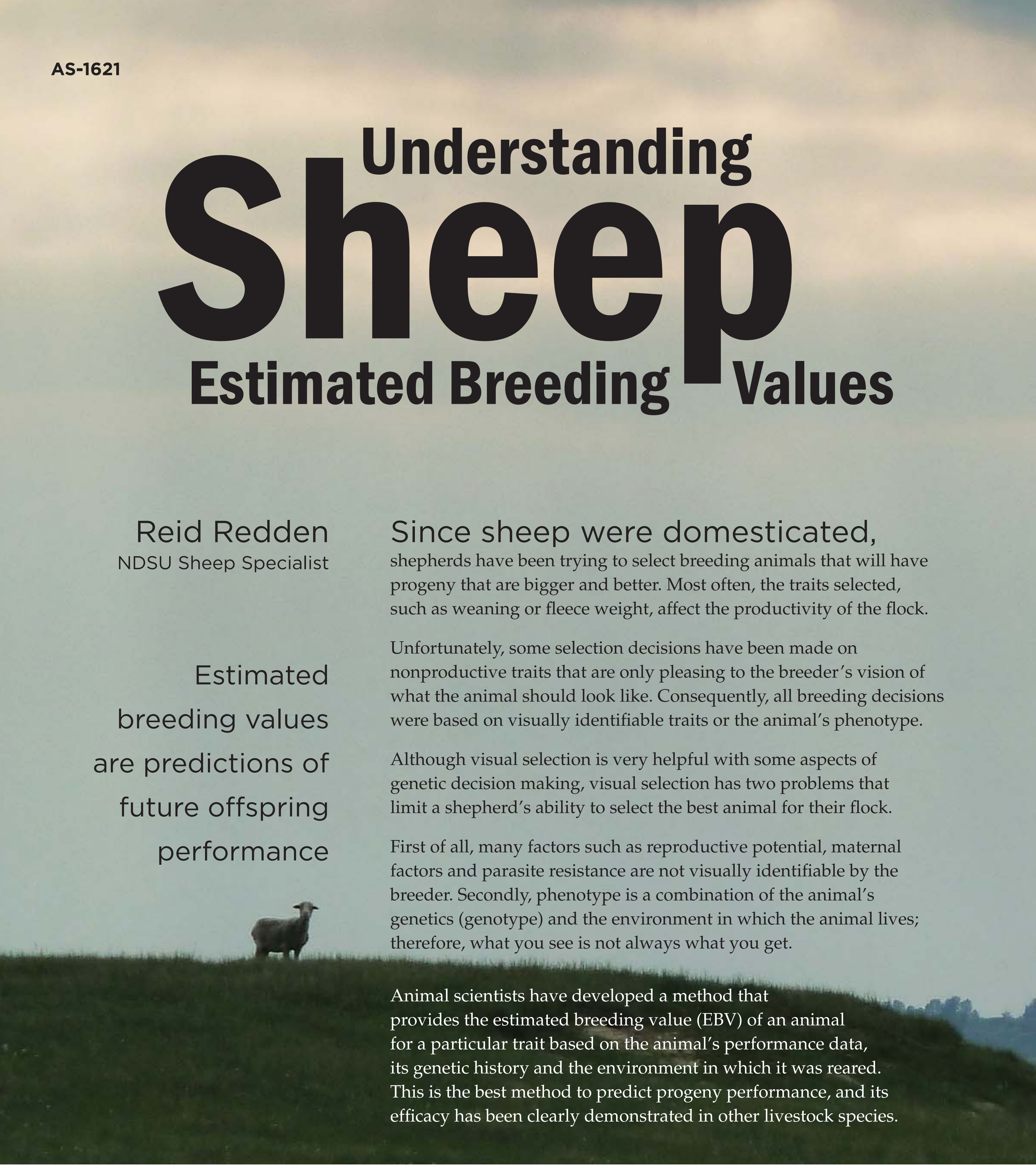

AS-1621

Understanding Sheep Estimated Breeding Values

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Estimated breeding values are predictions of future offspring performance

Since sheep were domesticated, shepherds have been trying to select breeding animals that will have progeny that are bigger and better. Most often, the traits selected, such as weaning or fleece weight, affect the productivity of the flock.

