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COMPARISON OF POST-WEANING PERFORMANCE
AND CARCASS TRAITS OF
COLUMBIA AND CORMO
CROSSBRED LAMBS

by

Carl Kim Chapman

A thesis submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

in

Animal Science

Approved:



UTAH STATE UNIVERSITY
Logan, Utah

1988

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Carl Kim Chapman

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ABSTRACT

Comparison of Post-Weaning Performance and
Carcass Quality of Columbia and Cormo
Crossbred Lambs

by

Carl Kim Chapman, Master of Science
Utah State University, 1988

Major Professor: Dr. Lyle G. McNeal
Department: Animal, Dairy, and Veterinary Science

Thirty-seven Columbia and Cormo crossbred July-weaned wether lambs were utilized in this study. A feeding trial was conducted to evaluate feed efficiency, average daily gain, feed cost per pound of gain, wool growth per day and per pound of gain, and average wool fiber diameter and distribution of fiber population of the wool. Lambs were raised to a uniform market weight of between 115 and 125 pounds and slaughtered to evaluate carcass weight, backfat thickness, loin eye area, internal body fat, leg circumference, dressing percentage, untrimmed wholesale cuts, trimmed retail cuts, and yield and quality grades. Suffolk x Cormo/Rambouillet lambs were most efficient ($P < .05$) in converting feed to gain, gaining .15 kg per kg feed intake. They also had the highest daily gain ($P < .05$), and lowest cost per kg gain ($P < .01$) of any treatment, .29 kg and \$0.75, respectively. Columbia lambs had .32 cm of wool growth per kg of gain, and Cormo x Columbia lambs had the finest fiber diameter (P

< .01) at 19.84 microns. No significant differences existed between treatments for any of the carcass traits observed. However, birth date and age at slaughter did have a negative effect on the percentage of trimmed retail cuts yielded by each carcass.

Key Words: Sheep, Crossbred, Cormo, Performance, Carcass

(44 pages)

INTRODUCTION

The goal of the American sheep producer is to produce high quality lamb and wool in the most efficient way possible. No matter what type of management system is used, the need for efficiency and profitability exists. Many sheep producers have turned to crossbreeding in an effort to capitalize on heterotic effects leading to increased growth rates in lamb production(Terrill, 1982a).

Contributing to this need for greater economy is the fact that feed prices escalated during the first half of the 1980s because of unusually high petroleum prices and inflation.

For the past several years, many western sheep producers have selected replacement ewes solely on the basis of lamb production because of the high monetary returns of marketing lamb verses wool. This has led to increased variability and coarseness in many wool clips throughout the western United States. This increased selection pressure toward accelerated lamb growth rates has also caused an increase in the body size of ewes and, coupled with increased body size, perhaps a decrease in efficiency of lamb and wool production. However, the value of wool has increased in recent years and wool is once again a valuable product for the producer to offer for sale. Wool represents nearly one-third of the total income on some western range units(McNeal, 1986).

Development of a crossbreeding program which would produce rapid gaining, more efficient lamb crops without reducing wool quality, and density now needs to be investigated to help improve sheep production in the western states.

In 1980 Utah State University initiated a crossbreeding program to address these issues. Rambouillet and Columbia ewes were crossed with Australian Cormo rams, which are smaller framed, fine-wooled sheep. The program had two main objectives. First, to develop a ewe which is intermediate in size between the Cormo and western white-face ewe breeds and requiring less maintenance, which would produce lambs which are comparable to those produced by conventional range ewes with wool which is finer and less variable than western whiteface ewes. Second, to develop a flock of commercial ewes which could be used in teaching sheep production and management courses. This study will evaluate the results of this crossbreeding program, with respect to both lamb and wool production efficiency and carcass quality of terminal crossbred lambs from these ewes and other conventional domestic ewes.

Objectives

The objectives of this study were as follows:

1. Evaluate post-weaning performance of lambs as measured by feed efficiency, average daily gain, feed cost per kg of gain, wool growth per day and per kg of gain, and average fiber diameter and standard deviation of the wool fiber population to determine if any significant differences exist between the different genotypes in the study.
2. Evaluate differences in quality of economically important carcass traits such as leg muscle mass, loin-eye area, backfat thickness, and percentage kidney, heart, and pelvic fat.

REVIEW OF LITERATURE

Crossbreeding is recognized throughout the world as a management practice which can give quick gains in efficiency due to heterosis (Terrill, 1982a). However, many of the crossbreeding programs in the United States, as well as in other countries, have concentrated on lamb production and have given little consideration to the quality or quantity of wool produced by the crossbred sheep (Hofmeyr, 1982; Terrill, 1982b). Due to changes in the marketplace, wool has once again become a valuable commodity for sheep producers to sell, and more attention is being paid, especially by the commercial sector, to those sheep which produce fine wool.

The first importation of Cormo sheep into the United States occurred during the mid-1970s. However, the Cormo story began long before that. The Cormo is a synthetic breed which was developed at Dungrove, near Bothwell in Tasmania, Australia, by crossing Corriedale rams onto "superfine" Saxon Merino ewes; hence the name Cormo. In 1960, Mr. I.K. Downie, owner of Dungrove, managed a high-quality flock of Saxon Merino ewes. Two conclusions, based upon commercial conditions at the time, led him to work on developing the Cormo breed. First, he concluded there was a need for a larger framed, more fertile, wool-producing sheep. Second, casual speculation into the sale of wool through objective testing and sale-by-sample led him to determine that a breeding program should be initiated that would facilitate this new marketing approach. Downie (1978) developed the Cormo with very specific production-oriented objectives, which could be objectively measured in mind.

