A STUDY OF LAMB GROWTH PERFORMANCE TRAITS: I. EFFECT OF SEASON OF BIRTH; II. TRANSMITTED EFFECT OF PUREBRED VS. CROSSBRED RAMS

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CHAPTER I

INTRODUCTION

In order to make raising sheep more competitive and profitable, the sheep industry needs to improve its efficiency of production. Two areas of research in which possible improvement of efficiency of sheep production could be made are the selection of certain breeds or breed combinations for ewes and rams and accelerated lambing.

In the selection of certain breeds or breed combinations and advantages of crossbreeding have been known for several years. Several workers have reported improved performance of crossbred dams and offspring over that of straight bred ewes and lambs. However, few reports have been published comparing crossbred and purebred rams regarding the performance of their offspring. The question of how the growth performance of crossbred and purebred sired lambs will compare is relatively unanswered.

Lambing twice in one year or lambing three times in two years are two systems of accelerated lambing under investigation. Lamb growth for lambs born twice a year has been characterized. It was reported that spring-born lambs were heavier at birth and weaning than fall born lambs. However, fall-born lambs gained faster from weaning to market and were marketed at an earlier age than were spring-born lambs.

Lambing three times in two years could result in lambs born in the fall, winter and summer. Comparisons of lambs, born in these seasons, for their growth performance has not yet been published.

The purpose of this study was to: I. compare the growth performance and variability of lambs sired by crossbred and purebred rams; and to II. compare the growth performance of lambs born during fall, winter and summer seasons.

CHAPTER II

LITERATURE REVIEW

This review is concerned with lamb growth traits and will be divided into two major sections. The first section is a discussion of seasonal effects on growth traits. Secondly the comparison of crossbred and purebred sires for performance and variability of growth traits of their progeny will be presented.

Seasonal Variation of Growth Traits

Recently, consideration of seasonal differences in growth measurements for lambs has resulted from accelerated lambing programs. Blackwell and Henderson (1955) compared Dorset lambs born in the spring and fall using data collected during the period 1930 to 1952. Seven-hundred and 485 records were available for birth weight and late-weaning weight, respectively. Spring-born lambs on the average weighed 0.40 $\pm$ .14 lb more at birth than did fall-born lambs. Spring-born lambs were also heavier (2.85 $\pm$ 1.192 lb) than fall-born lambs at weaning.

Dun et al. (1960) also reported seasonal difference in lamb growth. Higher 120-day weaning weights were usually found for autumn mated versus spring mated Peppin Merino ewes (table I). However, body weight at 17 months were similar.

Gould and Whiteman (1971) compared performance of spring versus fall-born lambs using ewes which were Dorset, Rambouillet and the cross

TABLE I

WEANING WEIGHTS FROM AUTUMN
AND SPRING MATINGS[a]

	Autumn Mated				Spring Mated			
Year	DF	Weaning Weight Mean	S.E.	First Day Of Mating	DF	Weaning Weight Mean	S.E.	First Day Of Mating
1953	92	41.7	0.8	March 30	50	48.8	1.2	Sept. 22
1954	105	59.2	0.8	March 23	66	58.5	1.0	Oct. 13
1955	68	61.7	1.1	March 22	71	37.6	0.9	Aug. 31
1956	32	71.9	1.3	March 4	71	48.8	0.8	Oct. 2
1957	89	58.6	0.8	Feb. 27	53	66.9	1.2	Sept. 2
1958	129	54.4	0.7	March 3	73	62.8	0.8	Sept. 3

[a]Source: Dun R.B. et al. 1960. Australian J. Agri Res: 11:805

of the two breeds. The breeding seasons were from April 20 to June 19 in the spring and from October 20 to December 19 in fall. Data were collected on fall-born lambs from 1964 through 1968 and on spring-born lambs from 1965 through 1968. Creep feed was available to all lambs from 10 days of age to weaning, at approximately 70 days of age, at which time the lambs were full fed until marketed. Hampshire, Suffolk and Dorset rams sired the lambs. The number of lamb records available for analysis for birth weight, 70-day weight and rate of gain from 70 days of age to market for spring and fall lambing seasons were: 1100, 980, 922; and 482, 407, 395, respectively. Spring-born lambs weighed 4.30 ± .06kg at birth while fall-born lambs weighed 3.36 ± .09kg. Spring-born lambs aslo weighed 27.16 ± .20kg at 70 days of age while fall-born lambs averaged 24.62 ± .28kg. However, rate of gain 70 days to market was 0.24 ± .003kg for fall-born lambs and 0.18 ± .05kg for spring-born lambs. An explanation for differences in rate of gain was the difference of outside temperature during the feeding periods. Spring-born lambs were finished during normally warm summer months while fall-born lambs were finished during cool late fall and early winter months.

Shelton (1968) reported lamb growth data which favors winter lambing, for producers in the southern area of the United States. Table II shows lamb gains which were recorded at McGregor, Texas under natural grazing conditions. It is important to note this does not indicate how lambs may perform under an improved feeding system. Two other researchers, Ospanov et al. (1978) and Orkiz and Un (1978) in separate trials found that lambs born outside of the natural lambing season and lighter birth and weaning weight.

TABLE II

GAINS FOR LAMBS AT MCGREGOR, TEXAS
UNDER NATURAL GRAZING
CONDITIONS[a]

Season	Lamb Number	Birth Weight	120 Day Weight
Winter	919	9.2	77.7
Spring	418	9.0	56.2
Summer	303	8.2	52.0
Fall	4404	7.9	71.3

[a]Source: Shelton (1968) In Proceeding Symposium Physiology of Reproduction in Sheep

Temperature

Seasonal changes in birth weight may be directly involved with changes in temperature. Shelton (1964) subjected 24 mated ewes to two different controlled temperature chambers. Twelve were placed in a facility where the temperature ranged from 100 to 105^{o}F, with the other twelve in a cooler facility, temperature range 75 to 80^{o}F. Nine of each group lambed with a total of 15 and 11 lambs born for the cooled and heated facilities, respectively. Significant differences between birth weight occurred only for twin lambs where actual mean birth weights were 7.6 and 6.0 lb for the cooled and heated facilities. A insignificant difference in birth weight of .06 lb in favor of the cooled treatment ewes was recorded for single born lambs.

Yeates (1956 and 1958) doing similar studies found statistically significant differences in birth weights. In two separate experiments, ewes kept in cooled confinement had heavier lambs (1 lb 13 oz and 2 lb 13 oz, $p < .001$) at birth than those ewes exposed to high temperatures during gestation.

Seasonal differences in weaning weight may be due to differences in birth weights. Harrington _et al._ (1958) estimated some sources of variation in body weight at different ages using two years of lambs data from May, June and July matings of Rambouillet and RambouilletXPanama - Rambouillet ewes and Dorset rams. He found the partial regression coefficient for subsequent weights on birth weight to increase from $1.5 \pm .20$ lb (p .01) at 45 days to $2.6 \pm .47$ lb ($p \leq .01$) at 135 days of age for the first year. The following year the regression coefficient increased from 2.0 $\pm$ .21 lb ($p \leq .01$) to 3.0 + .41 lb ($p \leq .01$) at 45 and 135 days, respectively. Therefore, this suggests that lambs born during seasons which result in low birth weights may also have lower weaning weight.

Grazing

Patterns of grazing behavior may also affect lamb growth, when pasture is an important source of feed. Seasonal differences in forages available and actual grazing may account for some seasonal differences in lamb and actual grazing may account for some seasonal differences in lamb growth. Asiedu (1978), studying the grazing behavior of sheep in Ghana found differences in the amount of grazing activity during wet and dry seasons. Temperature and rainfall were not related to the sheep's activity, but grazing time was positively correlated with hours of sunshine.

Summary

Season of birth is expected to influence birth weight, weaning weight and ADG from weaning to market in sheep. Birth weights have been shown would be expected to be highest during the normal lambing season. Weaning weights would be expected to follow a similar pattern to those of birth weight. Last of all, ADG from weaning to market for different seasons may or may not rank similar to the above two traits.

Crossbred vs. Purebred Sires for Progeny Performance

Only a few papers have been published comparing purebred and crossbred sires for performance of their offspring. Specifically, papers reporting comparisons for growth traits and/or the variability of growth traits for progeny from purebred and crossbred sires will be reviewed.

Other Species

Rempel et al. (1964) compared the performance of pigs sired by "purebred" and "crossbred" boars. Breeding stock consisted of Minnesota number 1's, Minnesota number 2's and Minnesota number 3's as "purebred" sires and 1/2 Minnesota number 2's and Minnesota number 3, 1/4 Minnesota number 2, 1/4 Minnesota number 1 as "crossbred" sires. Only Minnesota number 1's were used as dams. Two-hundred and thirty-six pigs from crossbred sires and 221 pigs from purebred sires were utilized. Differences in performance between progeny of purebred and crossbred sires were found only for daily gain and backfat thickness. Feedlot daily gains for the progeny were 1.85 $\pm$ .012 lb and 1.91 $\pm$ .013 lb with backfat thickness being 1.84 $\pm$ .023 in. and 1.74 $\pm$ .023 in. for crossbred and purebred sires, respectively. This is a slight advantage for the purebred boars. The variance of progeny performance was slightly more for the crossbred sires than the purebred sires.

Baker (1973) also compared purebred and crossbred boars using 180 crossbred gilts. Total litter weights were higher at birth (0.61kg) and at 28 days (1.9kg), for crossbred boars, however, the differences were not statistically significant. When comparing individual piglet weight at birth and 28 days, the progeny of the two types of boars performed similarly. In another study involving swine, Lishman et al. (1975) investigated the comparative performance of purebred and crossbred boars in commercial pig production. Twenty cooperating farms received boar trios which were either:

1 Large White	or	1 Landrace
1 Large White x Landrace		1 Landrace x Large White
1 Hampshire x Large White		1 Hampshire x Landrace

Boars within a trio were usually half sibs. Seventeen of 20 farms yielded satisfactory litter data, which included at least six litters per boar. No statistically significant differences between progeny sired by purebred (164 litters) and white crossbred boars (184 litters) were found for total litter birth weight (0.15kg), piglet birth weight (0.00kg) or weight at 35 days (0.07kg). Variation of individual piglet weights at birth and 35 days was slightly less for progeny from crossbred sires, but the differences were not statistically significant.

One drawback of these three studies is that the average gene pool of the offspring by crossbred and purebred boars was often quite different. This may result in confusing results when trying to determine differences between the two types of boars.