Unfortunately, some selection decisions have been made on nonproductive traits that are only pleasing to the breeder's vision of what the animal should look like. Consequently, all breeding decisions were based on visually identifiable traits or the animal's phenotype.

Although visual selection is very helpful with some aspects of genetic decision making, visual selection has two problems that limit a shepherd's ability to select the best animal for their flock.

First of all, many factors such as reproductive potential, maternal factors and parasite resistance are not visually identifiable by the breeder. Secondly, phenotype is a combination of the animal's genetics (genotype) and the environment in which the animal lives; therefore, what you see is not always what you get.

Animal scientists have developed a method that provides the estimated breeding value (EBV) of an animal for a particular trait based on the animal's performance data, its genetic history and the environment in which it was reared. This is the best method to predict progeny performance, and its efficacy has been clearly demonstrated in other livestock species.

NDSU EXTENSION SERVICE

October 2012

What are EBVs?

Simply put, EBVs are values assigned to ewes and rams that predict differences in the performance of their offspring.

For instance, a shepherd has two rams from which to choose. Ram A has an EBV of +2 and Ram B has an EBV of -2. Ram A is estimated to have lambs that are 2 pounds heavier than Ram B's offspring if they were bred to a similar set of ewes (half of the difference between the rams is inherited by the offspring because the rams contribute half of the genetics of the lambs).

See Figure 1 below for a more in-depth description of how this process works.

Estimated breeding values are calculated from the animal's own performance, performance from genetically related traits and performance of relatives for those traits.

The individual performance of a sheep will depend greatly on how the flock was managed. Differences in management among flocks are accounted for by evaluating individual lamb performance, compared with other lambs within the flock managed similarly. This is called the sheep's contemporary group. Genetically superior animals will be identified regardless of environment.

For a particular trait, animals are assigned EBV values that predict the differences in the performance of the animals' offspring. Normally, larger values equate to better EBVs (weaning weight and number of lambs born); however, some exceptions occur in which smaller is better (wool fiber diameter and fecal egg counts).

