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"Profit Improving Genetics": Indexes for sheep genetic improvement
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Most sheep producers have a central breeding goal that focuses on profitability. This translates into improving the flock's genetic potential for growth, wool, and maternal traits through selection while simultaneously keeping an eye on structural characteristics that are important for breeding animals, such as a good mouth and sound feet and legs. The most useful tool for identifying an individual's genetic merit for performance is the expected progeny difference (EPD) values that are available from across-flock national genetic evaluations such as those offered through the National Sheep Improvement Program (NSIP). Expected progeny differences are calculated using animal performance records with pedigree relationships to predict the future offspring's relative performance in the flock. The traits which EPD values are calculated for tend to be those that most producers associate with profitable lamb performance. However, sheep selection is different from other livestock species, both in the type of biological traits being selected for (including type of birth, lamb growth rate, and wool) and in the relationships that each trait has with profitability. As multiple traits are incorporated into a genetic evaluation, it becomes more difficult for breeders to determine the importance of individual EPD values reported for an animal.

Profit indexes are a means of multi-trait selection that rank individuals on their economic merit as a breeding animal, and includes all traits of economic importance based on the breeding goals of the operation. Indexes provide the proper weighting for EPD's to ensure the optimal amount of genetic improvement for each trait within a breed, to continually improving the profitability of commercial animals. Profit indexes use EPD values that weight the economic importance of each trait. A broad economic analysis of each trait is used to determine the change in profit for the production system associated with a one-unit change in performance of the trait, independent of all other traits. In other words, increasing one-pound of lamb weaned through selection increases income generated from market lambs, as well as increasing feed intake costs for those lambs. So the economic importance of the weaning weight trait is based on the changes in profit (income minus expense) associated with a one-pound change in weaning weight. A profit analysis such as this is applied to each trait to determine the economic advantage of changing performance levels.

Development of these profit indexes is not an easy task. In addition to economic inputs, consideration must be given to the non-genetic relationships between traits. For example, lambs that are born as twins tend to be smaller at birth, and also tend to gain body weight at a slower rate compared to lambs born a singles. Although the genetics for growth may be similar within a group of lambs, those born as twins are just smaller due to the non-genetic influences of birth size that are associated with multiple number born. Non-genetic relationships, such as those between type of birth and lamb growth, do impact profitability. Developing a good selection index needs to account for the economic contributions of genetic improvement as they influence non-genetic aspects of the production system.

The use of index values for selection is becoming more appealing to the livestock industry due to the overwhelming number of EPD values calculated for an individual animal. Many beef breeds have adopted the use of index values into their current sire summary evaluations; including Angus, Hereford, Simmental, Charolais, Limousin and Gelbvieh to name a few. These index values are used to compare the overall genetic potential of a bull's future progeny, as if offspring were exposed to the same commercial environmental conditions. For example, the "Beef Value" ($B) index in the Angus breed provides an economical comparison between different bulls based on their overall genetic merit for profit over all traits associated with post-weaning growth and carcass characteristics. If two bulls are put out in your breeding pasture, one high indexing and the other low indexing, we would expect the average profit from the resulting calf crop to be higher for those calves sired by the high indexing bull, based on there expression of post-weaning growth and carcass performance. This index is only one example, but each breed's indexes are developed to simultaneously improve all economically important traits associated with cattle profitability. Given the wide array of economically important traits in the sheep industry, profit index selection provides an opportunity to use multi-trait selection tools to objectively achieve genetic improvement of all traits associated with an economic breeding goal for commercial sheep producers, putting all measures of genetic value into one, easy to interpret index value.

Performance data from Tarhgee flocks participating in the NSIP genetic evaluation was used to develop a flock simulation model for researching unique economic relationships between EPD values and diverse flock production systems. This model generated profit indexes for the breed. Targhee breeders that are members of the NSIP have EPD's calculated for seven different economically important traits including; 120-day weaning weight, yearling weight, maternal milk (pounds of lamb growth associated with the ewe's milk), percent lamb crop (number of lambs born per 100 matings), fleece weight, fiber diameter, and staple length. The economic emphasis each trait receives in a profit index is determined by the current level of performance, management practices influencing performance and marketing systems that are practiced by commercial breeders. To appropriately reflect the diverse production systems of commercial breeders, a wide range of economic assumptions and management practices were considered in developing the indexes. Many years of data were used to establish multiple levels of management intensity, feed availability and costs, as well as different lamb marketing options were considered in the simulated model to appropriately reflect the typical diversity of Targhee flocks. For example, some flocks have a higher plane of nutrition, a higher lamb drop and/or survival, or have more forage available at different times of the year. In all livestock species, genetic improvement is limited by management practices that may not be appropriate for expressing superior performance; therefore all of these factors play a part in determining the profit associated with ram selection. In many instances the most profitable situation may be one (management and/or nutritional program) that does not express maximum genetic performance.