Lamb Studies

Bradford et al. (1963) developed an experiment specifically to compare the offspring of crossbred and purebred rams. Hampshire, Suffolk and Hampshire x Suffolk rams were mated to ewes which were white faces of mixed breeding, predominantly Corriedale. In addition to the university based flock, rams were also used in four cooperator's flocks. The university's flock was evaluated for two years, with the breeding season being

August 7 to September 20. Birth weights were compared only for the university's flock while weaning weights were compared for the university's and three of the cooperator's flocks. Birth weights were recorded on 140 crossbred sired lambs and 282 purebred sired lambs. The number of records available for weaning weight, presented for crossbred and purebred sired lambs are shown in table III. Means and variances were also reported for the two traits.

Cossbred sired progeny had birth weights (10.00 lb) similar to the midparent breed average (9.98 lb). Variability of the birth weight changed rank during the two years. However, on the average the crossbred sired lambs were slightly less variable than the purebred sired lambs(2.10 and 2.20, respectively). Weaning or 120-day weight means and estimates of the variance are shown in table III. Crossbred sired lambs were slightly heavier in four out of five comparisons for weaning weight. The difference of 1.8 lb for the university flock approached significant ($p \leq .10$). Data from the cooperator's flocks indicated a smaller difference. Variance of the 120-day weight indicated greater uniformity for crossbred-sired offspring in the university's flock, however, the difference between the variances for the purebred and crossbred sired progeny was not statistically significant. The pooled variance from the cooperator's flocks indicated the crossbred sired progeny were slightly more variable than purebred sired progeny.

Sidwell et al. (1964) did a crossbreeding experiment involving Hampshire, Shropshire, Southdown and Merino, plus one strain evolved from a Columbia - Southdale cross. Utilizing 47

TABLE III

120-DAY WEIGHT MEANS AND VARIANCES FOR PROGENY FROM PUREBRED AND CROSSBRED RAMS[a]

		Purebred			Crossbred		
Flock	Year	Number	Mean	S^2	Number	Mean	S^2
University	1960	100	69.1	44.4	58	72.3	61.6
University	1961	128	$\frac{76.1}{72.6}$	$\frac{75.4}{59.9}$	69	$\frac{76.6}{74.4}$	$\frac{44.6}{52.3}$
Cooperators							
II		43	84.3	73.0	22	84.8	132.8
III		59	92.3	58.0	38	90.2	48.5
IV		70	$\frac{73.8}{83.5}$	$\frac{82.3}{71.1}$	25	$\frac{76.5}{83.8}$	$\frac{51.2}{77.5}$

[a]Source: Bradford _et al_. 1963 J. Anim. Sci. 22:617

lambs produced by mating crossbred rams and Merino ewes and 167 lambs from purebred sires and Merino ewes, birth weight and weaning weight of progeny sired by the two types of rams were compared. The crossbred sired progeny had higher birth weights (8.12 lb vs. 7.78 lb) and weaning weight (55.5 lb vs. 52.4 lb) than did the purebred sired progeny.

Bidner et al. (1978) compared growth traits for lambs sired by Suffolk, Rambouillet and Suffolk x Rambouillet rams. Rams were mated to Louisiana Native, Hampshire x Native, Rambouillet x Native and Suffolk x Native ewes. When comparing 232 purebred and 134 crossbred sired lambs, it was revealed that crossbred sired progeny were significantly smaller at birth (-.17kg; $p < .05$) and gained slower after weaning (-10.5 g/day; $p < .05$). However, the author did feel limited credence should be placed on the slower growth of the crossbred sired lambs because of the small sire sample and because the cross rams and purebred Suffolk rams were from different sources. Table IV shows the variance associated with birth weight, weaning weight and feedlot ADG. The crossbred sired lambs were less variable in two of the three traits. The author did not include a test of significance in the paper.

Ram comparisons were also made by Vesely and Peters (1979). They reported that lamb growth performance of certain pure breeds are their 2-, 3- and 4-breed crosses. The four breeds involved in the experiment were Romnelet, Columbia, Suffolk and North Country Cheviot breeds. Crossbred rams were mated only to crossbred ewes, which resulted in 611 weaning weight records for four breed cross lambs. Purebred rams were mated to purebred and

TABLE IV

POOLED VARIANCES BY SIRES WITHIN BREED FOR LAMB GROWTH[a]

Trait	Breed of Sire	Number	Variance
Birth Weight, kg	Rambouillet	103	1.02
	Suffolk	129	0.98
	Suffolk x Rambouillet	134	1.06
Weaning Weight, kg	Rambouillet	85	8.75
	Suffolk	107	9.66
	Suffolk	107	6.90
Feedlot ADG, g	Rambouillet	79	1397.00
	Suffolk	104	1383.00
	Suffolk x Rambouillet	101	896.00

[a]Source: Bidner et. al. J. Anim. Sci. 47:114

crossbred ewes resulting in growth trait records from 126 purebred lambs, 375 two breed cross lambs and 622 three breed cross lambs. The average growth performance of lambs by crossbred rams was similar to that of lambs sired by purebred rams. The purebred sired lambs were slightly heavier (.04kg) at 110 days than the crossbred sired lambs. However, the crossbred sired lambs had a higher (.29kg) post-weaning gain.

Genetic Theory

Falconer (1976) writing about inbreeding reported that the variance for inbreds is often greater than that for hybrids even though the expected genetic variance would be less. This decrease in phenotypic variance was attributed to the greater susceptibility to environmental variation of inbred individuals. The cause of the greater environmental variance is not fully understood. Crossbred sired offspring would be expected to have greater genetic variability than purebred sired offspring. However, whether or not the phenotypic variability for crossbred sired progeny is different than purebred sired progeny is still questionable.

Summary

There have been many conflicting reports of comparison of crossbred and purebred sired progeny. The conflicting reports may be partly due to the sources of experimental data and the complexity of analyzing such data. However, differences in growth performance traits have generally been small. Results comparing variability of offpring from crossbred and purebred sired indicate that the crossbred sired progeny probably would have equal or only slightly greater variability than those sired by purebreds.

CHAPTER III

EFFECT OF SEASON OF BIRTH ON LAMB GROWTH PERFORMANCE TRAITS

Introduction

In order to maximize net profits from the present flocks, the sheep industry needs to improve its efficiency of production. Currently research is being undertaken to determine the feasibility of accelerated lambing. Two proposed accelerated lambing schedules would be to lamb twice a year or to lamb three times in two years. This would result in lambs being born during several different times of the year. Blackwell and Henderson (1955) and Gould and Whiteman (1971) reported that spring born lambs were heavier at birth and at weaning than were fall born lambs, with the fall born lambs reaching market weight at an earlier age than the spring born lambs. However, no information is available directly comparing winter, summer and fall born lambs produced on an accelerated lambing schedule involving eight month intervals.

The purpose of this study was to compare lambs born during three different seasons, fall (Oct.-Nov.), winter (Jan.-March) and summer (June-July) for their growth performance when fed similarly. The growth traits studied were birth weight, 70 day weaning weight and ADG during the weaning to market period.

Materials and Methods

Experimental animals

Data from lambs produced from the fall of 1974 to the winter of 1979 were utilized. Ewes rearing these lambs were produced in March and April of 1971 and 1972 at the Southwestern Livestock in Forage Research station, El Reno, Oklahoma. The ewes were five combinations of Rambouillet(R), Dorset(D) and/or Finnish Landrace(F) sheep. They were 1/4F1/2D1/4R, 1/4F1/4D1/2R, 1/4F3/4R,1/2D1/2R and 1/4D3/4R. The breed combinations and matings used to produce these ewes, have been reported by Thomas and Whiteman (1979). At the start of this study 246 3 and 4 year old ewes were available for breeding.

In the experiment being discussed another study was imposed to compare crossbred and purebred rams. There were two rams of each of the Hampshire and Suffolk breeds and four rams representing the two reciprocal crosses used to sire lambs each season. To insure the crossbred and purebred rams would be paternal half sibs, individual sheep producers were contracted to produce the rams.

Generally three rams of each pure breed and five crossbred rams were purchased each year when they were approximately 4 months old. The rams were developed for breeding at a minimum age of 16 months. Before mating, the rams were electroejaculated and the semen evaluated microscopically to select those rams which appeared most fertile. A total of 37 rams were used during the seven seasons. Only five rams were used twice during the first four seasons. The data from only two of the last three seasons were utilized with only ten rams producing lambs during those two seasons.

The mating schedule and resulting lambing seasons are shown in table V. Breeding seasons lasted about 50 days, with approximately 30-36 ewes per ram. Usually about five ewes of other breed groups were included in each of the breeding groups. The ewes in this study were allotted among the rams by breed combination of the ewe (BOD) and number of lambs reared in the previous season. Lambing seasons were classified as fall (Oct.-Nov.), winter (Jan.-March) and summer (June-July).

Ewes were kept in adequate flesh, with increased body weight gain through gestation during all seasons. The ewes were allowed access to whatever pastures were available at the time and were supplemented with alfalfa hay and milo before lambing to help meet their nutritional requirements. Supplemental feeding of the ewes was continued through lactation so that normal lamb growth could be attained. During the fall and winter lambing seasons, ewes grazed wheat pasture and were allowed dry hay and .22-.45kg of milo per head per day during lactation. Summer lambing ewes grazing sweet sudan, pearl millet pasture and/or alfalfa pastures were supplemented as needed with grain and hay to meet their nutritional needs for lactation.

The lambs were managed and fed similarly during the three seasons. A ground mixed creep feed consisting of 50% sorghum grain (4-04-383), 35% alfalfa hay, 10% soybean meal (5-04-600) and 5% sugarcane molasses (4-04-695) was available for the lambs after they reached approximately 10 days of age. After weaning, when the average weight of the lambs reached approximately 27kg the ration was changed by placing the 10% soybean meal with 10% alfalfa hay which was self fed. Lambs were allowed to graze

TABLE V

BREEDING SCHEDULE AND RESULTING LAMBING SEASON

Year	Breeding Season	No. of Ewes Available	Lambing Season	Lambing Year
1974	May 15-July 2	246	Fall	1974
1975	May 14-July 3	239	Fall	1975
1976	Jan. 15-March 5	226	Summer	1976
1976	Sept. 15-Nov. 4	222	Winter	1977
1977	May 16-July 13	218	Fall	1977[a]
1978	Jan. 5-Feb. 24	203	Summer	1978
1978	Aug. 25-Oct. 10	199	Winter	1979

[a]Due to the complexity of the analyses, data from this season was deleted because of the low numbers of lambs born resulting in an incomplete coefficient matrix.

wheat pastures with their dams during the fall and winter seasons. During the summer season lambs grazed with their dams until weather and pasture conditions made it more beneficial to keep the lambs in dry lot.

