UNITED STATES LAMB RESOURCE CENTER

Increasing Your Lamb Crop Series

Use Crossbreeding

Introduction

Crossbreeding is a predictable and cost-effective method to genetically increase lambs raised per ewe (lamb crop) by mating sheep of two or more breeds. The practical objective of crossbreeding is to increase lamb crop relative to the pure breed that performs best in a given production system and environment.

Genetic basis for crossbreeding

Sheep have evolved over thousands of generations to adapt to specific environmental conditions by the natural selection of roughly 30,000 genes. All sheep have two copies of each gene, one inherited from each parent. Each gene typically has two or more forms. Sheep with two copies of the same form of a particular gene are said to be homozygous for that gene, whereas sheep with two different forms are heterozygous. As a result of evolution and selection by shepherds, each breed has unique genetic information that produces characteristics that distinguish it from another breed.

Purebreeding creates sheep that have a relatively high level of homozygosity, whereas crossbreeding produces sheep with less homozygosity and more heterozygosity than the purebreds used to make the cross. The increased heterozygosity of crossbred sheep relative to purebred sheep is the basis for heterosis effects – also called hybrid vigor. Crossbreeding systems combine genetic effects of breeds and heterosis, while complementarity is also used in terminal crossbreeding systems. These three aspects of crossbreeding systems are addressed below.

Choice of breeds

The most important genetic considerations to increase lamb crop are to use breeds and crossbreds that are suitable for the production system and also well adapted to environmental conditions. Sustainable production systems are rather complex, integrating resources such as land usage, labor supply, feed costs, facility accessibility, marketing options and managerial skills. The production system essentially establishes which traits have the most impact on profitability and determines target levels of performance for these key traits.

Lamb crop is the key trait affecting profitability in most production systems. For example, farm flocks intensively-managed in confinement need highly productive ewes to offset substantial production costs, whereas a low-input range operation may depend on less productive ewes which are very well adapted to extensive environmental conditions.

Breeds differ greatly for number of lambs born, allowing producers to use purebred or crossbred ewes to achieve their lamb crop goal for their production system and environmental conditions. Assuming that the optimal number born for an intensively-managed farm flock is about 2.5 lambs for mature ewes, roughly equivalent to an overall flock average of 2.2 lambs born. Mature Rambouillet ewes produce about 1.8 lambs at birth, whereas mature Finnsheep ewes average about 3.2 lambs. If Finnsheep rams are bred to Rambouillet ewes, one intuitively expects the crossbred daughters to achieve the target of 2.5 lambs at maturity; 2.5 simply being the average of the two parental breeds.

A more pasture-based production system might target fewer lambs born. Perhaps the production system dictates that quarter-Finnsheep ewes are suitable and therefore a producer breeds Finnsheep x Dorset crossbred rams to Rambouillet ewes. Assume that mature Dorset ewes average 2.0 lambs born. What should the producer expect the resulting daughters (¼ Finnsheep, ¼ Dorset, and ½ Rambouillet) to average for number born at maturity? The intuitive answer, 2.2, is the weighted average of the three parental breeds (2.2 = (0.25 x 3.2) + (0.25 x 2.0) + (0.50 x 1.8)).

So, breed diversity for number born can be used to achieve virtually any goal. The importance of maternal ability, both behavior and milk production, must also be considered in choosing breeds. For example, lamb survival can be improved by creating crossbred ewes with intermediate optimums to balance number born and maternal ability.

Information about trait performance of many breeds is provided in the Breeding and Selection chapter of the *Sheep Production Handbook.*

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Heterosis effects

Crossbreds often outperform the average of the pure breeds used to make the cross, a phenomenon known as heterosis. Heterosis is caused by the increased heterozygosity of crossbred sheep relative to purebred sheep. Heterosis effects tend to be greatest for lowly heritable traits such as reproduction, survival and health. Effects of heterosis on lamb crop can be realized through crossbred ewes, lambs and, to a lesser extent, rams.

Let us use Rambouillet and Finnsheep to demonstrate effects of ewe heterosis on number born. Again, assume number born averages 1.8 and 3.2 for Rambouillet and Finnsheep ewes, respectively. The average for the two breeds is 2.5 lambs born. If Rambouillet x Finnsheep crossbred ewes actually average 2.58 lambs born, then the ewe heterosis effect for number born is 2.58 – 2.5, or 0.08 lambs. Heterosis effects can also be expressed as a percentage of the purebred mean. For this example, percentage ewe heterosis for number born is 3.2% (0.08/2.5 x 100).

Breeding ewes to produce crossbred lambs rather than purebred lambs also increases lamb crop raised. This is an example of lamb heterosis, whereby crossbred lambs have a higher survival rate than purebred lambs.