With enough grain, anything can look good; the key is to identify the genetics that perform well under your management regime.

Income was assumed to be generated by the selling of market lambs, culling of adult ewes, and wool produced by a flock. Variable expenses were considered for additional feed intake requirements associated with the level of performance for each economically important trait. Ten year averages were assumed for all market values to account for the year-to-year variability in markets. The value of improving each trait was determined by comparing the change in profit associated with selecting the top 5% of rams within the breed for each trait. This change in performance was equivalent to changing the average of each trait, one genetic unit (standard deviation) from the current average. The change in performance represented a realistic change that can be achieved through one generation of intense selection. Index values were then scaled to each trait's unit of measure (i.e. $/lb).

Two profit indexes were developed for the Targhee breed to best select sheep for different commercial operations. A "Western Range Index", which measures genetic merit based on a typical western range management system where the flock is maintained on year round rangeland, and market lambs are sold shortly after weaning. The second is a "Farm Flock Index" which measures genetic merit of sheep based on a slightly more intensive management system where forage and supplemental feed resources can be purchased, and pre-weaning lamb growth is realized in market lambs where a weight discount is not imposed. These indexes were designed to incorporate an animal's EPD values into a formula that estimates economic merit. An animal's actual measure of performance should not be used in indexes that were developed for EPD values because the EPD values have already been adjusted for the animal's actual performance.

Differences between the two indexes relate primarily to the marketing opportunities ranchers have for their market lambs and the source or value placed on the additional forage needed for more productive sheep. For example, market lamb value is based on $/cwt, however, heavy market lambs tend to gain less weight during the feedlot stage and therefore in a western range environment, where lambs are sold shortly after weaning, heavy lambs receive a discount (or slide) per cwt compared to lighter lambs that have more growth potential in the feedlot phase. The Western Range index was developed for sheep breeders who sell market lambs to this type of market, while the Farm Flock index assumes a lamb market that does not discount for heavy lamb weights. Forage value is less straight forward because it truly depends on the value or cost associated with an individual's rangeland. Differences in land value, debt load, or ownership all influence the breakeven price associated with land. To represent Targhee production it was assumed that no rangeland could be purchased, so the cost of additional forage assumed the renting rate of western rangeland, or the cost of reducing breeding ewe numbers to maintain a consistent level of range usage, and for flocks that rely less on available rangeland, the commodity value of purchasing hay was used as the cost of additional forage.

Basically the difference between the two indexes is that the Western index takes into account that as weaning weight of lambs are over about 80 lbs. those additional lbs. are worth less (priced at a discount or a slide). As a result growth rate in this profitability index is of slightly less value. As a producer this means if weaning weight of your lambs are normally a price factor (i.e. high portion of lambs above the pricing cut off weight) the Western index is appropriate. But if your lamb weights are lighter, or you're not subject to a pricing slide, the Farm flock index is more appropriate because of the stronger emphasis on lamb growth rate.

Both indexes express the economic merit of a breeding ram in dollars per ewe bred and include the average expected lifetime performance of progeny for all growth, wool and maternal traits, as compared to progeny of other rams. For example, if a ram with an index value of +$5.00 is mated to 40 ewes per breeding season, the resulting lamb crop from this mating would be expected to generate an additional $200.00 ($5.00 x 40 ewes) to the operation over their lifetime compared to a ram's offspring with an index value of $0.00 (offspring included market lambs and ewes retained for breeding). If the ram is used in four breeding seasons and is mated to the same number of ewes each year, the genetic contribution to profit of his offspring is expected to be $800.00 ($200.00 x 4 years) above the other ram.