Lamb birth weights were recorded within 8 hours of birth. Biweekly weights were collected after the first lambs of each season reached 45 days of age until all lambs were marketed. Lambs were weaned within 7 days of 70 days of age by removing the dam from the flock. Lambs were marketed after they had reached the minimum weight of 43.1kg. The biweekly weight provided 70-day weights (estimated by interpolation) and average daily gain for the period from 70 days to market. Table VI shows the number of records available for analysis. Due to the complexities of the analyses, data from the fall of 1977 were deleted because the low number of lambs available resulted in an incomplete coefficient matrix making the validity of the analysis questionable. Lambs which were noticeably ill were deleted from analyses of 70-day weight and ADG Many lambs were sold or allotted to other experiments after birth resulting in the considerably lower number of lambs available for 70-day weight and ADG analyses as indicated in table VI. Ram lambs were left intact.

Statistical Analyses

Known variables having an effect on birth weight, weaning and ADare sex, number of lambs per ewe and breed and age of ewe. In the preliminary analysis done for each lambing season, year and class of sire (purebred or crossbred) classification, terms for each breed combination of ewe (BOD), sex, type of birth and

TABLE VI

NUMBER OF BIRTH WEIGHTS, WEANING WEIGHTS AND ADG (70-DAYS TO MARKET) RECORDS AVAILABLE FOR ANALYSIS OF SEASONAL DATA

	Fall			Winter			Summer		
Variable	BW	70DW	ADG	BW	70DW	ADG	BW	70DW	ADG
Overall	457	316	314	510	232	162	640	470	394
Year[a]									
1	223	160	158	347	134	109	332	263	225
2	234	156	156	163	98	53	308	207	169
Breed of Dam[b]									
F D R	90	56	55	115	43	28	150	108	92
F D R	83	59	59	86	38	27	119	88	67
D R	115	85	84	115	48	32	135	103	90
D R	113	70	70	114	63	46	137	102	76
F R	56	46	46	80	40	29	99	69	69
Sex									
Female	236	193	191	245	115	80	307	223	203
Male	221	123	123	265	117	82	333	247	191

TABLE VI (Continued)

	Fall			Winter			Summer		
Variable	BW	70DW	ADG	BW	70DW	ADG	BW	70DW	ADG
Birth Type									
Single (S)	180	-	-	99	-	-	145	-	-
Twin (T)	262	-	-	340	-	-	447	-	-
Triplet	15	-	-	71	-	-	48	-	-
Birth-Rearing Type									
S-S	-	118	118	-	30	19	-	118	92
T-S	-	14	13	-	18	8	-	25	18
T-T	-	184	183	-	184	135	-	327	284

[a]Year 1= 1974-fall 1976-summer 1977-winter
2= 1975-fall 1978-summer 1979-winter

[b]Breed of Dam F=Finnish Landrace D=Dorset R=Rambouillet

sire, plus all two way interaction terms were included (tables XIX-XX). Age of the dam was not included because the ewes were considered to be mature at the beginning of this study. This analysis was to help to determine what possible two way interactions were present and to help simplify later analyses.

From the second model least square means and standard errors were calculated for birth weight, weaning weight and ADG (tables XXXIX-XLVII) by pooling the data over years and class of sire within each lambing season (fall, winter, summer). This model included terms for year; class or sire; breed or sire nested within class of sire; sire nested within breed of sire, class of sire and year; BOD; sex; birth type; and the interaction terms of the preliminary model which approached significance ($p \leq .1$) plus all two way interactions including year or class of sire for each season classification.

The mean squares for sire within breed of sire were used for the demoninator for testing year, class of sire, sire breed, year x class of sire and year x sire of breed. All other terms were tested with the residual mean squares. Interactions which were not statistically significant and sire were deleted from the model so least square means and standard errors for birth weight could be calculated.

The last model was an overall analysis to determine what main variables interacted with season of birth. (table XLVIII). The model included all the main effect used in the model for calculating the least squares means, plus season of birth and all two interaction terms including season of birth. Again the mean squares for sire were used to test for season, year, class of sire and sire breed differences and interactions between these four terms. All other main variables and interactions were tested with the residual mean squares.

Models for 70-day weight and ADG (70 days to market) were similar to the above three models except type of birth was replaced with birth-rearing type. All analyses were done using the general least squares method of the Statistical Analysis System developed by Barr and Goodnight. (1979). Individual means within seasons were tested by the least significant difference method.

Results and Discussion

Figure 1 illustrates growth from birth to market for fall, winter and summer-born lambs. Differences in birth weights due to season were statistically significant (P=.001). Winter-born lambs were .23kg heavier at birth than summer-born lambs and 1.28kg heavier than fall-born lambs. The least square means and standard errors are presented in table VII. These results generally agree with reports from other workers. Gould and Whiteman (1971) reported spring lambs were .94kg heavier at birth than were fall-born lambs from Dorset, Rambouillet and DorsetXRambouillet ewes. The Sheepman's Production Handbook (1977) reported data of lambs reared near McGregor, Texas. Season of birth was ranked winter, spring, summer and fall for birth weight. The seasonal differences found from this data in birth weight may be partly due to differences in temperature during gestation. Atmospheric temperatures were generally lower during gestation for winter and summer-born lambs than for fall-born lambs. Yeates (1958) reported ewes exposed to high temperatures

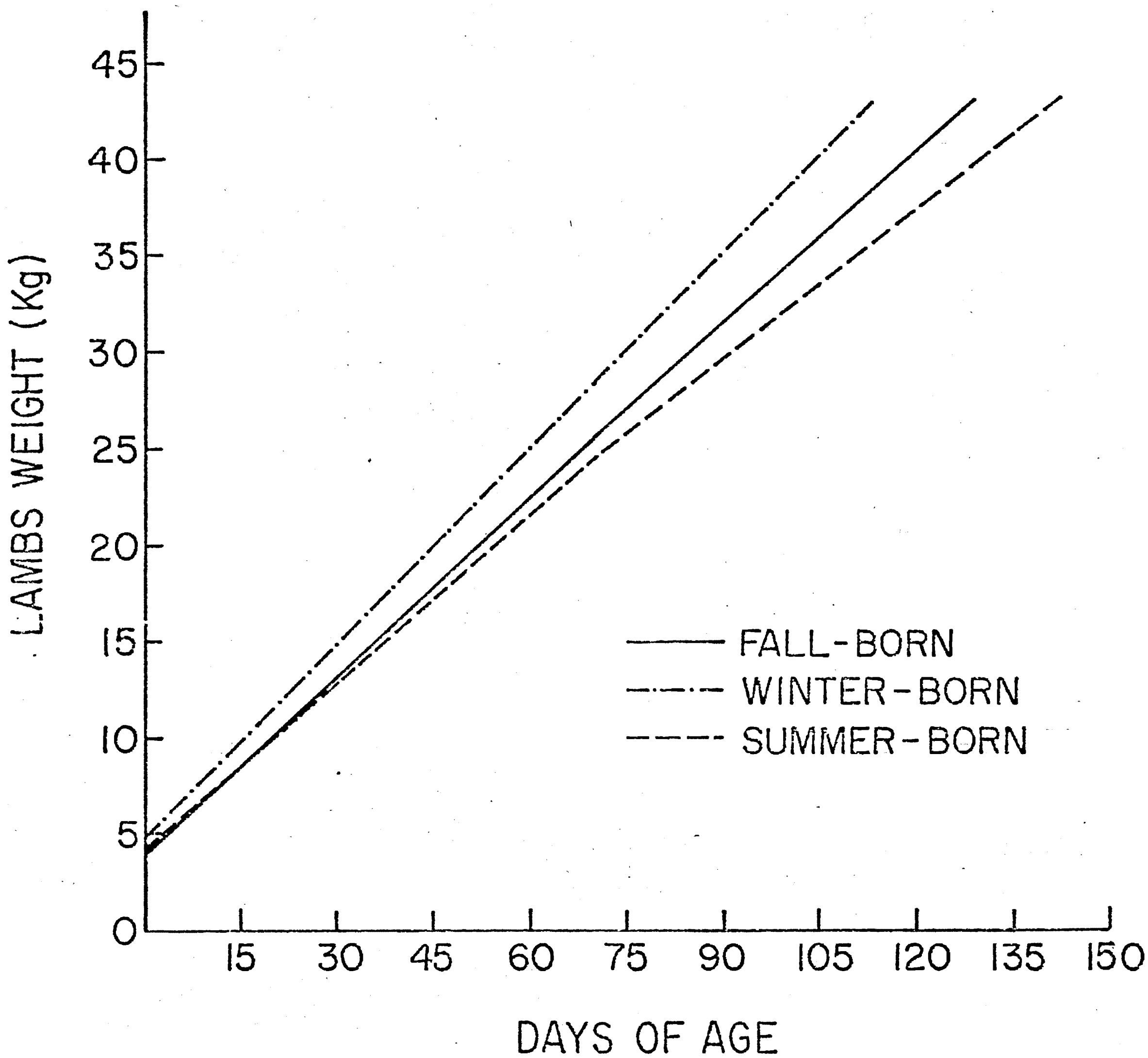

Figure 1. Performance of Winter-, Summer- and Fall Born Lambs From Birth to Market at a Minimum of 43.1 kg

TABLE VII

LEAST SQUARE MEANS AND STANDARD ERRORS FOR BIRTH WEIGHT (KG) FOR FALL, WINTER AND SUMMER BORN LAMBS

	Season of Birth					
	Fall		Winter		Summer	
Variable	Mean	SE	Mean	SE	Mean	SE
Overall	3.50	.05	4.78	.05	4.45	.04
Year[a]						
1	3.59[c]	.08	4.85[c]	.05	4.39[c]	.06
2	3.41[d]	.08	4.71[d]	.09	4.52[d]	.05
Breed of Dam[b]						
¼F ½D ¼R	3.31[e]	.10	4.53[e]	.09	4.25[e]	.07
¼F ¼D ½R	3.55[f]	.09	4.74[f]	.08	4.30[e]	.07
½D ½R	3.29[e]	.10	4.77[f]	.08	4.34[ef]	.07
¼D ¾R	3.74[f]	.09	5.06[g]	.08	4.91[g]	.07
¼F ¾R	3.60[f]	.12	4.78[f]	.09	4.48[f]	.08

TABLE VII (Continued)

	Season of Birth					
	Fall		Winter		Summer	
Variable	Mean	SE	Mean	SE	Mean	SE
Sex						
Female	3.43^{j}	.08	4.63^{j}	.06	4.36^{j}	.05
Male	3.57^{k}	.08	4.93^{k}	.06	4.55^{k}	.05
Birth						
Single	4.22^{l}	.05	5.74^{l}	.08	5.36^{l}	.06
Twin	3.33^{m}	.05	4.66^{m}	.05	4.35^{m}	.04
Triplet	2.95^{m}	.19	3.93^{n}	.09	3.65^{n}	.11

[a]Year 1=1974-fall 1976-summer 1977-winter
2=1975-fall 1978-summer 1979-winter

[b]Breed of Ewe F=Finnish Landrace D=Dorset R-Rambouillet

[c-n]Means in the same column and with the same variable name bearing different superscripts differ ($P \leq .05$)

(33^{o}-44^{o}C) during gestation had lambs weighing .71kg less than ewes lambing under natural winter conditions in New South Wales.

