Extreme muscling of callipyge ewes compared to normal ewes. Photos courtesy of Dr. Sam Jack–son, Texas Tech University.

CALLIPYGE:

A Stealthy Threat To The Sheep Industry

By Dr. Kreg Leymaster

There is growing concern that the callipyge mutation is finding its way back into the sheep industry, driven primarily by show-ring influences. Presence of the mutation in at least two breeds has been confirmed by genetic testing and some producers also question its existence in other breeds. I have been asked to address this issue due to my past involvement in callipyge research with colleagues at the U.S. Meat Animal Research Center in Clay Center, NE. The purpose of this article is to provide factual information about the callipyge mutation to help all segments of the sheep industry make prudent decisions.

A Dorset ram named Solid Gold was born in 1983 and some of his descendants, but not all, showed an extreme degree of muscling suggesting a discrete genetic basis. A brief description of this condition first appeared in the scientific literature in 1993, followed by numerous publications by scientists at universities and federal institutions in the United States and other countries. The condition is characterized by extreme muscle development at young ages, 3 to 8 weeks of age, most notably over the topline and hindquarters. The accompanying pictures of yearling Rambouillet and Suffolk ewes illustrate the extreme muscle development typical of the callipyge condition compared to normal sheep. This naturally-occurring mutation was called "callipyge," Greek for "beautiful buttocks." Producers should understand that all sheep carrying the callipyge mutation, regardless of stated breed, are descendants of the Dorset ram named Solid Gold.

The callipyge mutation is located on sheep chromosome 18 and the actual causative mutation was discovered in 2002 by ARS scientists at the U.S. Meat Animal Research Center. A genetic test for the mutation is commercially available (Gene Check; 970-472-9951; http:/www.genecheck.com/). The callipyge mutation is not a form of the myostatin gene on chromosome 2 that is typical in the Texel breed. In fact, the callipyge mutation lies outside of any known coding regions, that is, callipyge is not an actual gene. It is now known that the callipyge mutation regulates expression of several nearby genes. The outcome is an increase in muscle fiber size (hypertrophy) in specific muscles. Hypertrophy differs from an increase in muscle fiber number (hyperplasia), a condition that causes "double-muscling" in some breeds of cattle due to mutations in the myostatin gene.

To understand the association of callipyge genotypes with expression of the callipyge condition, let's use C to indicate the callipyge mutation and N the normal form. The only way that the callipyge condition is expressed is for a lamb to receive C from its' sire and N from its' dam. The genotype of such a lamb is designated CN, with the first letter representing the contribution from the sire and the second letter from the dam. For this CN genotype to occur, the sire must have 1 (CN or NC) or 2 (CC) copies of C and the dam must have 1 (CN or NC) or 2 (NN) copies of N. These are the only sire and dam genotypic combinations that can produce CN progeny that express the Callipyge condition.

There are four possible genotypes, but only two conditions:

• CN lambs express the callipyge condition as described above.
• NC, NN, and CC lambs are normal.

If a lamb has normal muscle development, its' genotype will be NC, NN, or CC. Genetic testing is required to determine its' actual callipyge genotype. However, if a lamb expresses the callipyge condition, its' genotype must be CN. Note that CN and NC, the two reciprocal heterozygotes, have very different effects on muscle development depending on whether the callipyge mutation came from the sire or the dam. Also, the two homozygous genotypes, CC and NN, both result in normal muscle development. This unusual association of genotypes with effects, called "paternal polar overdominance," was first discovered in callipyge experiments.

Information in Table 1 summarizes the expected outcomes from all possible mating combinations of callipyge genotypes. For example, 50% of lambs from a CC normal ram mated to either CN callipyge or NC normal ewes are expected to show the callipyge condition. This happens because the ram must contribute C and ewes are expected to transmit N to half of their lambs, resulting in CN callipyge lambs. In an analogous manner, 50% of lambs produced from either CN callipyge or NC normal rams mated to NN normal ewes will have the callipyge condition. No lambs from CC normal ewes will express the callipyge condition, regardless of their sires' callipyge genotype. Likewise, no lambs from NN normal rams will show the callipyge condition, regardless of their dams' callipyge genotype. Matings between heterozygous parents (CN or NC rams with CN or NC ewes) will produce 25% CN callipyge lambs. The only mating combination that will produce 100% CN callipyge lambs is CC normal rams bred to NN normal ewes, since the sire must transmit C and the ewe N. What a genetic slight-of-hand: All parents are normal, but all lambs express the callipyge muscling condition! This table illustrates that producers of callipyge-free flocks run the risk of unknowingly buying CC or NC normal ewes or rams, only to see the callipyge condition appear in subsequent generations of CN lambs.

How do lambs expressing the callipyge condition compare to normal lambs for growth, carcass, and meat quality traits? Callipyge and normal lambs have similar growth rates to birth, weaning and slaughter weight, but dressing percentages of callipyge lambs are substantially greater than normal lambs. Callipyge carcasses have less kidney-pelvic fat, less fat depth at the 12th rib, and less percentage carcass fat relative to normal carcasses. Carcasses of callipyge lambs are more compact than normal carcasses, being shorter in length and thicker at the shoulders and rump. Callipyge carcasses have more pronounced muscle development, with increased leg conformation scores and greater loin eye areas. Weights of specific muscles are heavier in callipyge carcasses compared to normal carcasses. The overall effect of the callipyge condition on carcass composition is to vastly increase percentage lean, with a corresponding decrease in percentage fat.

Unfortunately, favorable effects of the callipyge condition on muscle development and carcass composition are overwhelmed by adverse effects on meat quality traits like marbling, juiciness, and tenderness. For example, when traditional cooking methods for fresh lamb were used (broiling), loin chops of callipyge lambs were intolerably tougher than normal chops as indicated by both sensory-panel evaluation and Warner-Bratzler shear force values. The tough loin chops occurred because the breakdown of myofibrillar proteins that normally happens while carcasses hang in coolers after slaughter, was greatly delayed in muscles affected by the callipyge condition. Many postmortem intervention strategies to resolve the toughness problem have been evaluated, but none have proven to be economically feasible.

The bottom line is that meat from the higher-priced cuts of callipyge lamb (rack, loin, and leg) is not acceptable to consumers because it is far too dry and tough. These observations have been reported repeatedly by scientists at numerous institutions. From the consumer standpoint, one might even consider the callipyge mutation to be a genetic defect. Meat from callipyge lambs is not a marginal or borderline product, but a product that must be purged from the food chain. Failure to do so will likely cause consumers to discriminate against American lamb and favor imported lamb.

Now is the time to address this mutation, while its occurrence is low and before it becomes embedded in more breeds. The sheep industry is working to improve eating characteristics of lamb through efforts outlined in the Sheep Industry Roadmap. There is no place for callipyge in the sheep industry.

Table 1. Percentage of offspring expected to show the callipyge condition for each possible mating combination.

		Ram			
	Genotype[a], Condition	CC Normal	CN Callipyge	NC Normal	NN Normal
Ewe	CC Normal	0	0	0	0
	CN Callipyge	50	25	25	0
	NC Normal	50	25	25	0
	NN Normal	100	50	50	0

[a]C indicates the callipyge mutation and N the normal form. The first letter of the genotype represents the contribution from the ram and the second letter from the ewe.