The Tarhgee profit indexes are proportionately more influenced by changes in EPD values associated with lamb growth and number of lambs born compared to wool trait EPD's. Selection on wool weight, fiber diameter, and staple length are important. However, staple length was not included in the index calculation (0 coefficient for several factors). Currently the available wool data from participating NSIP flocks indicates that the average staple length for Targhee sheep is sufficient to avoid price discounts for short stapled fleece. The economic advantage of improving staple length shows up in fleece weight selection (genetic selection of fleece weight indirectly selects for staple length). There are two major problems with direct selection pressure on staple length through the index: one is that there is no premium available for longer stapled fleece, and the second is a lack of variation within the breed EPD's. More variation within an EPD means that EPD values have a large range (high and low values). With less variation, the EPD values within the breed are not much different from zero. To better understand what's happening, one must understand how EPD calculations are estimated. Without any information we assume an animal starts with a zero EPD. Then, as information becomes available (its own performance, performance of its relatives in its flock or other producers flock), its EPD is adjusted up or down. With limited information (e.g. newly measured trait or a new animal with no known relatives), or when the relative accuracy of measured performance may be marginal (e.g. with visually appraised fiber diameter or not accurately evaluating performance), those adjustments will be small. Staple length data falls into the "newly measured trait" category because only in the last several years have we continued to measure the trait; and thus the master data base contains limited amounts of current data. Changes in wool performance through selection are more limited than change in growth because of the same reasons mentioned earlier, more variation in growth trait EPD values than wool trait EPD's. For example, two-thirds of Targhee rams have fleece weight EPD values that range plus or minus 0.2 lb from the breed average; where as the range of EPD values for 120-day weaning weight that includes two-thirds of rams is plus or minus 1.1 lb from the breed average. Although the economic emphasis of a one-pound change in performance of the two traits may be similar, the traits that are less variable achieve less change per pound through one generation of selection and therefore the profit index itself is less influenced by those traits. It takes more generations of selection to increase wool production than it does to increase lamb production by one-pound through genetics.

Percent lamb crop is the most economically important trait in the profit index. This selection emphasis is consistent with other livestock selection indexes which place a high economic value on reproductive traits and increasing healthy offspring numbers. If offspring are not successfully produced in the operation, fewer animals are marketed and/or less breeding stock are retained as replacements. The Targhee economic analysis strongly supported an increase in pounds of lamb weaned through selection on number born with large changes in profit driven by increased number of lambs weaned. One concerning issue regarding selection of reproductive performance in sheep is the increase in twinning and/or triplet lambings. Twin born lambs are more manageable than triplets in today's lambing system. But let's not forget, not long ago one single lamb was preferred over twins because of the added difficulties in the lambing barn. True, triplets are a pain in the lambing barn but realistically a higher twinning rate is profitable and the real problem with selection for litter size might be having a limited number of single lambing ewes to graft lambs onto.

It is safe to conclude that given today's management practices, triplets are undesirable and these indexes take this into consideration. Triplet lambs typically are smaller at birth, have a higher mortality rate than single and twin born lambs and tend to gain body weight at a slower rate. However, breeders may have a false sense of apprehension regarding the emphasis that the number of lambs born trait receives in the index due to increases in triplet born lambs. Data indicate that in the current Targhee breed, selection on percent lamb crop EPD results in more single litters being replaced by twins and few twin litters being replaced by triplets. For example, in a flock averaging a lamb drop of 1.7 lambs per ewe lambing, there is a 5:1 ratio between the increase of twin and triplet litters as genetic potential for number of lambs born increases. So through genetic change of number born, for every 5 additional twin lambings (5 ewes that typically had singles now having twins) there is 1 additional triplet lambing in the flock (1 ewe that would typically have twins now having triplets). Because of this disproportional type of birth increase, income generated from improving the number of lambs weaned is not trivial, and for now little change in lambing practices are needed to accommodate a larger lamb crop.

In the simulated model, a large range in lambing rates (1.40 through 1.75 lambs per ewe lambing) and lamb mortalities were assumed to reflect both seedstock and commercial flocks that manage their lambing seasons differently. The profitability of increasing number of lambs born did not vary greatly from high to low lambing rates nor did it from different lamb mortality levels. This indicates that profit is continually being improved as the number of lambs born increases even when the model includes the assumption that half of all triplet born lambs die (50% death loss, ewes giving birth to triplet lambs only wean, on average, 1.5 lambs). Even for breeders that may not have the same lambing resources as a seedstock breeder and suffer high triplet lamb death loss, the benefit of improved ewe prolificacy will undoubtedly be observed as total pounds of lamb weaned increases.