Table VIII presents the least square means and standard errors for 70-day weights. Differences due to season in 70-day weight were statistically significant ($P \leq .001$). Winter-born lambs weighed 2.93kg more than fall-born lambs and 3.79kg more than summer-born lambs at 70 days of age. These results generally agree with those from other workers. Gould and Whiteman (1971) reported that spring-born lambs were 2.54kg heavier at 70 days of age than were fall-born lambs. The Sheepman's Production Handbook (1977) ranks season of birth winter, fall, spring and summer for 120-day weights. Difference in weight at 70 days may partly reflect differences in temperature. Temperatures after birth and through 70 days of age would be expected to be highest for summer-born lambs, while lambs born in the fall and winter would be exposed to cooler temperatures. However, it should also be remembered that weaning weight is interrelated to birth weight. Harrington et al. (1958) reported that for each pound difference in birth weight there was approximately a 3 pound difference in 70-day weight.

Least square means are presented for ADG (70 days to market) in table IX. Again season of birth resulted in statistically significant difference (P=.001) in ADG. Lambs born in the winter had 41 g/day and 81 g/day higher ADG from 70 days until market than did fall and summer-born lambs respectively. The differences found here may be partly due to disease problems encountered in raising summer-born lambs. Pneumonia and polioencephalomalacia were more prevalent in summer-born lambs and even through lambs

TABLE VIII

LEAST SQUARE MEANS AND STANDARD ERRORS FOR 70-DAY WEIGHT (KG) FOR FALL, WINTER AND SUMMER BORN LAMBS

	Season of Birth					
	Fall		Winter		Summer	
Variable	Mean	SE	Mean	SE	Mean	SE
Overall	25.62	.30	28.55	.37	24.76	.26
Year[a]						
1	26.71[d]	.43	28.00[d]	.53	25.21[d]	.36
2	24.52[e]	.44	29.10[d]	.56	24.32[e]	.37
Breed of Dam[b]						
¼F ½D ¼R	25.11[f]	.72	27.92[f]	.75	23.83[fgh]	.49
¼F ¼D ½R	24.56[f]	.80	28.56[f]	.72	23.20[f]	.45
½D ½R	25.18[f]	.68	28.18[f]	.71	24.75[gh]	.46
¼D ¾R	27.96[g]	.77	29.31[f]	.68	26.99[i]	.47
¼F ¾R	25.78[f]	.65	28.79[f]	.76	25.06[h]	.55

TABLE VIII (Continued)

	Season of Birth					
	Fall		Winter		Summer	
Variable	Mean	SE	Mean	SE	Mean	SE
Sex						
Female	24.29^{l}	.41	27.50^{l}	.52	23.92^{l}	.37
Male	26.94^{m}	.45	29.60^{m}	.53	25.61^{m}	.35
Birth/Rearing[c]						
1	27.77^{n}	.37	30.36^{n}	.78	27.13^{n}	.39
2	27.15^{n}	1.00	29.98^{n}	1.01	25.89^{n}	.81
3	22.22^{o}	.29	25.31^{o}	.35	21.28^{o}	.23

[a]Year 1=1974-fall 1976-summer 1977-winter
2=1975-fall 1978-summer 1979-winter

[b]Breed of Ewe F=Finnish Landrace D=Dorset R=Rambouillet

[c]Birth/Rearing 1=single born-single reared 2=twin born-single reared
3=twin born-twin reared

[d-o]Means in the same column and with the same variable name bearing different superscript differ ($P \leq .05$)

TABLE IX

LEAST SQUARE MEANS AND STANDARD ERRORS FOR ADG (G/DAY)
FOR FALL, WINTER AND SUMMER BORN LAMBS

	Season of Birth					
	Fall		Winter		Summer	
Variable	Mean	SE	Mean	SE	Mean	SE
Overall	297	004	337	008	225	004
Year[a]						
1	304[e]	006	284[e]	011	284[e]	005
2	291[f]	006	389[f]	013	227[f]	005
Breed of Dam[b]						
¼F ½D ¼R	299[h]	008	334	016	256	007
¼F ¼D ½R	307	008	322	016	345	006
½D ½R	281	007	347	015	246	006
¼D ¾R	302	008	342	014	259	007
¼F ¾R	300	009	338	015	271	007

TABLE IX (Continued)

	Season of Birth					
			Winter			
Variable	Mean	SE	Mean	SE	Mean	SE
Sex						
Female	250^{l}	006	291^{l}	012	233^{l}	005
Male	345^{m}	006	382^{m}	012	278^{m}	005
Birth/Rearing						
1	299^{n}	005	333^{n}	016	245^{n}	005
2	292^{n}	015	358^{n}	025	266^{n}	012
3	302^{n}	004	319^{n}	007	255^{n}	003

[a]Year 1=1974-fall 1976-summer 1977-winter
2=1975-fall 1978-summer 1979-winter

[b]Breed of Dam F=Finnish Landrace D=Dorset R=Rambouillet

[c]Birth/Rearing 1=single born-single reared 2=twin born-single reared
3=twin born-twin reared

[d-n]Means in the same column and with the same variable name bearing different superscript differ ($P \leq .05$)

exhibiting these illnesses were excluded from the analysis the incidence of subclinical cases would also be expected to be higher for summer-born lambs than in the other two seasons.

Least square means were also presented by years within seasons, breed combination of dam, sex and birth or birth rearing type for the three growth traits (tables VII-IX). A test for interaction between breed combination of ewe and season approached statistical significance ($p \lesssim .1$) for both birth weight and 70-day weight (refer to tables VII and VIII due to the different levels of Rambouillet breeding which were present in the ewes, these interactions may be attributed to the genetic advantage the Rambouillet breed has for heat tolerance. No statistically significant interactions were found for sex x season and birth or birth rearing type x season for birth weight or 70-day weight.

For ADG, breed combination of ewe x season ($p \simeq .12$) and birth rearing type x season ($p \simeq .31$) were not statistically significant. However, a statistically significant ($p < .0001$) interaction was found between sex and season for ADG (table IX). This interaction resulted in a smaller difference between the ram and ewe lambs for summer than for fall or winter-born lambs. For the fall and winter seasons there was approximately a 90 g/day difference with only 40 g/day difference for the summer-born lambs. This would indicate that a different correction factor for ADG may be applicable for sex for fall-born lambs. Correction factors for birth weight, and 70-day weight for birth or birth-rearing type and sex would be similar for all three seasons. This generally agrees with Gould and Whiteman (1971) who found no statistically significant differences in partial regression coefficients for sex, birth-type or birth-rearing type in fall and spring-born lambs.

Results in tables VII and VIII also reveal differences ($p < .15$) due to year, breed combination of dam, sex and birth or birth-rearing type for birth weight and 70-day weight. Generally lambs from ewes which were 3/4 Rambouillet were heavier at birth and at 70 days of age than those from 1/4 or 1/2 Rambouillet dams. The ram lambs were .21kg heavier at birth and 2.15kg heavier at 70 days than the ewe lambs. Single born lambs were .99kg heavier than twin born lambs and 1.60kg heavier than triplets at birth. At 70 days of age the difference between single born - single reared and twin born - single reared lambs was .75kg, with the difference between single born and reared and twin born and reared lambs being 5.48kg. This is in agreement with other work done by Holtman and Bernard (1969), Gould and Whiteman (1971), Carter _et al._ (1971) and Hohenboken (1976).

Summary

The performance of fall, winter and summer-born lambs were compared for birth weight, 70-day weight and ADG (70 days to market). Data were collected from 457, 510 and 640 lambs born in the fall (Oct.-Nov.), summer (June-July) and winter (Jan.-March) respectively. There were statistically significant differences due to season of birth for birth weight, 70-day weight and ADG. Least squares means indicate that winter-born lambs were .23kg heavier at birth than were summer-born lambs and 1.28kg heavier than fall-born lambs.

Winter-born lambs were 2.93 and 3.79kg heavier at 70 days of age than fall and summer-born lambs, respectively. Winter-born lambs gained 41 g/day faster than fall-born lambs and 82 g/day faster than summer-born lambs after weaning. A statistically significant ($p \leq .0001$) interaction between sex and season existed for ADG. This interaction resulted in a smaller difference (40 g/day) between ram and ewe lambs born in the summer than the difference (90 g/day) for fall and winter-born lambs.

These results would indicate that differences in birth weight, 70-day weight and ADG exist for fall, winter and summer-born lambs under conditions where ewes are well fed and lambs are self fed the same ration. Corrections for sex or birth (birth-rearing) type appear to be similar for birth weight and 70-day weight. Only the correction used for sex for ADG would appear to depend on the season the lamb was born.

CHAPTER IV

TRANSMITTED EFFECT OF PUREBRED VS. CROSSBRED RAMS ON GROWTH PERFORMANCE TRAITS

Introduction

The advantages of crossbredding have been known for many years. Several workers (Holtman and Bernard, 1969; Sidwell and Miller, 1971; Hohenboken et al., 1976; and Vesely and Peters, 1972, 1979) have shown that crossbred lambs and crossbred ewes perform better than purebred offspring and dams. However, at the present time, only a few research reports have been published comparing crossbred and purebred sires. Bradford et al.(1963) reported only small differences in birth weight or 120 day weight between crossbred and purebred sired lambs, with sloghtly less variability of these traits for the crossbred sired offspring. However, the question of how the progeny of crossbred sires will compare to purebred sired offspring is relatively unanswered.

The purposes of this study were to compare crossbred and purebred sired lambs for birth weight, 70 day weight and ADG from weaning to market, and to compare the variability of the offspring for these three growth traits.