Less is known about effects of ram heterosis than lamb and ewe heterosis. Ewes exposed to crossbred rams for spring breeding tend to have greater pregnancy rates than ewes exposed to purebred rams.

Lamb crop is determined by three component traits: pregnancy rate, number born and pre-weaning survival. Estimates of lamb and ewe heterosis effects on these reproductive traits are summarized in Table 1. Lamb heterosis effects are favorable for each component trait, but greatest for pre-weaning survival. That is, crossbred lambs have a better chance of survival than purebred lambs. Effects of ewe heterosis on component traits are greatest for pregnancy rate, indicating that crossbred ewes are more likely to lamb than purebred ewes. Note that heterosis effects of component traits accumulate so that the combined effect on lamb crop is greatly increased.

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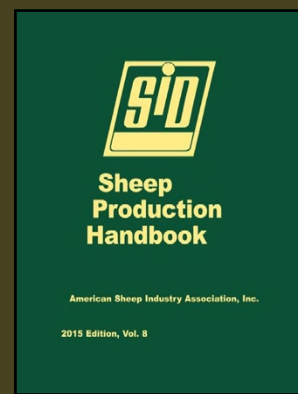
On average, crossbred lambs increase lamb crop by 15.2% relative to the pure breeds used to make the cross. Crossbred ewes have a similar effect, increasing lamb crop by 14.7% on average. Crossbreeding systems that fully exploit both lamb and ewe heterosis effects can increase lamb crop by roughly 30%. In summary, favorable effects of lamb and ewe heterosis greatly increase overall productivity of crossbred sheep.

Sheep Production Handbook



The *Sheep Production Handbook*, updated in 2015, is an excellent resource to learn more about this topic. A fully searchable USB drive is included with each book. This newest edition has chapters on reproduction, management, breeding/selection, forages, nutrition, lamb quality, marketing, predator damage control, health and wool. It is available for purchase from the American Sheep Industry Association, 303-771-3500, or www.sheepusa.org.

Table 1. Lamb and ewe heterosis effects on reproductive traits as a percentage of purebred average.

Trait	Lamb	Ewe
Pregnancy rate	2.6	8.7
Number born	2.8	3.2
Pre-weaning survival	9.8	2.7
Lambs weaned per ewe exposed	15.2	14.7

Complementarity

In addition to breed and heterosis effects, terminal crossbreeding systems also take advantage of complementarity. Complementarity improves production efficiency by mating ewes of maternal breeds to rams of terminal sire breeds. Maternal breeds excel in adaptability and reproductive traits and have moderate feed requirements. In contrast, terminal sire breeds are superior for growth and carcass traits. By separating maternal and terminal sire roles, complementarity allows favorable traits of breeds to be expressed while minimizing less desirable traits. Mating Rambouillet-Targhee crossbred ewes to Hampshire rams is an example of matching complementary strengths of breeds to optimize efficiency in an extensive production system.

General purpose crossbreeding systems

Four genetic types of sheep can be used in general purpose crossbreeding systems:

- Purebreds provide the genetic resources that drive crossbreeding systems.
- First-cross (F1) sheep are produced by mating ewes and rams of different breeds.
- Two-breed rotational sheep are produced by using rams of two breeds in alternating generations. The addition of a third breed to the rotation results in three-breed rotational sheep.
- Composite sheep are produced by crossing two or more breeds in the foundation generation, with subsequent generations descending from the original crossbred sheep.

Levels of heterosis expressed by these genetic types are listed in Table 2. By definition, purebreds do not show heterosis effects whereas heterosis is maximized in first-crosses. Intermediate levels of heterosis are realized by rotational and composite sheep, with values increasing as additional breeds are added to each genetic type.

Table 2. Percentages of first-cross (F1) heterosis expressed by different genetic types.

Genetic type	Percentage heterosis
Purebred	0
First-cross (F1)	100
Two-breed rotation	67
Three-breed rotation	86
Two-breed composite	50
Three-breed composite	62
Four-breed composite	75

Types of crossbreeding systems

Three types of general purpose crossbreeding systems are shown in Figure 1. In the first-cross system, purebred ewes are bred to produce purebred replacement ewes and also to rams of a different breed to produce first-cross market lambs. In the rotational system, ewes are mated to rams of the least-related breed, producing both replacement ewes and market lambs. The composite system is the simplest, as composite ewes are mated only to composite rams to produce replacement ewes and market lambs.