The most economically significant growth traits in both profit indexes are 120-day weight and yearling weights. These two traits are highly related. Pre-weaning growth directly contributes to the 120-day weight, however, yearling weight can be thought of as a combination of 120-day weight plus post-weaning gain (weight gained 245 days post-weaning). Therefore selection for 120-day weight influences yearling weight. With weaning weight EPD's accounted for in an index, selection for the yearling weight trait is equivalent to selection for post-weaning gain. If a premium were available for improved post-weaning gain in the feedlot, positive selection for yearling weight would be more desirable. However, most lamb markets do not provide such premiums thus genetic selection for post-weaning gain adds little to the value of market lambs. In addition, increases in yearling weight are associated with larger mature ewe body size. These types of ewes tend to have higher maintenance energy requirements, meaning more feed intake is needed to maintain adequate body condition for production. This does have a detrimental effect on profit, although heaver cull ewes are more valuable, the added expense of feeding larger ewes is more costly either through the purchase of more feed or maintaining fewer ewes on a fixed range resource. Because of this economic relationship rams with high 120-day weight EPD's and low yearling weight EPD's are genetically more valuable (having high growth potential without increasing body size) but rams that meet this criteria are hard to find due to the genetic relationship between the two traits. Producers often relate the relative weight placed in the index equation for a trait with the relative importance of that trait. This should be avoided; a small negative weighting of a trait, like yearling weight, could still result in a positive change in performance when selection is applied to a highly related trait, like weaning weight. One advantage of multi-trait index selection is that rams are economically selected simultaneously for both traits in the directions that best fit the breeding goal. Ideally, we want to select for sheep with great genetic potential for lamb growth and efficient feed utilization and index values help filter these type of animals into the breeding group.

Milk production by the ewe is needed to supply newly born lambs with antibodies that support a good immune system and nutrients to encourage fast healthy growth early in life. Once a lamb develops a functional ruminate and can efficiently digest available forage, weight gain from additional milk consumed from the ewe is much less efficient both economically and nutritionally, as compared to body weight gained from forage dry matter intake. According to extensive dietary research on sheep growth and production, nearly 2.5 times more caloric intake is required by the ewe to produce enough milk for her lamb to gain one pound of body weight when compared to the lamb's caloric intake required to gaining a pound through consumption of dry matter forage. When considering the cost of hay supplementation or summer forage there is a detrimental economic effect to increasing the milking potential of the ewe flock, provided the current level of production is sufficient to promote early lamb health. It takes about two and a half times as much feed to produce one-pound of lamb gain through milk than through the lamb's intake of forage. Many economic evaluations of cattle production systems have found a similar relationship where selection to increase the cow's milk has a very small effect on profit because of the high caloric intake needs of a lactating cow. In fact, in many beef cattle profit indexes the milk EPD is selected against. Compared to beef cattle, the poor economical effect of increasing milk production in the ewe flock is tempered by being slightly more efficient at partitioning caloric energy into milk because of a smaller body size, having a longer time interval between lambing and breeding, and commonly nurse more than one lamb at a time spreading the additional lamb growth and feed requirements over more offspring. These differences between beef cows and ewes provide the basis for the small economic advantage of improving milk production through genetic selection in the sheep selection indexes. Although more milk does improve the total pounds of lamb weaned, the efficiency of lamb growth is more profitable through selection on 120-day weight. Lets not downplay the economic importance of milk as it contributes to maintaining lamb health and vigor; however as a trait to improve lamb growth rates it plays a much smaller role.

Genetic improvement of livestock is not one dimensional. Many interactions exist among the traits we consider to be economically important so determining the best way to improve these traits can be difficult. The use of profit indexes combines the tools of large scale genetic evaluations (i.e. EPD's) with economic reasoning to establish a straightforward, objective means of improving the profit potential of the commercial flock through genetic improvement. It's important to remember that index values are determined for optimal genetic change according to the profit goals and that these index values are not always intuitive. For example, negative selection on yearling weight EPD's does not necessarily mean a reduction in yearling body size, due to the corresponding positive selection for weaning weight. By having a broad focus on selection, profit indexes provide a structure that is needed to simultaneously improve all performance traits proportionally to achieve the most optimal genetic advantages. For the sheep industry, indexes can provide a means of accumulating the different EPD values into a more efficient selection tool, reducing the need to fully comprehend the large list of numbers that are presented for an animal and provide a single economic measure that can be used to choose breeding stock for your flock.