Materials and Methods

Experimental Animals

Data for this study came from an ongoing experiment which was designed to compare certain ewe breed combinations (BOD) under different lambing conditions. Lambs born between the fall of 1974 and the winter of 1979 were utilized. Ewes rearing these lambs were born in March and April of 1971 and 1972 at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma. The ewes were five combinations of Rambouillet(R), Dorset(D) and/or Finnish Landrace(F) sheep. They were 1/4F1/2D1/4R, 1/4F1/4D1/2R, 1/4F3/4R, 1/2R D1/2R and 1/4D3/4R. The breed combinations and matings used to produce these ewes, have been reported by Thomas and Whiteman (1979). The 246 ewes were 2 1/2 and 3 1/2 years old when producing the first seasons lambs used in this study.

Eight rams were used each season to sire the lambs, two each of Hampshire and Suffolk breeds and four of the two reciprocal crosses. To insure the crossbred and purebred rams would be paternal half sibs, individual sheep producers were contracted to produce the rams. Three Hampshire, three Suffolk and five crossbred rams were usually purchased each year when they were approximately 4 months old. The rams were reared together and used first at a minimum age of 16 months. Before mating, the rams were electroejaculated and the semen evaluated microscopically to select those rams which appeared most fertile. Those rams selected were usually first used for breeding in May. A total of 37 rams were used during the seven seasons with only five rams used twice during the first four seasons. The data from only two of the last three seasons were utilized with only ten rams producing lambs during those two seasons (table X).

The mating schedule and resulting lambing seasons are shown in table X. Breeding seasons lasted about 50 days, with approximately 30-36 ewes per ram. About five ewes of other breeding were included in each of the breeding groups each season. The ewes in this study were allotted among the rams by breed combination of the ewe (BOD) and number of lambs reared in the previous season. Lambing seasons were classified as fall (Oct.-Nov.), winter (Jan.-March) and summer (June-July).

The lambs were fed and managed similarly during the three seasons. A ground and mixed creep feed consisting of 50% sorghum grain (4-04-383), 35% alfalfa hay, 10% soybean meal (5-04-600) and 5% sugarcane molasses (4-04-695) was available for the lambs after they reached approximately 10 days of age. After weaning, when the average weight of the lambs reached approximately 27kg the ration was changed by replacing the 10% soybean meal with 10% alfalfa hay which was self fed.

Ewes were kept in adequate flesh, with increased body weight gain through gestation during all seasons. The ewes were allowed access to whatever pastures were available at the time and were supplemented with alfalfa hay and milo before lambing to help meet their nutritional requirements. Supplemental feeding of the ewes was continued through lactation so that normal lamb growth could be attained.

Lamb birth weights were recorded within 8 hours of birth. Biweekly weights were collected after the first lambs of each season reached 45 days of age. Lambs were weaned within 7 days of 70 days of age by removing the dam from the flock. Lambs were

TABLE X

BREEDING SCHEDULE AND RESULTING LAMBING SEASONS

Year	Breeding Season	No. of Ewes Available	Lambing Season	Lambing Year	No. of Rams Repeated from Previous Season
1974	May 15-July 2	246	Fall	1974	0
1975	May 14-July 3	239	Fall	1975	0
1976	Jan. 15-March 5	226	Summer	1976	5
1976	Sept. 15-Nov. 4	222	Winter	1977	0
1977	May 16-July 13	218	Fall	1977[a]	0
1978	Jan. 5-Feb 24	203	Summer	1978	8
1978	Aug. 25-Oct. 10	199	Winter	1979	6

[a]Due to the complexity of the analyses, this season's data was deleted because of the low numbers of lambs making the coefficient matrix incomplete.

weaned within 7 days of 70 days of age by removing the dam from the flock. Lambs were marketed after they had reached the minimum weight of 43.1kg. The biweekly weights provided 70-day weights (estimated by interpolation and average daily gain from the estimated 70-day weight to market. Table XI shows the number of records available for analyses.

Due to the complexity of the analysis, lambs born in the fall of 1977 were deleted because of the low lamb number available and the incompleteness of the coefficient matrix. Records of 70-day weight and ADG of lambs which were noticeably ill were deleted from the analyses. Several lambs were also sold or allotted to other experiments after birth accounting for much of the reduction in numbers of records available for subsequent analyses. Ram lambs were left intact.

Statistical Analysis

Three different models were utilized for this analysis. An overall model was used to test for possible interactions between season of birth and class (crossbred or purebred) or breed of sire for the three growth traits (table XLVIII). Data were pooled over years within seasons to calculate least square means and standard errors for birth weight, 70-day weight and ADG for class and breed of sire.

The modelsused for calculating least square means for 70-day weight and AD were similar to the above model except birth type was replaced with birth-rearing type. The model for calculating least square means for birth weight included terms for year; class sire; breed or sire nested within class of sire; sire nested within

TABLE XI

NUMBER OF BIRTH WEIGHTS, WEANING WEIGHTS AND AVERAGE DAILY GAIN (70-DAYS TO MARKET) RECORDS AVAILABLE EACH SEASON FOR ANALYSIS

	Fall			Winter			Summer		
Variable	BW	70DW	ADG	BW	70DW	ADG	BW	70DW	ADG
Total	457	316	314	510	232	162	640	470	394
Type of Sire									
Purebred	224	143	143	243	105	73	325	245	206
Crossbred	233	173	171	267	127	89	315	225	188
Breed of Sire									
Suffolk (S)	123	74	74	151	67	45	160	121	102
Hampshire (H)	101	69	69	92	38	28	165	124	104
S x H	92	67	67	166	82	57	108	86	71
H x S	141	106	104	101	45	32	207	139	117

breed of sire, class of sire and year; BOD; sex; birth type; plus all two way interactions including year or class of sire for each season classification (table XXXI-XLVII).

The mean squares from sire within breed of sire were used for the denominator for testing year, class or sire, sire breed, year x class of sire and year x sire breed. All other terms were tested with the residual mean squares. Terms for interaction which were not statistically significant and sire within breed of sire were deleted from the model so least square means and standard errors for birth weight could be calculated.

The third model was used to estimate variability of the offspring sired by purebred or crossbred rams. The estimated variability was the variability of paternal half sibs for crossbred and purebred rams after removing the effects due to BOD, sex, sire within breed of sire and birth type or birth-rearing type. The model used was derived from a preliminary model which included terms for sire, BOD, sex and birth or birth-rearing type, plus all two way interactions for each season, year and class of sire classification. For variance estimates for any one particular lambing season, all the main effects and any interaction terms which approached statistical significance (p   .1) in either the purebred or crossbred preliminary models for that season were retained (table XXI-XXXVII). Therefore the model used for estimating variability for the crossbred and purebred sired lambs of equality of variance were made according to Steel and Torrie (1960), section 5.9.

Results and Discussion

Performance

Least squares means by season for birth weight, 70-day weight and ADG (70-days to market) are given in table XII for breed and class of ram. A test for interaction between season of birth and class of sire indicated that there was no statistically significant interaction present for birth weight (P=.8). Purebred rams sired slightly heavier lambs at birth (.08 [P=.28], .15 [P=.20] and .13kg [P=.03]) than crossbred rams for fall, winter and summer respectively. Over all seasons purebred rams were .11kg ($P \simeq .09$) heavier birth weight. These data would suggest that purebred sired lambs may be slightly heavier at birth than crossbred sired lambs. However, only one other report supports this conclusion. Bidner et al. (1978) who found a statistically significant difference of .17kg between purebred and crossbred sired lambs. However, Bradford et al. (1963) reported slightly heavier (.01kg) birth weights for crossbred sired lambs. Sidwell et al. (1964) also reported that lambs which were produced by two-breed cross rams and purebred ewes were .23kg heavier at birth than those produced by purebred rams and ewes.

The test for interaction between class of sire and season of birth for 10-day weight approached statistical significance (P=.09). During the winter season the purebred sired lambs were 1.42kg (P=.02) heavier at 70 days than were the crossbred sired lambs. However, the crossbred sired lambs were slightly heavier (.26kg P=.44 and .27kg P=.48) than the purebred sired lambs during the fall and winter lambing seasons. Vesely and Peters (1979)

TABLE XII

LEAST SQUARE MEANS AND STANDARD ERRORS FOR BIRTH WEIGHT, 70-DAY WEIGHT AND ADG BY SEASON FOR TYPE AND BREED OF SIRE[a]

	Birth Weight (kg)			70-Day Weight (kg)			ADG 70-Days to Market[b]		
Variable	Fall	Winter	Summer	Fall	Winter	Summer	Fall	Winter	Summer
Type of Sire									
Purebred	3.54c	4.85c	4.52c	25.49c	29.26c	24.63c	284c	354c	258c
	.07	.07	.05	.45	.54	.36	008	013	005
Crossbred	3.46c	4.70c	4.39d	25.75c	27.84d	24.90c	311d	319d	253c
	.08	.07	.05	.41	.52	.36	007	012	005
Breed of Sire									
Suffolk (S)	3.69e	4.71e	4.51e	26.26e	28.95e	24.85ef	295f	354f	269f
	.09	.06	.07	.55	.63	.46	012	013	006
Hampshire (H)	3.39f	4.99f	4.53e	24.59f	29.58e	24.42f	273e	355f	247e
	.09	.13	.06	.55	.78	.43	009	018	006
S x H	3.54ef	4.74e	4.37e	26.19e	28.75e	24.26f	306f	308g	254ef
	.10	.06	.08	.54	.61	.50	008	013	007
H x S	3.38f	4.66ef	4.40e	25.45ef	26.93f	25.53e	315f	329fg	251e
	.09	.11	.06	.48	.72	.42	008	016	006

[a]All weights are in kg

[b]ADG is g/day

[c-g]Means in the same column and with the same variable name bearing different superscrits differ ($P \leq .05$)

reported that crossbred and purebred sired offspring had similar weaning weights. However, Bradford et al. (1963) and Sidwell et al. (1964) reported heavier (.82kg and 1.41kg) weaning weights for crossbred sired lambs.

The interaction between class of sire and season of birth approached statistical significance (P=.08) for ADG. Average daily gains were 35 g/day (P=.01) and 5 g/day (P=.28) higher for purebred sired lambs than crossbred sired lambs during the winter and summer lambing seasons. However, during the fall lambing season the crossbred sired lambs gained 27 g/day (P=.01) faster than the purebred sired offspring. No logical explanation of this inconsistency is apparent. Bidner et al. (1978) reported slightly faster gains (10.5 g/day $P < .05$) for the purebred sired offspring, whereas Vesely and Peters (1979) reported similar average daily gains for purebred and crossbred sired lambs. When combining the results of this study and that of other workers, one finds no consistent difference between crossbred and purebred sired progeny for weaning weight and ADG. This would indicate that if differences do exist they are probably quite small.