Those objectives were as follows:

1. Average fiber diameter of 21 to 23 microns.
2. Fast growing lambs.
3. High yielding, dense fleece.
4. High fertility by selecting only twins for replacements.
5. Open face, and freedom from excessive skin wrinkles.
6. Mothering ability.

Once the initial crosses were made and the performance of the offspring measured, the first Cormos were selected and the flock was closed. This group became the ram breeding nucleus. The replacement ewes for the nucleus flock came from the nucleus or from the commercial flock of Cormos, depending upon their individual performance. Both flocks were managed under the same conditions so that their true genetic capabilities were comparable. The sheep were each numbered, objective measurements, not subjective visual appraisals, were made on each individual, and computer records and indices were utilized in the selection program. The Cormo is considered one of the most progressive genetically improved breeds in the industry(Downie, 1986).

The Cormo possesses many attributes which could be beneficial to the American range sheep industry. The area where the Cormo was developed is known to have very hot, dry summers and very cold, snowy winters, not unlike conditions encountered on western ranges. Jeffries(1984) reported the young Cormo lambs thrive in the cold, wet environment existent during the Tasmanian spring. Both the ram nucleus flock and the commercial ewe flocks at Dungleigh are run under these natural conditions throughout the year. Some of the other

commercial merits which are inherent to the Cormo are as follows:

1. Cormo wool is fine, long stapled, and very white and high yielding. Average fiber diameter for most Cormo wool is between 20 and 23 microns, which gives it a spinning count of 62's to 64's. Jones(1986) reported some Cormo wool which had staple lengths exceeding five inches. Clean wool yield is reported to average between 70 and 80 percent, compared to 45 to 60 percent of many U.S. breeds. Figure 1 illustrates the difference in color between a Cormo x Rambouillet ewe used in this study and a purebred Rambouillet ewe fleece.

2. The characteristic openness of the Cormo fleece allows the Cormo to be resistant to problems caused by high humidity, such as fleece rot and mycotic dermatitis. This resistance is brought about because the openness of the fleece allows excess moisture to drain out of the fleece, instead of being trapped within the fleece, as seen with Merinos and Rambouillets.

3. Cormos are very hardy in relation to productivity on range lands. Downie(1986) reported the ewes are managed in Tasmania on native rangeland throughout the entire year, requiring no supplemental feeding. He also stated that under these conditions, the ewes wean over 110 percent of lambs born.

4. Finally, when the Cormo was crossed with other coarser woolled sheep, the resulting offspring produced a finer fleece than the coarse-wooled parent and retained the body size and fertility of the Cormo(Downie, 1986). This observation is supported by the crossbreeding program at Utah State University, which led to this



(a)



(b)

Figure 1. Differences in brightness between (a) Cormo x Rambouillet and (b) Rambouillet ewe fleeces.

study. Figure 2 shows that Cormo x Rambouillet ewes produced under the Utah State University crossbreeding program are intermediate in



Figure 2. Differences in body size between Cormo(left), Cormo x Rambouillet(middle), and Rambouillet(right) post-puberal ewes.

body size between purebred Cormo and Rambouillet ewes.

Due to the relatively short time that the Cormo has been in the United States, very little work has been done on utilizing this breed in a crossbreeding program. However, the other breeds being utilized in the study have been used extensively in crossbreeding programs in the United States.

The Suffolk has been used in numerous crossbreeding studies as both sire and dam stock. Dickerson et al.(1972) cited the merit of the Suffolk breed in their study of Suffolk, Hampshire, Dorset, Rambouillet, Targhee, Corriedale, and coarse-wooled crossbred ram lambs. It was reported that Suffolk weights at ten weeks and older

were 111% and 115%, respectively, of the average of the seven breeds which were studied. At 26 weeks of age, Suffolks had the highest liveweight of any breed in the study, with Suffolk lambs weighing 63.8 kg compared to the other breeds, which averaged between 48.5 and 56.5 kg at the same age. Suffolk lambs also produced higher quality carcasses upon slaughter. Dressing percentages for Suffolk carcasses averaged 53.2 percent, compared to Rambouillet dressing percentages which averaged 48.1 percent. Suffolks also had the highest quality grades and lowest yield grades of any of the seven breeds. Suffolk lambs had higher leg scores and loin-eye area, and lower backfat than the other breeds. Rastogi, et al.(1982) also found that Suffolk lambs out-performed Targhee and Columbia lambs in growth. Suffolks reached market weight 18 and 25 days earlier than the Targhee and Columbia lambs, respectively. Clarke and Meyer(1982) stressed the importance of using Down breeds, such as the Suffolk, in crossbreeding programs for the production of market lambs. They reported that in New Zealand the larger Down breeds, like Suffolks and Hampshires, are now taking preference to the Southdown as the sire breeds for terminal crossbred lambs. This alteration of traditional breeding schemes has occurred because demand for leaner, heavier lambs has increased drastically.