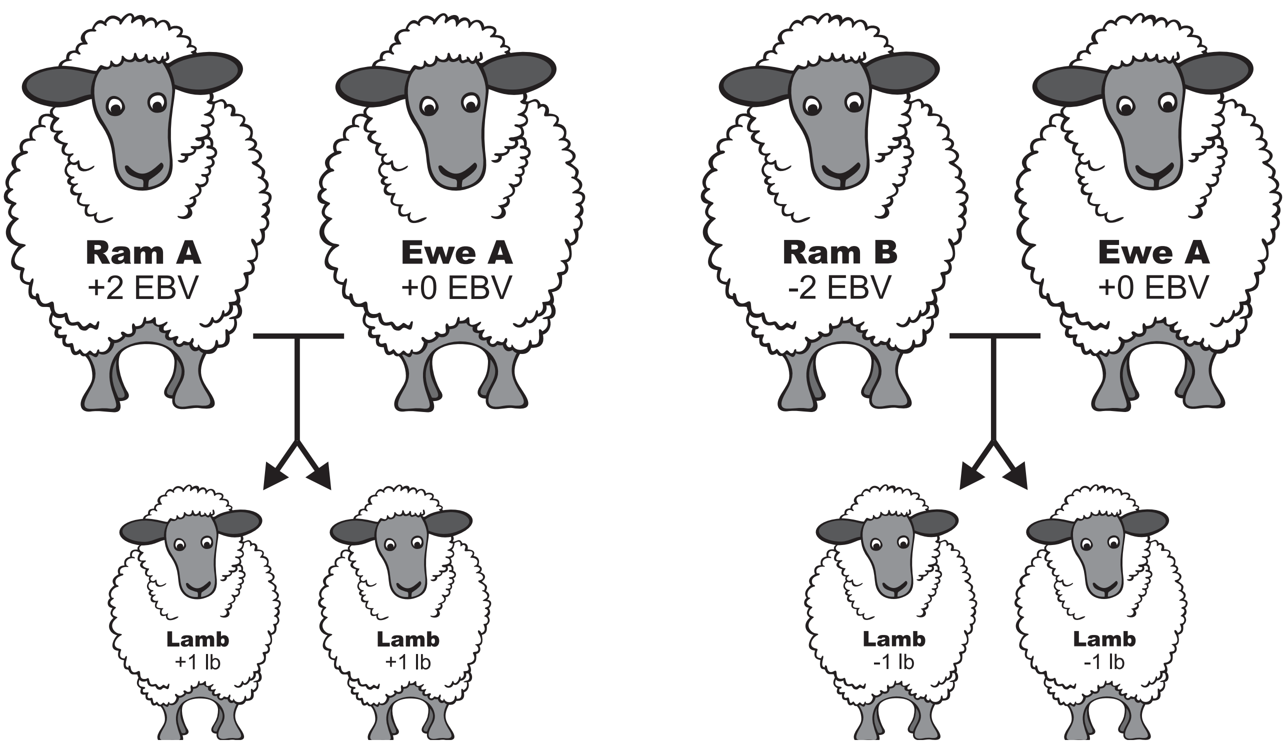


Figure 1. Example of differences in lamb weaning weight from Ram A and Ram B.

What are EBV Accuracy Values?

Estimated breeding values are predictions of future offspring performance; therefore, we need a measure of confidence in an animal's EBV. Each trait EBV for a particular animal has an accuracy value (acc.) that is an expression of whether the EBV is representative of the animal's true breeding value (TBV). Accuracy values are on a scale of 0 to 100, with 100 being the animal's TBV. **Table 1** illustrates numerous EBVs for a particular animal and accuracy values for growth, carcass, reproduction and wool traits.

Many factors influence accuracy:

- Amount of performance information available on the animal and its relatives
- Heritability of the trait
- Size of the group in which the animal is compared

The higher the accuracy, the more confident we are in the EBV. The accuracy of an EBV also can be expressed as a range of confidence in the EBV. This range commonly is called the confidence interval. The confidence interval is plus or minus the prediction error for a specific EBV.

For instance, if the EBV is 5 and the prediction error is 2, then we are 68 percent confident that the TBV is between 3 and 7 (5 ± 2) and 95 percent confident that the TBV is between 1 and 9 (5 ± 4).

The reason accuracy is more commonly used than prediction error is that accuracy is consistent across all traits, whereas prediction error changes for each particular trait, depending on the unit of measurement. Nonetheless, accuracy and prediction error are highly related to one another. **Table 2** illustrates how increasing accuracy from 20 to 95 percent decreases the prediction error across different traits. It also illustrates why accuracy is easier to assess quickly than prediction error.

Accuracy is an important part of using EBVs to improve flock production; however, commercial sheep producers should not overanalyze accuracy values when making multiple breeding decisions. Selecting rams that have high predicted genetic merit is more important than selecting rams with high accuracies.

Accuracy values are more important to seedstock producers who put a lot of emphasis on one ram in their flock. For instance, if 10 rams are purchased and all of them have positive EBVs, but their accuracy is low, then having the group EBV average change in a positive or negative direction is very unlikely.

In contrast, if one purchased ram has a positive EBV but has a low accuracy, the likelihood is much greater that his individual EBV may change in a positive or negative direction and have a significant effect on flock productivity, which ultimately impacts the next generation's EBVs **(Table 3)**.

Table 1. Illustration of an animal's EBV and accuracy values.

ID	WWT	YWT	YFAT	YEMD	NLW	HGFW	Growth Acc.	Carcass Acc.	NLW Acc.	Wool Acc.
030001	7.05	12.35	-.047	.12	.1	1.1	74%	65%	54%	35%

Table 2. Illustration of how accuracy of EBVs decreases prediction error for different traits.