Results are also presented for breed of sire for birth weight, 70-day weight and ADG in table XII. Caution should be used when applying these estimates to the general population of Hampshire and Suffolk rams, however, because no attempts were made to choose a larger random sample for these breeds. It was deemed more important to have crossbred and purebred rams which were half-sibs and of typical merit. Interaction between season of birth and breed of sire approached statistical significance ($P < .1$) for birth weight and was statistically significant (P=.05) for 70-day weight. These interactions resulted a change of rank from season to season of breed of sired within the purebred and crossbred classification for birth weight and 70-day weight. The Hampshire sired lambs weighed more at birth than the Suffolk sired lambs during the winter and summer seasons, however, during the fall the Suffolk sired lambs were heavier at birth. Comparisons of Suffolk and Hampshire rams with respect to their progeny's 70-day weight and post-weaning ADG indicated that the Suffolk sired lambs had higher 70-day weights and ADG during the fall and summer lambing seasons. These results were reversed for the winter lambing season.

Variability

Six independent comparisons of variability of progeny of purebred and crossbred sires were made for each of the three growth traits (table XIII). The six season's estimates of variability were then pooled for each growth trait and compared. However, the validity of pooling across seasons is questionable. Only one comparison was statistically significant ($P < .05$) and this was for birth weight for the winter of 1979. In this comparison the crossbred sired offspring were more variable than the purebred sired progeny. It should be noted that there were fewer degrees of freedom for this comparison than for any of the other comparisons of variability of birth weight. Although five of the six comparisons for variability of birth weight showed more variability for crossbred sired progeny, there was no statistical significance ($P=.15$) for the pooled estimate of variance. These results are slightly different than those reported by Bradford et al. (1963) and Bidner et al. (1978 who found the variability of birth weight

TABLE XIII

ESTIMATES OF VARIABILITY OF BIRTH WEIGHT, 70-DAY WEIGHT AND ADG FOR THE PROGENY OF PUREBRED AND CROSSBRED RAMS[a]

	Birth Weight				70-Day Weight				ADG			
	Purebred		Crossbred		Purebred		Crossbred		Purebred		Crossbred	
Season	df	S^2	df	S^2	df	S^2	df	S^2	df	S^2	df	S^2
Fall 1974	83	.342	91	.558	59	11.914	71	14.312	43	.00267	54	.00188
Fall 1975	89	.491	91	.545	38	8.224	55	14.074	53	.00183	70	.00243
Winter 1977	150	.478	150	.387	58	23.625	54	23.263	39	.00654	37	.00373
Winter 1979	45	.227	65	.707	24	8.916	50	11.239	8	.00420	25	.00501
Summer 1976	145	.427	141	.455	126	10.727	115	13.072	92	.00173	79	.00175
Summer 1978	134	.577	128	.579	84	19.815	75	19.415	72	.00251	67	.00273
Pooled	646	.457	666	.514	389	14.436	420	15.638	307	.00274	332	.00258

[a]Variance is in kg^2

for crossbred sired lambs to be slightly less than that of purebred sired lambs.

In these data, the pooled estimates of variability indicated crossbred sired lambs were slightly more variable than the purebred sired lambs at 70 days (p=.44). In four of six of the individual season comparisons the crossbred sired progeny were more variable. Bradford et al. (1963) reported three of five comparisons for variability of 120 day weight more variable for purebred sired offspring. Bidner et al.(1978) also indicated that the purebred sired lambs were slightly more variable for weanimg weight than were the crossbred sired lambs.

The pooled estimates of variability for ADG indicated that the purebred sired lambs were slightly more variable than the crossbred sired lambs (p=.60). However, in four of the six individual comparisons the crossbred sired lambs were more variable. Bidner et al. (1978) reported that the purebred sired progeny were more variable than the crossbred sired progeny in the two comparisons he made.

These data whne considered along with previous reports in the literature would suggest little or no difference in the variability of growth traits for lambs sired by purebred and crossbred rams.

Summary

Data from 457 fall, 510 winter-, and 640 summer born lambs were utilized to compare the performance and variability of lambs sired by purebred and crossbred rams. The purebred Suffolk and Hampshire rams and their crossbred paternal half sibs were compared for the birth weight and postnatal growth rate of their progeny. Eight rams

(4 crossbred and 4 purebred) were used per season using a total of 37 rams. The rams were mated to 199 to 246 crossbred ewes for seven seasons, with approximately 30 ewes/ ram, producing progeny in the fall(October-November), summer (June - July) or winter (January-March).

These data indicated that purebred sired lambs were heavier at birth than crossbred sired lambs for all three seasons (p=.10). The differences between purebred and crossbred sired lambs were .08 kg (p=.28), .15kg (p=.20) and .13kg (p=.02) for fall, winter and summer seasons, respectively. The differences between purebred and crossbred sired lambs were not the same over seasons for 70 day weight and ADG. Purebred sired lambs were 1.62kg heavier (p=.02) at 70 days of age for the winter season but were .26kg (p=.44) and .27kg (p=.48) lighter than the crossbred sired lambs for the fall and summer lambing seasons respectivley. The differences for ADG between lambs sired by purebred and crossbred rams were -27 g/day (p=.01), 35 g/day (p=.01) and 5 g/day (p=.28) for fall, winter and summer seasons respectively.

Six comparisons of the variability of the progeny from crossbred and purebred rams were available for each growth trait. In five comparisons of birth weight and four comparisons for both 70 day weight and ADG lambs sired by crossbred rams were more variable, however, only one of the differences was statistically significant. When pooled, the variance estimates were .46 vs. .51 kg for birth weight, 14.4 vs. 15.6kg for 70 day weight and .0027 vs. .0026kg for ADG for purebred vs. crossbred rams. When these estimates are added to previous reports, it would appear that if differences invariability of growth rate do exist, they are probably quite small.

LITERATURE CITED

Asiedu, F.H.K. 1978. Grazing behavior of sheep under tree crops in Ghana. Tropical Agri. 55:181.

Baker, D.H. 1973. Postbreeding flushing of first litter crossbred gilts, with a note of efficacy of crossbred versus purebred boars in total confinement. Amer. J. Vet. Res. 34:1051.

Barr, A.J. and J.H.Goodnight. 1979. A user's guide to the Statistical Analysis System. Student Supply Stores. North Carolina University, Raleigh.

Bidner, T.D.,P.E.Humes, R.Boulware and P.E.Schilling. 1978. Characterization of ram and ewe breeds. II. Growth and carcass traits. J. Anim. Sci. 47:114.

Blackwell, R.L. and C.R.Henderson. 1955. Variation in fleece weight, weaning weight and birth weight of sheep under farm conditions. J. Anim. Sci. 14:831.

Bradford, G.E., D.T. Torrell, G.M. Spurlock and W.C.Weur. 1963. Performance and variability of offspring of crossbred and purebred rams. J. Anim. Sci. 22:617.

Carter, R.C., G.M.Carmen, F.S.McClaugherty and P.S.Haydon. 1971. Genotype-environment interaction in sheep. II. Lamb performance traits. J. Anim. Sci. 33:732.

Dun, R.B., W.Ahmed and A.J.Morrant. 1960. Annual reproductive rhythm in Merino sheep related to the choice of mating time at Trangie, Central Western New South Wales. Australian J. Agr. Res. 11:805.

Falconer, D.S. 1972. Introduction to quantitative Genetics. The Ronald Press Company, New York.

Gould, M.B. and J.V.Whiteman. 1971. Association of certain variables with the performance of spring versus fall born lambs. J. Anim. Sci. 33:531.

Harrington, R.B., J.V.Whiteman and R.D.Morrison. 1958. Estimates of some sources of variation in the body weight of crossbred lambs at different ages. J.Anim. Sci. 17:743.

Hohenboken, W.D., W.H Kennick and R.Bogart. 1976. Genetic, environmental and interaction effects in sheep. II. Lamb growth and carcass merit . J. Anim. Sci. 42:307.

Holtmann, W.B. and C. Bernard. 1969. Effect of general combining ability and maternal ability of Osford, Suffolk and North County Cheviot breeds of sheep on growth performance of lambs. J.Anim. Sci. 28:155.

Lisman, W.B., W.C.Smith and M. Bichard. 1975. The comparative performance of purebred and crossbred boars in commercial pig production. Anim. Prod. 21:69.

Rempel, W.E., R.E.Comstock and F.D.Enfield. 1964. Comparison of performance of crossbred pigs sired by purebred and crossbred boars. J. Anim. Sci. 23:87.

Sheepman's Producton Handbook (The). 1977. G. Scott. Sheep Industry Development Program. Abegg Printing Co., Inc., Denver, Colorado.

Shelton, J.M. 1964. Relation of environmental temperature during gestation to birth weight and mortality of lambs. J.Anim. Sci. 23:360.

Shelton, J.M. 1968. Lambing out of season and accelerated lambing. In: Proceeding Symposium Physiology and Reproduction in Sheep, Stillwater, Oklahoma, 136.

Sidwell, G.M., D.O.Everson and C.E.Terrill. 1964. Lamb weights in some pure breeds and their crosses. J.Anim.Sci. 23:105.

Sidwell, G.M. and L.Miller. 1971. Production in some pure breeds of sheep and their crosses. II. Birth weight and weaning weights of lambs. J.Anim.Sci. 32:1090.

Steel, R.G.D. and J.H.Torrie. 1960. Priciples and Procedures of Statistics. McGraw-Hill Book Co., New York.

Thomas, D.L. and J.V. Whiteman. 1979. Effects of substituting Finnsheep and Dorset breeding for Rambouillet breeding. I. Productivity of young spring lambing ewes. J.Anim.Sci. 48:256.

Vesely, J.A. and H.F.Peters. 1972. Lamb growth performance of Romnelet, Columbia, Suffolk and North County Cheviot breeds and all single and three breed crosses among them. Can. J. Anim. Sci. 52:283.

Vesely, J.A. and H.F.Peters. 1979. Lambs growth performance of certain breeds and their 2-, 3-, and 4-breed crosses. Can. J. Anim. Sci. 59:349.

Yeates, N.T.M. 1956. The effect of high air temperature on pregnancy and birth weight in Merino sheep. Australian J.Agr.Res. 7:435.

Yeates, N.T.M. 1958. Foetal dwarfism in sheep - an effect of high atmospheric temperature during gestation. J.Agri.Sci. 51:84.