The merits of Suffolk crossbred lambs have been documented in numerous reports. Solomon et al.(1980) reported that Suffolk x Rambouillet lambs had heavier weight per day of age and a higher percentage of muscle mass than Suffolk x Finn x Southdown lambs. They further reported that Suffolk x Rambouillet/Finnish Landrace did

have higher dressing percentages and quality grades than the Suffolk x Rambouillet lambs, indicative of the advantages some three-breed crosses have over two-breed crosses. Rastogi et al.(1982) also found that different three-breed crosses between Suffolks, Targhee, and Columbia parents were superior in performance to the two-breed crosses of similar parentage. Their report stated that three-breed cross lambs born to Suffolk ewes surpassed all other crosses in average daily gain before weaning, weaning weight, and age at market. Suffolk-Targhee x Columbia lambs were superior in post-weaning average daily gain. Hohenboken(1977) also reported that three-breed Suffolk crosses had superior yield grades, generally had less fat thickness, and had higher leg conformation scores when compared to three-breed Columbia crossbred lambs. Similar results were reported by Crouse et al.(1981), who concurred that Suffolk-sired lambs generally had leaner carcasses. However, they also reported that with the leaner carcasses came a yellow color to the fat and more pronounced secondary sex characteristics, which have been thought to be detrimental overall. These secondary sex characteristics and the greater physiological maturity of the Suffolk-sired lambs compared to Rambouillet-sired lambs were decidedly due to the increased weight of the Suffolk-sired lambs, since these differences were not evident when the data was adjusted for weight difference.

Though many references extoll the virtues of the Suffolk breed, the other domestic breeds used in the present study also have virtues which cannot be overlooked. A study by Hohenboken and Clarke(1981)of ewe productivity, with respect to lamb birth rates, survivability and amount of lamb weaned per ewe, showed that Columbia crossbred ewes

were more productive than Suffolk crossbred ewes under range conditions, and that the reverse was true on irrigated pastures. Over a five-year cumulative period, Columbia crossbred ewes on non-irrigated hill pastures had an average of 6.4 lambs, raised 83.4 percent of those lambs, and weaned a total of 136.2 kg of lamb. During this same time period and under the same management, Suffolk crossbred ewes only had 5.4 lambs, raised only 77.3 percent of their lambs, and weaned 114.1 kg of lamb. The poor performance of the Suffolk crossbreds was attributed to the poor pasture conditions beginning at mid-summer and continuing through early-autumn and an apparent unwillingness of Suffolk crossbreds to forage as aggressively as the Columbia crossbred ewes (Hohenboken and Clarke, 1981).

The only documented work which was available on the Cormo and its use in crossbreeding programs in the United States was a report by Jones (1986). He reported the production of a breeding program which utilized the Cormo after the first importation of Cormo in 1976. Under extensive management on western Colorado range, 1/4 Cormo x 3/4 Columbia crossbred lambs were as efficient in pre-weaning growth and had higher dressing percentages than lambs sired by Suffolk rams crossed with Columbia ewes. The three-breed cross using Cormo, Columbia, and Rambouillet parentage had higher 150-day weaning weights than either the Cormo or Columbia straightbred lambs. He also reported that the wool production from this "new breed" (Cormo x Columbia x Rambouillet) called "Hecho Merino" is higher quality than our territory wools. Hecho Merino wool averaged 19 to 22 microns,

had a staple length of 4"-5" in length, and a fleece yield of approximately 62.5 percent. These unique wool traits, and the reduced body size of Cormo crossbred ewes are quite desirable for the western range sheep industry. These traits could improve the quality of lamb and wool produced by western range sheep and thus increase the profitability of the range sheep industry. Researchers at Utah State University decided to use the Cormo in developing a crossbred ewe flock in 1980.

MATERIALS AND METHODS

Post-Weaning Performance Trial

Thirty-seven July-weaned wether lambs representing four genotypes were used in this study. The number of lambs in each group was as follows: eight Suffolk x Cormo/Columbia(Group 1; S x CoC), ten Suffolk x Cormo/Rambouillet (Group 2; S x CoR), eight Cormo x Columbia(Group 3; Co x C), and eleven Columbia straightbreds (Group 4; C x C). Lambs in groups 1 and 2 were raised at the Utah State University Animal Science Farm from Cormo x Columbia and Cormo x Rambouillet dams crossed with Suffolk sires. The lambs in groups 3 and 4 were provided by the Charles Redd Sheep Company of LaSal, Utah, and were raised through weaning on the Redd Ranch in Southern Utah.

Lambs were weaned at an approximate age of 90 to 120 days and were placed in the feedlot in the latter-part of August 1986. Prior to beginning the feeding trial, the lambs were shorn and treated for external parasites by using Ectrin(Cyano[3-phenoxyphenyl] methyl-4-chloro-alpha[1-methylethyl]benzeneacetate) insecticide in a pour-on solution. The lambs were also vaccinated for Clostridium perfringens types C and D and were treated for internal parasites by oral administration of Tramisol(levamisole hydrochloride). A three-week interim period was provided for the lambs to become adjusted to the new environment and feeding regime. The extended adjustment period was necessary since the lambs had been raised on forage-based diets as opposed to the concentrate-based ration utilized for the feeding trial.

The lambs were placed on a ration consisting of one pound of chopped long-stem alfalfa hay to maintain rumen integrity(Wiedmeier, 1986) and to meet the protein requirement. The balance of the ration consisted of a concentrate mix of 75 percent whole barley and 25 percent whole corn. The concentrate mix was fed at a rate of 1.15 kilograms per animal per day initially and then increased according to utilization as lamb appetites permitted.