Accuracy Level	BWT	WWT	PWWT	YWT	YFAT	YEMD	NLW	YGFW
	(LB)	(LB)	(LB)	(LB)	(IN)	(IN)	(%)	(LB)
20%	.68	4.52	6.11	6.9	.05	.04	.139	.81
40%	.57	4.23	5.71	6.46	.046	.037	.130	.76
50%	.53	3.99	5.4	6.11	.044	.035	.122	.72
60%	.51	3.68	4.98	5.64	.041	.033	.113	.66
70%	.44	3.28	4.45	5.03	.036	.029	.101	.59
80%	.37	2.76	3.75	4.23	.031	.024	.085	.5
90%	.26	2.01	2.71	3.06	.022	.018	.062	.36
95%	.2	1.43	1.94	2.2	.016	.013	.044	.26

Table 3. Illustration of how likely change in EBV is impacted by purchase of one, five or 10 rams.

Mating Unit	EBV or average EBV	Standard Error	Likely range in breading outcome
1 young ram with 24 half siblings	+11.02 LB	±3.62 LB	+7.41 to +14.64 LB
5 young rams each with 24 half siblings	+11.02 LB	±1.61 LB	+9.41 to +12.63 LB
10 young rams each with 24 half siblings	+11.02 LB	±1.15 LB	+9.88 to +12.17 LB

Who Calculates EBV and Accuracy Values?

The National Sheep Improvement Program (NSIP), established in 1986, was developed to assist producers in compiling records into a usable form for selection decisions. Sheep producers who enrolled in the program collected data and sent it to Virginia Tech. Virginia Tech was home to the U.S. NSIP Genetic Evaluation Center. Center personnel calculated expected progeny difference values (EPDs) for the sheep producers, stored the genetic information, and generated sire summaries and producer breed notebooks.

However, with the retirement of David Notter of Virginia Tech, the NSIP solicited the assistance of an Australian-based company, LAMBPLAN, to perform these duties. With the transition from an American-based system to an Australian-based system, the sheep industry had to change from EPDs to EBVs. The only difference is an animal's EPD is essentially half its EBV.

Sheep producers in the U.S. still go through the NSIP to enroll and submit their data.

To enroll or get more information, contact the NSIP (http://nsip.org/) at info@nsip.org or (712) 579-6378.

Which U.S. Breeds are Enrolled?

Enrollment in the NSIP is based on the need expressed by a breed association and activity of producers within the breed. If your breed of sheep is not listed below, then you should contact your breed association and/or the NSIP. Breeds also are classified into different categories, and each category can submit different data.

Hair

- Dorper/White Dorper
- Katahdin
- Royal White

Maternal Wool

- Black Welsh Mountain
- Border Leicester
- Columbia
- Finnsheep
- Icelandic
- Lincoln
- Meat Merino
- Oxford
- Polypay

Terminal Sire

- Hampshire
- Shropshire
- Suffolk
- White Suffolk
- Texel

Western Range

- Rambouillet
- Targhee

What EBV Traits are Calculated?

Estimated breeding values are created for growth, reproduction, carcass and disease-resistance traits. They target economically important end points for sheep producers. Some traits, such as birth weight, are created from one particular measurement, whereas post-weaning weight can be influenced by lamb weights taken at 60, 120, 180 and 360 days of age.

The EBVs that each breed uses have subtle differences. That's because different breeds put different emphasis on different traits and end points. Be sure to check with your breed association NSIP director to discuss what measurements to collect. **Table 4** lists the most common EBVs for each category, acronyms, definitions and breeds that use them.

Table 4. Description of growth, wool, carcass, reproduction and parasite-resistance EBVs.