APPENDIX

TABLE XIV

MEAN SQUARES FROM ANALYSES OF VARIANCE FOR BIRTH WEIGHT, WEANING WEIGHT AND ADG (WEANING TO MARKET) FOR FALL 1974

	Birth Weight				70-Day Weight				ADG (70-Day-Market)			
Source	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred
Sire (S)	3	.98	3	1.16	3	26.33	3	12.13	3	.01721**	3	.00330
Breed of Dam (D)	4	1.42**	4	1.80*	4	23.40	4	20.38	4	.00275	4	.00582*
Sex	1	1.64*	1	.77	1	57.67*	1	110.75**	1	.12136*	1	.14661***
Type of Birth[a] (T)	2	5.82*	2	11.58*	2	66.59**	3	113.63***	2	.00167	3	.00344
S x D	11	.45	12	1.01	11	13.62	12	16.38	11	.00255	12	.00370*
S x Sex	3	.07	3	.31	3	10.09	3	18.43	3	.00510	3	.00944**
S x T	3	.07	3	.69	3	9.45	4	32.60	3	.00359	3	.00118
D x Sex	4	.34	4	.89	4	8.39	4	8.01	4	.00389	4	.00717
D x T	3	.08	4	.39	3	1.61	6	10.85	3	.00069	5	.00149
Sex x T	2	1.25*	2	.34	1	4.05	1	6.15	1	.00050	1	.00980
Residual	69	.38	77	.54	37	11.15	45	14.41	37	.00278		.00160

[a]"Birth-rearing" type for model other than birth weight

*$P \leq .05$; **$P \leq .01$; ***$P \leq .001$

TABLE XV

MEAN SQUARES FROM ANALYSES OF VARIANCE FOR BIRTH WEIGHT, WEANING WEIGHT AND ADG (WEANING TO MARKET) FOR FALL 1975

	Birth Weight				70-Day Weight				ADG (70-Day-Market)			
Source	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred
Sire (S)	3	.75	3	.80	3	37.72*	3	6.00	3	.00063	3	.00141
Breed of Dam (D)	4	1.95**	4	.78	4	26.36*	4	45.45*	4	.00195	4	.01057*
Sex	1	.08	1	.69	1	56.76*	1	90.52*	1	.10232	1	.12100***
Type of Birth[a] (T)	2	10.53***	1	12.95***	2	166.45***	2	275.31***	2	.00079	2	.00480
S x D	12	.91*	12	.44	11	21.68*	12	6.35	11	.00148	12	.00294
S x Sex	3	.60	3	.18	3	13.33	3	5.09	3	.00190	3	.00157
S x T	3	.88	3	.29	3	43.28**	3	9.76	3	.00072	3	.00249
D x Sex	4	.37	4	.76	4	5.26	4	16.30	4	.00279	4	.00287
D x T	4	1.94**	4	.35	4	19.29	4	4.76	4	.00456	4	.00324
Sex x T	2	.14	1	.04	1	9.33	1	29.09	1	.00036	1	.00070
Residual	77	.48	81	.56	30	8.96	47	13.58	30	.04127		.00237

[a]"Birth-rearing" type for model other than birth weight

*P ≤ .05; **P ≤ .01; ***P ≤ .001

TABLE XVI

MEAN SQUARES FROM ANALYSES OF VARIANCE FOR BIRTH WEIGHT, WEANING WEIGHT AND ADG (WEANING TO MARKET) FOR SUMMER 1976

	Birth Weight				70-Day Weight				ADG (70-Day-Market)			
Source	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred
Sire (S)	3	.08	3	1.22*	3	11.75	3	29.12	3	.00891**	3	.00567*
Breed of Dam (D)	4	1.91**	4	3.02***	4	83.16***	4	67.13**	4	.00912***	4	.00338
Sex	1	.51	1	.74	1	56.44*	1	244.66***	1	.11112***	1	.12239***
Type of Birth[a] (T)	2	20.84***	2	12.22***	3	326.30***	3	160.88***	3	.00094	3	.00078
S x D	12	.73	12	.50	12	13.78	12	8.36	12	.00381*	12	.00201
S x Sex	3	.63	3	.62	3	3.28	3	6.78	3	.00294	3	.00329
S x T	3	.23	3	.80	4	10.86	4	23.04	4	.00306	4	.00143
D x Sex	4	.46	4	.50	4	15.80	4	2.00	4	.00190	4	.00472*
D x T	4	1.60	4	.68	4	8.67	5	18.91	4	.00103	5	.00077
Sex x T	1	.00	2	.16	1	.11	2	2.08	1	.00000	2	.00034
Residual	129	.40	123	142	97	10.07	86	13.14	79	.00168	67	.00179

[a]"Birth-rearing" type for model other than birth weight

*P ≤ .05; **P ≤ .01; ***P ≤ .001

TABLE XVII

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR BIRTH WEIGHT, WEANING WEIGHT AND ADG (WEANING TO MARKET) FOR WINTER 1977

	Birth Weight				70-Day Weight				ADG (70-Day-Market)			
Source	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred
Sire (S)	3	.69	3	.06	3	1.32	3	27.40	3	.00142	3	.00259
Breed of Dam (D)	4	2.11**	4	1.35**	4	9.12	4	6.24	4	.00636	4	.00131
Sex	1	3.65**	1	2.91	1	90.57	1	35.19	1	.14599***	1	.06466***
Type of Birth[a] (T)	3	18.06***	3	13.80***	4	36.20	4	82.47*	4	.00245	4	.00649
S x D	12	.25	12	.37	8	11.32	10	16.66	8	.00821	10	.00460
S x Sex	3	.38	3	.28	3	4.00	3	14.72	3	.00338	3	.00029
S x T	5	.27	6	.86*	4	19.89	3	15.68	3	.00117	2	.00343
D x Sex	4	.43	4	.18	3	14.81	4	26.87	3	.01561*	4	.00211
D x T	7	.45	7	.73	1	26.40	5	12.59	0	0	4	.00134
Sex x T	3	.24	3	.21	1	16.97	2	12.39	1	.00021	1	.01018
Residual	134	.50	130	.39	38	23.86	31	29.34	26	.00523	22	.00298

[a]"Birth-rearing" type for model other than birth weight

*P ≤ .05; **P ≤ .01; ***P ≤ .001

TABLE XVIII

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR BIRTH WEIGHT, WEANING WEIGHT AND ADG (WEANING TO MARKET) FOR FALL 1977

	Birth Weight				70-Day Weight				ADG (70-Day-Market)			
Source	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred
Sire (S)	3	.16	3	1.42*	3	29.16	3	23.67	Only four observations		3	.00695*
Breed of Dam (D)	4	.45	4	.52	3	34.16	4	12.57			4	.00232
Sex	1	.43	1	.08	1	24.48	1	40.34			1	.00032
Type of Birth[a] (T)	1	.03	1	2.26*	3	29.23	3	94.42***			2	.00645*
S x D	2	2.40*	9	.82	0	0	6	17.91			0	0
S x Sex	1	.01	3	.12	0	0	2	31.20			0	0
S x T	1	.78*	3	.11	0	0	3	10.63			0	0
D x Sex	4	.21	4	.23	0	0	3	5.04			0	0
D x T	0		4	1.37*	0	0	4	7.93			0	0
Sex x T	1	.10	1	.17	0	0	3	5.01			0	0
Residual	7	.11	48	.48	4	29.66	20	10.99			3	.00043

[a]"Birth-rearing" type for model other than birth weight

*P $\leq$ .05; **P $\leq$ .01; ***P $\leq$ .001

TABLE XIX

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR BIRTH WEIGHT, WEANING WEIGHT AND ADG (WEANING TO MARKET) FOR SUMMER 1978

	Birth Weight				70-Day Weight				ADG (70-Day-Market)			
Source	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred
Sire (S)	3	1.42	3	1.43	3	10.98	3	53.06*	3	.00098	3	.00061
Breed of Dam (D)	4	2.02**	4	1.55*	4	90.19**	4	32.46	4	.00441	4	.00275
Sex	1	2.32*	1	1.01	1	1.19	1	12.25	1	.01788*	1	.00606
Type of Birth (T)	2	7.11***	2	13.34***	3	107.73**	4	133.33***	3	.00222	4	.00216
S x D	12	.64	12	1.01	11	20.68	12	23.66	11	.00210	11	.00055
S x Sex	3	.24	3	.20	3	18.24	3	18.39	3	.00131	3	.00228
S x T	4	.38	4	.13	4	9.26	7	17.66	4	.00043	6	.00253
D x Sex	4	.72	4	.49	4	9.17	4	36.54	4	.00489	4	.00765*
D x T	4	.40	6	.86	6	19.91	10	33.86	6	.00219	7	.00308
Sex x T	2	1.08	2	.32	2	10.60	3	92.43**	2	.00334	3	.00279
Residual	116	.56	108	.59	66	21.22	60	17.40	45	.00260	47	.00247

[a] "Birth-rearing" type for model other than birth weight

*P ≦ .05; **P ≦ .01; ***P ≦ .001

TABLE XX

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR BIRTH WEIGHT, WEANING WEIGHT AND ADG (WEANING TO MARKET) FOR WINTER 1979

	Birth Weight				70-Day Weight				ADG (70-Day-Market)			
Source	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred	df	Purebred	df	Crossbred
Sire (S)	3	.41	3	.92	3	16.94	3	16.29	1	.00181	2	.00361
Breed of Dam (D)	4	1.26**	4	.63	4	25.46	4	9.89	4	.00579	4	.00453
Sex	1	1.72*	1	2.86	1	28.95	1	108.49*	1	.03901*	1	.02170
Type of Birth[a] (T)	2	8.53***	2	6.11**	3	16.34	4	67.44*	3	.00118	4	.00196
S x D	5	1.12**	7	.45	4	6.18	6	12.51	0	0	3	.00471
S x Sex	2	.48	3	.14	2	.53	3	10.22	0	0	2	.00154
S x T	3	1.24**	3	.95	1	.02	4	15.55	0	0	0	0
D x Sex	4	.21	4	.52	4	3.27	4	7.11	0	0	4	.00452
D x T	3	1.96*	6	.14	3	3.51	6	12.97	0	0	1	.00805
Sex x T	2	.17	2	.20	2	3.01	2	24.21	0	0	0	0
Residual	37	.27	56	.74	10	12.72	28	8.70	2	.00109	12	.00500

[a]"Birth-rearing" type for model other than birth weight

*$P \leq .05$; **$P \leq .01$; ***$P \leq .001$

TABLE XXI

LEAST SQUARES ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE FALL OF 1974 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	1.169*	3	.894
Breed of Ewe (E)	4	1.480*	4	1.770*
Sex	1	1.473*	1	.666
Type of Birth (T)	2	6.700***	2	11.365***
S x E	11	.531	12	.914
Sex x T	2	1.190	2	.242
Residual	83	.342	91	.558