Whole grains were used as opposed to rolled or chopped grains for three reasons. First, Canadian researchers have shown that lambs grow faster when fed whole-grain rations than when fed rolled or pelleted rations(Knapp, 1986). This is possibly due to the fact that the rate of passage from the rumen is slower with whole grains than with rolled or pelleted, thus allowing better utilization of the energy provided by the grain to the rumen microbes(Malechek, 1986). Second, by leaving the grain whole, the dustiness of the feed was greatly reduced. This led to increased palatability of the feed for the lambs and thus faster acceptance of the ration by the lambs. Third, the cost of the whole grain mixture was considerably less because of less handling required at the mill.

The lambs were fed in two groups with groups 1 and 2 being fed together and groups 3 and 4 being fed together. This was done because the lambs had been together in these groups for some time so a "pecking order" was already established, and the physical space was such that it was not possible for the lambs to be fed separately.

The total ration required for each pen was weighed and mixed daily and divided into two parts, for a morning feeding at approximately 7:00 a.m. MST and an afternoon feeding at approximately 5:00

p.m. MST. Each Monday afternoon, any feed that was not consumed was collected from the feeders, weighed back, and this weight was then deducted from the feed total for the respective pen for that week.

The lambs were weighed each Monday afternoon throughout the course of the trial. Lamb weights were taken on Monday so that those lambs which had reached the desired market weight could be slaughtered on Tuesdays at the Utah State University slaughter facility.

Post-Weaning Performance Traits

The following post-weaning performance traits were examined throughout the trial or calculated when the lambs had reached a market weight of 52 to 56 kilograms.

Feed Efficiency. Feed efficiency was measured as the kg of gain per kg of feed consumed for the two feeding pens. This was calculated by dividing the total weight which the individual lambs gained by the average consumption of feed within the respective feeding groups to the point at which that lamb was slaughtered.

Average Daily Gain. Average daily gain was calculated by dividing the total kilograms which each individual lamb gained during the trial by the number of days that individual was on the trial.

Feed Cost per Kilogram of Gain. Feed cost per kilogram of gain was calculated by dividing the total cost of feed consumed by the number of kilograms gained by that individual while on test.

Wool Growth per Day. Total wool growth for each lamb was determined by measuring the staple length from skin to the tip of the fibers with a backfat probe 15 cm from the backbone down the left side of each animal just prior to slaughter. This value was then

divided by the number of days the animal was on test.

Average Fiber Diameter and Distribution of Wool Fiber Population. Fleece Sample Collection. A 10 cm x 10 cm sample of wool was taken from the right side of each animal prior to slaughter using a pair of surgical scissors to cut the fibers as close as possible to skin.

Scouring Procedure. Each sample was agitated by hand for two minutes in a 500 ml beaker containing an 8 percent solution of Tergitol(Nonionic Surfactant NP-9)soap and water at a temperature of 55 degrees C. The samples were then rinsed for two minutes in water at a temperature of 45 degrees C. Upon completion of the scouring and rinsing, the samples were dried on a 1.25 cm screen rack.

Preparation of Slides. Small locks were taken at random from the scoured samples and were placed in a Hardy microtome. A thin-section of the wool fibers was then made and the slides were prepared according to ASTM standards(ASM, 1979).

Measurement of Fibers. The fiber bits were measured into cells on a wedge-scale for statistical analysis according to USDA and ASTM standards for objective testing of wool(USDA, 1966; ASTM, 1979).

Number of Days on Test. The number of days required for each animal to reach market weight was also recorded, with the first day of the trial being subtracted from the date when the lambs were slaughtered.

Carcass Processing

When the lambs reached a live, unshrunk weight of 52 to 56 kilograms they were slaughtered and processed at the Utah State

University Meats Laboratory.

After the lambs were slaughtered, the carcasses were chilled for a minimum of 48 hours before being processed and evaluated for carcass data. Immediately upon removal from the cooler, the carcasses were weighed and the chilled carcass weight recorded. The circumference of the leg was measured with a flexible tape measure as a measure of relative muscle mass in the hind saddle. At this time a subjective conformation score for the leg was assigned to be used in the determination of the carcass yield grade, and a quality grade was assigned to the carcass.

The hind and foresaddles were separated between the twelfth and thirteenth ribs. The loin-eye (Longissimus dorsi muscle) area was calculated by using a dot-grid, and the backfat thickness was measured. The kidney, heart, and pelvic fat was removed and weighed as an indicator of waste due to internal fat buildup. The carcasses were split into the following untrimmed primal cuts: five rib shoulder, seven rib rack, loin, leg, and the remaining cuts such as the flank, shanks, and breast. Weights were taken on each of these five groups of primal cuts.

After processing the primal cuts, the carcass was divided into the retail cuts. The shoulder was boned and rolled into a boneless roast. This included removal of the large mass of fat in the anterior portion of the shoulder on the dorsal side of the scapula. The rack was divided into 2.2 cm thick rib chops and riblets. The loin was also cut into 2.2 cm thick chops. Four 2.2 cm thick sirloin chops were cut from the leg and the rest of the leg was boned and

rolled into a boneless roast. The remaining cuts were boned and made into stew meat. The retail cuts were weighed together to give some idea of cutability of the carcasses.