Trait	Abbreviation	Description	Breeds
Growth Traits			
Birth Weight	BWT	Predicts differences in offspring weight at birth. Birth weight is measured within 24 hours of birth.	All breeds
Maternal Birth Weight	MBWT	Predicts differences due to genetic effects of the ewe on the birth weight of her lambs.	All breeds
Weaning Weight	WWT	Predicts differences in offspring live weight at 60 days of age. Weaning weight is recorded between 45 and 90 days of age.	All breeds
Maternal Weaning Weight	MWWT	Predicts differences in offspring from daughters based upon the maternal ability of the daughters. They are expressed as kilograms of live weight at weaning.	All breeds
Postweaning Weight	PWWT	Predicts offspring differences for postweaning weight at 120 days. Up to two postweaning weights can be recorded from 91 to 305 days of age. In extensively managed operations that wean from 90 to 150 days of age, this measurement predicts genetic differences in body weight at weaning.	All breeds
Yearling Weight	YWT	Predicts offspring differences in live weight at 360 days of age. Yearling weight is recorded between 290 and 430 days of age.	Western Range, Maternal Wool
Hogget Weight	HWT	Predicts differences in offspring weight at 450 days of age. Hogget weight is recorded between 410 and 550 days of age.	Western Range, Maternal Wool
Adult Weight	AWT	Predicts differences in offspring for live weight at 540 days of age. Four repeat measurements of adult weight (kg) may be submitted; however, this option is not active for the NSIP.	
Wool Traits			
Fleece Weight	FW	Predicts offspring differences for wool production (greasy).	Western Range, Maternal Wool
Fiber Diameter	FD	Predicts offspring differences for fleece quality.	Western Range, Maternal Wool
Staple Length	SL	Predicts offspring differences for length of the wool fiber.	Western Range, Maternal Wool
Fiber Diameter Coefficient of Variation	FDCV	Predicts offspring differences for fleece uniformity, expressed as the coefficient of variation (%) among individual wool fibers	Western Range, Maternal Wool
Fiber Curvature	CURV	Predicts offspring differences in crimp frequency. This EBV is based on an OFDA optical measurement of fiber curvature.	Western Range
Carcass Traits			
Fat Depth	FAT	Predicts offspring differences in carcass backfat depth between the 12th and 13th rib. It is derived from ultrasonic measurements of fat depth in live animals and adjusted to standard postweaning weight of 120 pounds for Terminal and Maternal Wool breeds and a standard yearling weight of 190 pounds for Western Range breeds.	Terminal, Maternal Wool, Western Range
Loin Muscle Depth	EMD	Predicts differences in offspring performance in carcass eye muscle depth between the 12th and 13th rib. It is derived from ultrasonic measurements of loin muscle depth in live animals and adjusted to standard postweaning weight of 120 pounds for Terminal and Maternal Wool breeds and a standard yearling weight of 190 pounds for Western Range breeds.	Terminal, Maternal Wool, Western Range
Reproduction			
Number of Lambs Born	NLB	Predicts differences in daughters for prolificacy. This EBV is expressed as number of lambs born per 100 ewes lambing.	All breeds
Number of Lambs Weaned	NLW	Evaluates the combined effect of prolificacy and lamb survival to weaning. This EBV is expressed as number of lambs weaned per 100 ewes lambing.	All breeds
Scrotal Circumference	SC	Predicts differences in offspring performance, testicular size at postweaning (Maternal Wool) and yearling weights. It may be used to improve the breeding capacity in males and reproductive performance in females.	Maternal Wool, Western Range
Parasite Resistance			
Worm Egg Count	WEC	Predicts offspring differences for parasite resistance based on worm egg counts recorded at weaning or postweaning ages.	Hair

What are Selection Indexes?

Selecting an animal based on EBVs can become overwhelming due to the number of traits an individual animal will have. Shepherds should be looking for breeding stock that will improve their flock in numerous traits, not just increase one particular trait.

Selection indexes have been created to combine numerous traits into one number. In addition, selection indexes will put more emphasis on traits for a particular setting that has the most economic impact for that particular production scenario.

For instance, Western range operations normally generate 85 percent of their profits from weaned lamb and 15 percent from wool. Therefore, NLB and PWWT will have more impact than FW or FD on the Western range index, whereas terminal sire breeds generate most of their profits from the sale of rams to maternal-based breeds to produce fast-growing and high-quality carcass lambs. Thus, the Carcass Plus index puts the most emphasis on PWWT, less emphasis on carcass traits and no emphasis on wool or maternal traits.