Figure 1. Diagram of three types of general purpose crossbreeding systems:

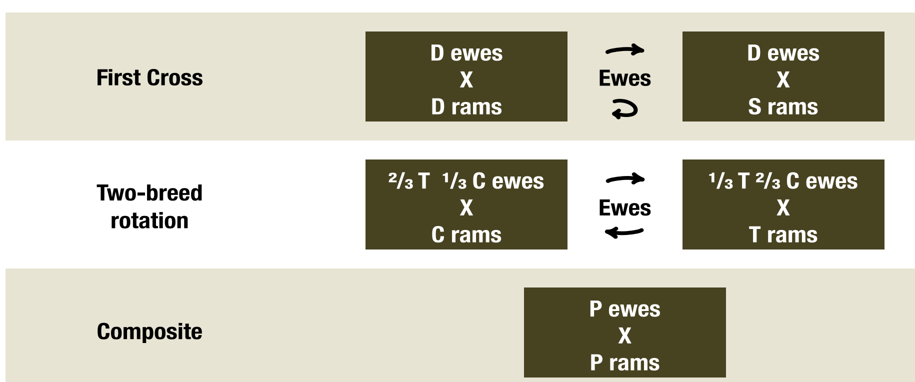
D = Dorset

S = Shropshire

T = Targhee

C = Corriedale

P = Polypay



The first-cross system is the least efficient because all ewes are purebred and do not benefit from ewe heterosis. Both the rotational and composite systems use ewe and lamb heterosis effects quite effectively. Although rotational systems achieve higher levels of heterosis than composites for a given number of breeds (Table 2), they require more breeding groups, each differing in breed composition. In contrast, composites are managed as a single breed, maintain very beneficial levels of heterosis, and have stable breed composition. *Fundamental Aspects of Crossbreeding in Sheep* (Leymaster 2002) provides more detailed information about crossbreeding systems.

Terminal crossbreeding systems

Terminal crossbreeding systems use maternal breeds and terminal sire breeds to complement each other. Depending on reproductive and attrition rates of the breeding flock, only 15 to 40% of ewes are needed to produce replacements. The remaining ewes can be bred to rams of terminal sire breeds. Growth and carcass traits are strengths of terminal sire breeds and all terminally-sired lambs realize 100% of lamb heterosis effects.

Three types of terminal crossbreeding systems are illustrated in Figure 2. These systems are similar to general purpose systems except maternal breeds are used to produce replacement ewes, while rams of terminal sire breeds are bred to an additional flock of maternal ewes. These genetic advantages cause terminal crossbreeding systems to increase lamb crop substantially relative to corresponding general purpose systems.

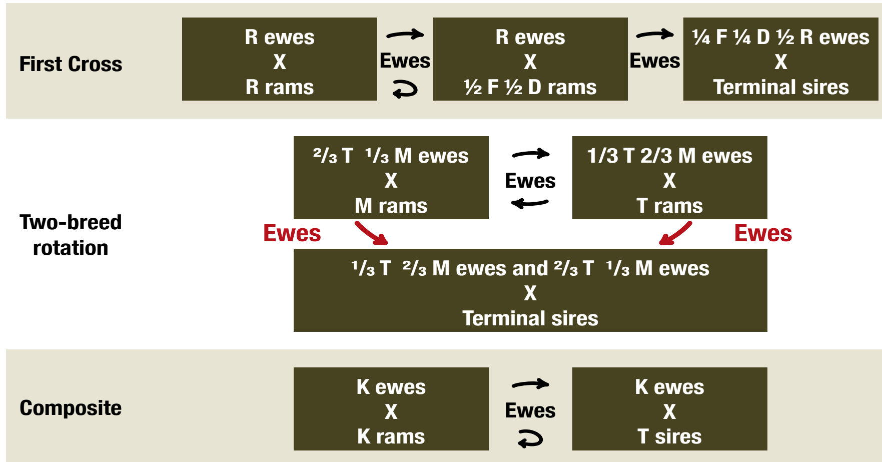


Figure 2. Diagram of three types of terminal cross-breeding systems:
R = Rambouillet F = Finnsheep D = Dorset T = Targhee
M = Montadale K = Katahdin

In terminal crossbreeding systems, the productivity is similar for first-cross (F1), two- and three-breed rotations, and three- and four-breed composites due to effective use of ewe and lamb heterosis. The use of breed, heterosis, and complementarity effects in terminal crossbreeding systems can increase lamb crop by roughly 35% compared to the average of purebreds.

Conclusion

Crossbreeding systems vary in complexity and use of breed, heterosis and complementarity effects. Lamb crops can be increased most effectively by use of maternal breeds and terminal sire breeds to complement each other in terminal crossbreeding systems. Producers should carefully weigh the long-term practical ramifications of different crossbreeding systems before embarking on a specific plan.

More information

U.S. Lamb Resource Center
http://lambresourcecenter.com/production-resources/productivity/

National Sheep Improvement Program
http://www.nsip.org

U.S. Sheep Industry Roadmap
http://lambresourcecenter.com/reports-studies/roadmap/

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