Carcass Traits

Carcass Weight. The carcass weight refers to the 48 hour chilled carcass weight and is the total carcass weight prior to the removal of the internal fat(nearest 1/10 kg).

Backfat. Backfat was measured between the twelveth and thirteenth ribs using a steel backfat probe(nearest 1/100 cm).

Loin-Eye Area. Loin-eye(Longissimus dorsi) area in square cm was determined by using a dot-grid transparency which was placed over the loin-eye(nearest 1/10 square cm).

Kidney, Heart, and Pelvic Fat. The kidney, heart, and pelvic fat was removed from the carcass and weighed after the chilled carcass weight was determined. This weight was then converted to a percent of the overall carcass weight(nearest 1/100 percent).

Leg Circumference. The circumference of the hind leg was determined by measurement with a flexible steel tape at the widest portion of the leg(nearest hundredth cm).

Dressing Percentage. A dressing percentage was calculated for each carcass by dividing the chilled carcass weight by the live-shrunk weight taken prior to slaughter(nearest 1/100 percent).

Untrimmed Cuts. This represents the four primal wholesale cuts (shoulder, rack, loin, and leg) reported as a percentage of the total carcass weight. This figure excludes the cuts of lower economic value to the packer, such as the shanks, neck, flank, and

breast(nearest 1/100 percent).

Miscellaneous Cuts. Miscellaneous cuts represent those cuts excluded from the untrimmed cuts reported as a percentage of the total carcass weight(nearest 1/100 percent).

Trimmed Retail Cuts. The trimmed retail cuts represent the final saleable product from each carcass, reported as a percentage of the total carcass weight. The less-valuable cuts excluded from the untrimmed cuts were included in the trimmed retail cuts as stew meat(nearest 1/100 percent).

Yield and Quality Grades. A yield grade(1 to 5) was calculated for each carcass according to USDA guidelines(Boggs and Merkel, 1984). Quality grades were assigned to each carcass as the carcass was being processed in the meats laboratory. The USDA quality grades were then assigned numerical values so that they could be evaluated statistically. The assigned values ranged from 1, which was assigned to represent prime plus, to 9, which represented a good minus grade.

Statistical Analysis

A least squares analysis of variance was performed on the data. The birth date, reported in Julian days, the number of days on test, and the age in days at slaughter were held as covariates.

The model equation for evaluating the data, using the least squares method, was:

$$Y_{ij} = \mu + t_i + b_1x_1 + b_2x_2 + b_3x_3 + e_{ij}$$

where t =genotype groups, x_1 =days on test, x_2 =birth date, and x_3 =slaughter age in days.

RESULTS AND DISCUSSION

Post-Weaning Performance Trial.

Least-squares means for feed efficiency, reported as kg of gain per kg of feed (efficiency), average daily gain (A.D.G.), feed cost per kilogram of gain (Cost/Kg), wool growth per day (Wool/Day) and per kilogram of gain (Wool/Kg), and average fiber diameter (A.F.D.) and standard deviation (Wool SD) of wool are presented in Table 1.

Table 1. LEAST-SQUARES MEANS FOR PERFORMANCE TRAITS

Item	S x CoC		S x CoR		Co x C		C x C	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Efficiency (kg)	.128	.017	.150a	.021	.112	.013	.091a	.007
A.D.G. (kg)	.24a	.02	.29bd	.02	.18ab	.03	.16ad	.02
Cost/kg (\$)	.88a	.11	.75d	.11	.99	.11	1.21ad	.11
Wool/day (cm)	.05	.003	.043	.003	.048	.003	.05	.003
Wool/kg (cm)	.198a	.033	.154d	.028	.254b	.033	.32abd	.028
A.F.D. (microns)	23.98ad	.62	23.50be	.57	19.84cde	.63	21.43abc	.52
Wool SD (microns)	4.86de	.22	4.81fg	.20	3.40df	.22	3.44eg	.18

a,b,c Means with similar letters differ at (P < .05).

d,e,f,g Means with similar letters differ at (P < .01).

Differences in efficiency were exhibited between S x CoR and C x C (P < .05). Suffolk x Cormo/Rambouillet lambs had a feed efficiency of 150 g per kg of feed, and the C x C lambs only gained 91 g per kg of feed. This is probably due to the heterosis exhibited by the crossbred lambs, as the other crossbred groups tended to be more efficient than the purebred group, though these differences were not significant. Suffolk x Cormo/Columbia lambs excelled in average daily gain over C x C lambs (P < .05) with gains of 240 g and 160 g per day, respectively. Suffolk x Cormo/Rambouillet lambs also had

significantly higher A.D.G. over both Co x C and C x C lambs ($P < .05$), ($P < .01$), respectively. Suffolk x Cormo/Rambouillet lambs had daily gains of 290 g compared to Co x C lambs with 180 g and C x C with 160 g. This data is similar to reports by Dickerson et al. (1972) which stated relative growth rates of 115% for Suffolks compared to Hampshire, Dorset, Rambouillet, Targhee, Corriedale, and Coarse Wool crossbred lambs. Suffolk x Cormo/Columbia and S x CoR lambs also had significantly lower feed cost per kg of gain compared to C x C lambs ($P < .05$), ($P < .01$), respectively. This is a direct reflection of the kg of gain per kg of feed. However, this relationship is reversed when examining the wool traits.