Selection Indexes

Western Range Index	WRI	Developed to select for multiple traits that impact extensively managed range flocks. WRI = PWWT + 0.26*MWWT - 0.26*YWT + 1.92*GFW - 0.47*FD + 0.36*NLB	Western Range
Katahdin Ewe Productivity	KT EP	Developed to select for multiple traits that impact hair sheep production systems. KT EP = 0.245*WWT + 2.26*MWWT + 0.406*NLW - 0.035*NLB	Hair
Polypay Ewe Productivity	PP EP	Developed to select for multiple traits that impact Polypay sheep production systems. PP EP = 0.265*WWT + 1.2*MWWT + 0.406*NLW - 0.035*NLW	Maternal Wool
Carcass Plus		Developed to improve carcass value in Australian markets CP = 5.06*PWWT - 13.36*FAT + 7.83*EMD	All breeds; most applicable to Terminal Sire
LAMB 2020		Developed in Australia as an alternative to Carcass Plus and designed to reflect projected demand for lamb in 2020. LB = 0.32*WWT + 0.47*PWWT - 0.21*BWT – 0.55*FAT + 1.54*EMD – 0.04*WEC	All breeds; most applicable to Terminal Sire

How Do I Use EBVs to Improve My Flock?

For commercial sheep producers purchasing terminal sires, the greatest potential for improvement in productivity is in purchasing rams that have high EBVs for weaning weight.

For instance, two rams are available for purchase: Ram A (+3) and Ram B (-2) for weaning weight. Ram A's offspring are likely to be 2.5 pounds (5 pounds divided by 2; lambs only have half the ram's genetics) heavier than Ram B's offspring. If you breed Ram A to 35 ewes and wean 50 lambs, your flock weaning weight is likely to be 125 pounds heavier than if Ram B bred the ewes, assuming no other traits were affected adversely.

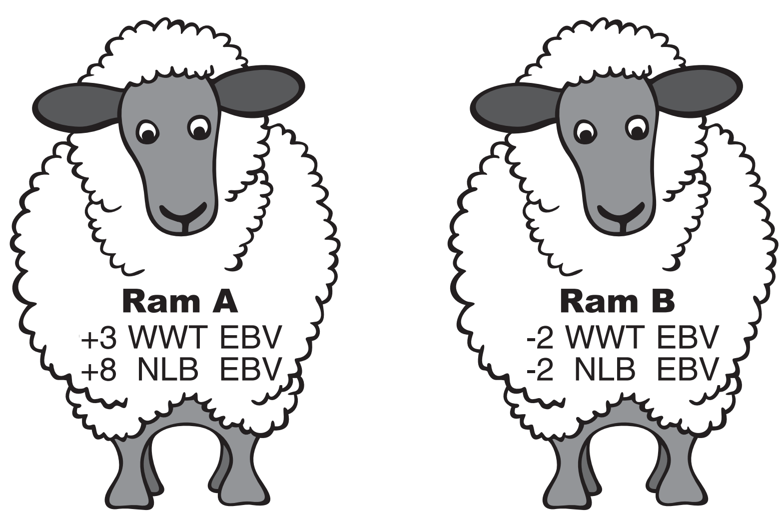
For sheep producers purchasing rams that will produce replacements, two areas of emphasis must be evaluated: performance of the offspring and performance of future generations.

Again, we have **two rams to choose from in the figure below**. Ram A will have lambs that are 2.5 pounds heavier than Ram B. However, Ram A has a +8 number of lambs born EBV compared with a -2 number of lambs born EBV for Ram B. Therefore, daughters of Ram A will produce 5 percent more lambs than Ram B.

Typically, an improvement in reproductive performance has the greatest impact on the ewe's lifetime productivity.

In general, sheep producers should select rams that have good EBV traits in which their flock is most deficient, and the ram should have above-average EBVs for the other traits that are important to their flock.

It is highly discouraged to select rams based solely on one outstanding EBV trait without regard to the other traits important for the breed type, especially if replacements are going to be kept from that ram. This is why most sheep producers would benefit from using an index that fits their farm production goals.



Example of two rams that have differing weaning weight and number of lambs born EBVs.

Sources of Information:

"Breeders Guide to LAMBPLAN, Merino Genetic Services, and KIDPLAN."
Meat and Livestock Australia Limited.
www.nsip.org/wp-content/uploads/2012/06/Breeders-Guide.pdf

National Sheep Improvement Program. "NSIP Historically."
www.nsip.org/?page_id=1585

For more information on this and other topics, see www.ag.ndsu.edu

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