age of dam, and flock management. In addition, EBVs are calculated using performance of the individual animal, related animals in the same flock, and related animals in other flocks. Genetic correlations among traits are also considered in the calculations.

Conclusion

Wool traits are relatively easy to change through selection while lamb production (reproduction and growth) and carcass traits are more difficult and slower to improve. When selecting for improvement in wool, the major goal should be to increase fleece weight within grade. Fortunately, gains in wool quality and quantity are unlikely to be associated with major undesirable effects on other economically important production characteristics.

Finally, decisions concerning the relative selection emphasis on wool versus lamb (meat) are often difficult in wooled flocks. The balance between fiber and meat production should be determined by the relative efficiency or cost of production and price received for the two commodities. However, it seems reasonable that if sheep have to be shorn, neglecting wool entirely may be poor business management.