The wool growth per kg of gain was significantly greater for C x C lambs compared to the S x CoC ($P < .05$), S x CoR ($P < .01$), and Co x C lambs ($P < .05$). The differences between the Columbia lambs and the Suffolk crossbreds can be explained in that the dual-purpose Columbia breed is known to grow a fairly long-stapled wool (8.75 cm to 12.5 cm), whereas the S x CoC and S x CoR lambs were 1/2 Suffolk which, being a meat-type breed, is known to be relatively short stapled (4.5 cm to 7.5 cm) (SID, 1983). However, it is unknown why the difference between Co x C and C x C groups exists, since both treatments are from wool-type breeds. Perhaps this difference is due to the relatively small numbers of lambs in each of the genotypes.

It is interesting that there were no significant differences between the genotypes for wool growth per day on test. This suggests that even though the Co x C and C x C lambs had more wool growth per kg of gain, the wool was not necessarily growing at a more rapid rate on a daily basis. This could be explained by several variables which

impact wool growth. Since the lambs in these two groups come from parentage known for wool production, they could be more efficient in producing wool versus meat. This is supported by the fact that they had significantly lower average daily gains than the Suffolk crossbred lambs and yet no differences in average daily wool growth. Since wool and muscle growth are competitors, the energy and proteins, especially the amino acid methionine, utilized by the wool follicles for wool growth are no longer available to the lamb for use in depositing muscle (McNeal, 1987). Furthermore, the Cormos and Columbias possess much denser fleeces than the Suffolks in general, and this density translates to an increased number of follicles per unit of area (McNeal, 1986). Even though the wool growth rates did not significantly differ, this increase in follicle numbers may have had a negative effect upon the deposition of muscle because of decreased protein and energy availability.

Average fiber diameter of the Co x C wool was 19.84 microns which was significantly finer [C x C, ($P < .05$); S x CoC and S x CoR, ($P < .01$)] than the wool of any of the other genotypes. The differences between the Co x C and the Suffolk crossbreds were because the straightbred parent breeds vary so greatly in fiber diameter. The Cormo averages between 19 and 23 microns, whereas the Suffolk may be as coarse as 33 microns. The Co x C lambs retained the fine fleece character of the Cormo, and the S x CoC and S x CoR lambs retained the coarser fleece and increased muscle growth characteristics of the Suffolk (Table 1) (Downie, 1986).

The differences which existed between the Co x C and C x C

groups were due to the wool characteristics of the Cormo being expressed through the crossbred lambs. This is supported by Downie(1986), who discussed the use of the Cormo in crossbreeding work in Australia. When Cormos were crossed onto other coarser-wooled sheep the resulting offspring retained the fleece character exhibited by the Cormo parent.

The within-fleece variability of fiber diameter was also significantly less for the Co x C and C x C lambs compared to both Suffolk crossbred groups ($P < .01$). Again, this is because the Suffolk fleece characteristics are so vastly different from those of the Cormo, Columbia, and Rambouillet, which represented the other 50% of the genetic contribution in the Suffolk crossbred lambs.

Intraclass correlations between performance traits and some carcass traits are presented in Table 2. Efficiency was correlated to daily gain ($P < .01$), meaning that as efficiency increased daily gain also increased. Thus, those animals which were most efficient in converting feed to gain were also the animals which possessed the highest average daily gain.

Feed efficiency was negatively correlated to the cost per kg of gain ($P < .01$). The cost figure is the feed cost per kg of gain, thus this is a cross-correlation, since relative data is being reported in a different manner for both variables and reflects a decrease in cost as the animals become more efficient, since less feed is required per unit increase in gain.

Feed efficiency also had a negative correlation of -0.79 with wool growth per kg of gain ($P < .01$). As the animals gained more per

Table 2. WITHIN-TREATMENT CORRELATIONS
FOR PERFORMANCE AND CARCASS TRAITS

Variable 1	Variable 2	Correlation Coefficient
Feed Efficiency	Daily Gain	0.89**
	Cost/kg Gain	-0.99**
	Wool/Day	0.13
	Wool/kg Gain	-0.79**
	Wool A.F.D.	-0.09
Daily Gain	Cost/kg Gain	-0.89**
	Wool/Day	-0.01
	Wool/kg Gain	-0.79**
	Yield Grade	-0.59**
	Quality Grade	0.08
Cost/kg	Internal Fat	0.38*
	Yield Grade	-0.50**
	Quality Grade	0.08
Wool A.F.D.	Wool SD	0.34*

* (P < .05)

** (P < .01)

kg of feed, the wool growth, in relation to that increase in efficiency, decreased. Those animals which were the highest wool producers were less efficient in converting feed to body growth. This is further supported in that daily gain was negatively correlated to wool growth per kg gain.

No significant correlations existed between either wool growth per day or average fiber diameter and efficiency.

The negative correlation between daily gain and yield grade demonstrates that those animals which had high daily gains were probably depositing muscle rather than fat, since the yield grade increases as backfat and internal fat increase and muscling decreases, according to the yield grade determination method outlined by Boggs and Merkel(1984).

Feed cost per kg of gain was significantly correlated to internal

body fat ($P < .05$) and thus to yield grade ($P < .01$). It gives further evidence that, as the excess feed intake is being converted to internal body fat, the animal becomes less efficient. There was no significant correlation between feed efficiency or feed cost per kg of gain and quality grade.

Carcass Traits.

Least-squares means for chilled carcass weight (carcwt), backfat thickness (backfat), loin-eye area (LEA), kidney, heart, and pelvic fat (KHP fat), leg circumference (leg), dressing percentage (dress %), untrimmed primal cuts (utcuts), trimmed retail cuts (trcuts), yield grade (ygrade), quality grade (qgrade), and miscellaneous untrimmed cuts (miscuts) are reported in Table 3.

Table 3. LEAST-SQUARES MEANS FOR LAMB CARCASS EVALUATION TRAITS

Trait	S x CoC		S x CoR		Co x C		C x C	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Carcass Wt. (kg)	22.73	.51	22.94	.47	24.83	.52	24.52	.43
Backfat (cm)	.38	.08	.35	.20	.55	.08	.53	.20
L.E.A. (sq. cm)	15.00	.56	15.00	.50	14.40	.56	13.80	.50
KHP Fat (%)	4.09	.49	4.42	.46	5.10	.50	4.52	.42
Leg Circum. (cm)	63.00	.65	63.20	.60	64.40	.65	64.00	.55
Dress % (%)	45.08	.93	45.21	.86	47.90	.94	47.70	.78
UT Cuts (%)	68.19	1.04	68.53	.96	69.48	1.05	68.94	.87
TR Cuts (%)	60.24	1.27	62.89	1.16	60.02	1.28	59.97	1.06
Yield Grade	3.24	.23	3.25	.21	3.64	.23	3.51	.19
Quality Grade	5.03	.43	5.06	.40	4.47	.44	4.86	.37
Mis Cuts (%)	27.37	.95	28.40	.87	26.20	.96	26.79	.80

a, b Means with similar letters differ at ($P < .05$).

c, d Means with similar letters differ at ($P < .01$).

No significant differences were found between treatments for any of the measured carcass traits. All lambs were fed out to approximately the same slaughter weight, which may explain the lack

of variation in carcass traits. Although the Co x C lambs appeared to have smaller skeletal frames, the composition of their carcasses was not significantly different from that of the larger-framed Suffolk crossbred and Columbia lambs.

Date of birth and age at slaughter did have a negative effect upon the amount of trimmed retail cuts which was produced by each carcass ($P < .05$). Those lambs which were born later, or slaughtered at an older age, did not yield as many kg of trimmed retail cuts as those born earlier in the year or slaughtered at a younger age.

Intraclass correlations between carcass traits are presented in Table 4.

Carcass weight was highly correlated to the loin eye area and leg circumference ($P < .01$). The leg and loin make up much of the overall muscle mass of the carcass, as much as 49 percent of the total carcass weight, and approximately 60 percent of the untrimmed primal cuts (Romans, et al., 1985). Carcass weight was also highly correlated to the dressing percentage ($P < .01$), since the carcass weight is used in calculating the dressing percentage.

A positive correlation was found between carcass weight, backfat, and yield grade ($P < .05$). This suggests that, as the carcass weight increases, so does the external body fat and the yield grade. However, Hawkins et al. (1985) reported lambs which produced heavier carcass weights had less internal and external fat than lambs which produced lighter carcasses. No significant correlation was found between internal body fat and carcass weight in this study.

A negative correlation of -0.54 was found between carcass

Table 4. WITHIN-TREATMENT CORRELATIONS
FOR CARCASS CHARACTERISTICS

Variable 1	Variable 2	Correlation Coefficient
CarcWt	Backfat	0.37*
	LEA	0.43**
	Leg	0.55**
	Dress %	0.87**
	Yield Grade	0.36*
Backfat	Quality Grade	-0.54**
	Yield Grade	0.84**
LEA	Quality Grade	-0.51**
	Leg	0.52**
KHP Fat	UTCuts	-0.44**
	TRCuts	-0.51**
	Yield Grade	0.65**
Leg	Quality Grade	-0.29
	Dress %	0.36*
	Yield Grade	0.16
Dress %	Quality Grade	-0.43**
	Yield Grade	0.19
UTCuts	TRCuts	0.56**
TRCuts	Yield Grade	-0.35*
	Quality Grade	0.18
Yield Grade	Quality Grade	-0.60**

* (P < .05)

** (P < .01)

weight and quality grade (P < .01). Body fat content increases yield grade and leads to higher USDA quality grades (Boggs and Merkel, 1984).

Backfat thickness was positively correlated to yield grade and negatively correlated to quality grade (P < .01). Backfat thickness is used to calculate yield grade. Furthermore, a minimum of approximately .33 cm external fat covering is required for a lamb carcass to grade choice or prime, so an increase in backfat will increase the quality grade toward the prime grade, which is reported as a smaller number (ie. Prime + = 1, vs. Choice - = 6)(Boggs and

Merkel, 1984).

Loin-eye(Longissimus dorsi) area and leg circumference were positively correlated($P < .01$), since both are indicators of the overall muscle content of the carcass(Romans et al., 1985). Crouse et al.(1981) also reported significant increases in both loin-eye area and leg conformation scores in their evaluation of Suffolk- and Rambouillet-sired lambs.

Internal fat content was positively correlated to the yield grade ($P < .01$). Kidney, heart, and pelvic fat is one factor used to determine the yield grade, and as internal fat content of the carcass increases, yield grade also increases. However, no significant correlation existed between internal fat and quality grade.

The internal fat was negatively correlated with both the un-trimmed primal cuts and the trimmed retail cuts ($P < .01$). For every 1 percent increase in internal fat, untrimmed primal cut weights decreased .44 kg and trimmed retail cut weights decreased .51 kg. Lambs which produced the highest amount of both primal and retail cuts deposited less internal fat in proportion to the muscle deposition. Bidner et al.(1978) reported similar findings in a study of crossbreeding using Suffolk x, Hampshire x, and Rambouillet x Louisiana Native ewes to produce market lambs. They reported that Suffolk crossbred lambs had higher cutability scores and less internal fat than Rambouillet crossbred lambs.

Circumference of the leg was positively correlated with dressing percentage ($P < .05$) and was negatively correlated to the quality grade ($P < .01$). This suggests that the lambs with larger muscle mass in the hindsaddle had higher dressing percentages and also

scored higher in quality grade since smaller quality grade values represent better carcass quality. Crouse et al. (1981) found that lambs with significantly higher leg conformation scores also had higher quality grades. Dickerson (1975) reported lambs with high leg conformation scores also excelled in dressing percentage.

Trimmed retail cut weights were positively correlated with the untrimmed primal cut weights ($P < .01$). For each kg increase in untrimmed primal cut weight, trimmed retail cut weight increased .56 kg. The retail cuts are derived from the primal cuts, and thus, as the weight of the primals increases, the amount of retail cuts should also increase. The reason this correlation is not higher between these two variables could be because the miscellaneous cuts such as the shanks, flank, and breast are included in the retail cuts but not in the primal cuts.

There was a negative correlation of -0.35 between the trimmed retail cuts and yield grade ($P < .05$). Yield grade represents the cutability of the carcass which reflects the degree of fatness on the carcass, most of which is trimmed away during the cutting process and deducted as waste. No significant correlation between retail cuts and quality grade was found.

CONCLUSIONS

Post-Weaning Performance Trial.

Overall, the data collected in this study demonstrates that the lambs from the crossbred treatments performed as well, or better than, the purebred lambs representing the normal western white-face lambs. During the post-weaning performance trial the crossbred groups tended to have higher feed efficiency and average daily gains and lower cost per kg of gain, although significant differences were not exhibited for all these traits between all crossbred groups and the purebred group. The C x C lambs excelled in the length of wool grown per kg of gain. However, the Co x C lambs had significantly finer wool than the C x C group. This greater wool production of the white-face lambs was manifested because these lambs were the offspring of breeds developed for wool production.

Carcass Traits.

There were no significant differences for any of the carcass traits evaluated. Thus, the carcasses for retail sale from the crossbred lambs were equal in quality and quantity when compared to the standard represented by the purebred Columbia lambs.

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APPENDICES

APPENDIX A

Feeding trial data sheet completed for each lamb on the trial.

USU SHEEP CROSSBREEDING STUDY
POST-WEANING FEED TRIAL DATA SHEET
1986 LAMB CROP EVALUATION

CARL KIM CHAPMAN
UTAH STATE UNIVERSITY
DEPARTMENT OF ANIMAL, DAIRY, AND VETERINARY SCIENCE
LOGAN, UTAH

_____ LAMB NUMBER
_____ SLAUGHTER DATE
_____ NUMBER OF DAYS ON TEST
_____ BEGINNING WEIGHT
_____ SLAUGHTER WEIGHT
_____ TOTAL WEIGHT GAINED ON TEST
_____ TOTAL FEED CONSUMED WHILE ON TEST
_____ WOOL STAPLE LENGTH(INCHES/CM)
_____ AVERAGE FIBER DIAMETER(MICRONS)
_____ WOOL STANDARD DEVIATION

APPENDIX B

Carcass evaluation data sheet completed for each lamb at the time the carcass was processed.

USU SHEEP CROSSBREEDING STUDY
CARCASS EVALUATION DATA SHEET
1986 LAMB CROP EVALUATION

CARL KIM CHAPMAN
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LOGAN, UTAH

_____ LAMB NUMBER

_____ 48 HOUR CHILLED CARCASS WEIGHT

_____ LEG CONFORMATION SCORE

_____ CIRCUMFERENCE OF LEG

_____ BACKFAT THICKNESS OVER LOIN EYE
BETWEEN 12TH AND 13TH RIBS

_____ LOIN EYE AREA

_____ WEIGHT OF KIDNEY, HEART, AND PELVIC FAT

_____ 5 RIB SHOULDER WEIGHT

_____ 7 RIB RACK WEIGHT UNTRIMMED

_____ LOIN WEIGHT WHOLESAL

_____ LEG WEIGHT CUTS

_____ WEIGHT OF OTHER CUTS

_____ TOTAL WEIGHT OF TRIMMED RETAIL CUTS
(INCLUDES BONED SHOULDER AND LEG ROASTS, LOIN AND
RIB CHOPS, BONE-IN SIRLOIN CHOPS, RIBLETS, AND STEW MEAT)

_____ CARCASS QUALITY GRADE(INCLUDING + OR - SCORE)

_____ CARCASS YIELD GRADE(CUTABILITY GRADE)

APPENDIX C

Additional Readings

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