*$P < .05$; ***$P < .001$

TABLE XXII

LEAST SQUARES ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE FALL OF 1974 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	32.989*	3	9.699
Breed of Ewe (E)	4	23.722	4	19.108
Sex	1	74.361*	1	74.178*
Type of Birth-Rear (T)	2	138.681***	3	125.921***
S x T	3	6.308	6	12.203
Residual	59	11.914	71	14.312

*$P < .05$; ***$P < .001$

TABLE XXIII

LEAST SQUARES ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE FALL OF 1974 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.01912***	3	.00469
Breed of Ewe (E)	4	.00282	4	.00781**
Sex	1	.13088***	1	.14029***
Type of Birth-Rear (T)	2	.00167	2	.00344
S x E	11	.00176	12	.00248
S x Sex	3	.00500	3	.00506
E x Sex	4	.00286	4	.00345
Sex x T	1	.00258	2	.00566
Residual	43	.00267	54	.00188

**P < .01; ***P < .001

TABLE XXIV

LEAST SQUARES ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE FALL OF 1975 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.694	3	.515
Breed of Ewe (E)	4	1.761**	4	.843
Sex	1	.220	1	.721
Type of Birth (T)	2	11.410***	1	14.145***
S x E	12	.969*	12	.378
E x T	5	1.250*	4	.366
Residual	89	.491	91	.545

*P < .05; **P < .01; ***P < .001

TABLE XXV

LEAST SQUARES ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE FALL OF 1975 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	33.350*	3	5.037
Breed of Ewe (E)	4	20.388	4	39.275*
Sex	1	56.756*	1	90.521*
Type of Birth-Rear (T)	2	204.432***	2	337.863***
S x E	11	25.916	12	4.273
S x T	3	42.931**	3	5.361
E x T	4	28.901*	4	14.567
Residual	38	8.224	55	14.074

$*P < .05$; $**P < .01$; $***P < .001$

TABLE XXVI

LEAST SQUARE ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE FALL OF 1975 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.00033	3	.00250
Breed of Ewe (E)	4	.00135	4	.00799*
Sex	1	.16322***	1	.18385***
Type of Birth-Rear (T)	2	.00454	2	.00392
E x T	6	.00317	5	.00594*
Residual	53	.00183	70	.00243

*P < .05; ***P < .001

TABLE XXVII

LEAST SQUARES ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE SUMMER OF 1976 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.145	3	1.581*
Breed of Ewe (E)	4	2.093**	4	2.582***
Sex	1	.762	1	.380
Type of Birth	2	21.378***	2	12.123***
S x E	12	.435	12	.239
Residual	145	.427	141	.455

*$P < .05$; **$P < .01$; ***$P < .001$

TABLE XXVIII

LEAST SQUARES ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE SUMMER OF 1976 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	11.918	3	44.434*
Breed of Ewe (E)	4	84.671***	4	70.997***
Sex	1	64.067*	1	213.928***
Type of Birth-Rear (T)	2	541.962***	2	323.807***
Residual	126	10.727	115	13.072

*$P < .05$; ***$P < .001$

TABLE XXIX

LEAST SQUARES ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE SUMMER OF 1976 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	s^2	df	s^2
Sire (S)	3	.00803**	3	.00880**
Breed of Ewe (E)	4	.00803**	4	.00393
Sex	1	.11640***	1	.12541***
Type of Birth-Rear (T)	2	.00107	2	.00064
S x E	12	.00310	12	.00261
E x Sex	4	.00199	4	.00458*
Residual	92	.00173	79	.00174

*$P < .05$; **$P < .01$; ***$P < .001$

TABLE XXX

LEAST SQUARES ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE WINTER OF 1977 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.715	3	.074
Breed of Ewe (E)	4	2.072**	4	1.394**
Sex	1	3.955**	1	3.029**
Type of Birth (T)	2	27.762***	2	19.517***
S x T	5	.200	6	.527
E x T	7	.713	7	.719
Residual	150	.478	150	.387

**P < .01; ***P < .001

TABLE XXXI

LEAST SQUARES ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE WINTER OF 1977 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	10.496	3	25.612
Breed of Ewe (E)	4	19.746	4	6.131
Sex	1	110.934*	1	53.340
Type of Birth-Rear	2	48.099	2	181.054**
Residual	58	23.625	54	25.263

*P <.05; **P <.01

TABLE XXXII

LEAST SQUARES ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE WINTER OF 1977 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.00279	3	.00223
Breed of Ewe (E)	4	.00353	4	.00234
Sex	1	.12170***	1	.08109***
Type of Birth-Rear (T)	2	.01366	2	.00674
Sex x T	1	.00933	2	.00051
E x Sex	4	.00693	4	.00459
Residual	39	.00654	37	.00373

***$P < .001$

TABLE XXXIII

LEAST SQUARE ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE SUMMER OF 1978 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	2.309**	3	1.264
Breed of Ewe (E)	4	2.565**	4	2.075**
Sex	1	2.251	1	.883
Type of Birth	2	7.492***	2	13.127***
S x E	12	.833	12	.841
Residual	134	.577	128	.579

**P < .01; ***P < .001

TABLE XXXIV

LEAST SQUARES ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE SUMMER OF 1978 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	10.980	3	19.335
Breed of Ewe (E)	4	87.491**	4	32.987
Sex	1	2.701	1	149.095**
Type of Birth-Rear (T)	2	248.608***	2	265.357***
E x T	7	30.587	7	13.680
E x Sex	4	10.512	4	54.488*
Sex x T	2	18.781	2	10.166
Residual	84	19.815	75	19.416

*P < .05, **P < .01; ***P < .001

TABLE XXXV

LEAST SQUARES ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE SUMMER OF 1978 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.00089	3	.00098
Breed of Ewe (E)	4	.00385	4	.00276
Sex	1	.01223*	1	.00914
Type of Birth-Rear (T)	2	.00138	2	.00284
E x Sex	4	.01053**	4	.00918*
Residual	72	.00251	67	.00273

*P <.05; **P <.01

TABLE XXXVI

LEAST SQUARES ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE WINTER OF 1979 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	3	.503	3	.966
Breed of Ewe (E)	4	1.101*	4	.414
Sex	1	1.717*	1	2.856*
Type of Birth (T)	2	9.142***	2	6.426***
S x E	5	1.469***	2	.269
S x T	3	.910*	3	.922
E x T	3	2.762***	6	.266
Residual	45	.277	65	.707

*$P < .05$; ***$P < .001$

TABLE XXXVII

LEAST SQUARES ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE WINTER OF 1979 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	2	16.520	3	17.492
Breed of Ewe	4	22.938	4	15.007
Sex	1	11.039	1	108.592**
Type of Birth-Rear (T)	2	55.186**	2	87.415
Sex x T	2	1.018	1	10.420
Residual	24	8.916	50	11.239

**$P < .01$

TABLE XXXVIII

LEAST SQUARE ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE WINTER OF 1979 USED TO ESTIMATE VARIABILITY OF OFFSPRING SIRED BY PUREBRED AND CROSSBRED RAMS

	Purebred		Crossbred	
Source	df	S^2	df	S^2
Sire (S)	2	.00056	2	.00236
Breed of Ewe	4	.00518	4	.00321
Sex	1	.02905*	1	.00962
Type of Birth-Rear	2	.00420	2	.00222
Residual	8	.00420	25	.00501

*$P < .05$

TABLE XXXIX

LEAST SQUARE ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE FALL, USED FOR LEAST SQUARE MEANS

Source	df	MS
Year	1	3.445*
Class of Sire	1	1.327
Breed of Sire	2	3.130**
Breed of Ewe	4	3.677***
Sex	1	2.165*
Birth-Rearing Type	2	43.594***
Residual	445	.526

$^*P \leq .05$; $^{**}P \leq .01$; $^{***}P \leq .001$

TABLE XL

LEAST SQUARE ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE FALL, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year (YR)	1	309.493***
Class of Sire (COS)	1	1.645
Breed of Sire (BOS)	2	62.070**
Breed of Ewe (BOE)	4	61.386**
Sex	1	501.910***
Birth-Rearing Type (T)	2	1091.499***
BOE x T	7	30.242*
YR x COS	1	173.433***
Residual	296	13.273

*$P \leq .05$; **$P \leq .01$; ***$P \leq .001$

TABLE XLI

LEAST SQUARE ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE FALL, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year (YR)	1	.01112*
Class of Sire (COS)	1	.00016
Breed of Sire (BOS)	2	.00979*
Breed of Ewe (BOE)	4	.00507
Sex	1	.63210***
Birth-Rearing Type (T)	2	.00071*
YR x COS	1	.01544*
YR x COS	2	.01146**
COS x BOE	4	.00703*
COS x T	2	.00869*
Residual	293	.00245

*P ≤ .05; **P ≤ .01; ***P ≤ .001

TABLE XLII

LEAST SQUARE ANALYSIS OF VARIANCE OF BIRTH WEIGHT OF LAMBS BORN IN THE SUMMER, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year (YR)	1	1.597
Class of Sire (COS)	1	1.471
Breed of Sire (BOS)	2	.030
Breed of Ewe (BOE)	4	9.228***
Sex	1	5.575**
Litter	2	69.276***
YR x BOS	3	1.334
Residual	625	.523

*P ≤ .05; **P ≤ .01; ***P ≤ .001

TABLE XLIII

LEAST SQUARE ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE SUMMER, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year (YR)	1	81.196*
Class of Sire (COS)	1	23.025
Breed of Sire (BOS)	2	45.310
Breed of Ewe (BOE)	4	207.892***
Sex	1	318.160***
Birth-Rearing Type (T)	2	1498.541***
COS x Sex	1	57.913
Residual	457	15.889

*$P \leq .05$; **$P \leq .01$; ***$P \leq .001$

TABLE XLIV

LEAST SQUARE ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE SUMMER, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year (YR)	1	.24445***
Class of Sire (COS)	1	.00167
Breed of Sire (BOS)	2	.01259**
Breed of Ewe	4	.00854**
Sex	1	.23805***
Birth-Rearing Type	2	.00497
YR x COS	1	.01003*
YR x Sex	1	.06993***
Residual	380	.00247

*P ≦.05; **P ≦.01; ***P ≦.001

TABLE XLV

LEAST SQUARE ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF LAMBS BORN IN THE WINTER, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year	1	2.857*
Class of Sire	1	.347
Breed of Sire	2	1.243
Breed of Ewe	4	3.587***
Sex	1	10.821***
Birth-Rearing Type	2	71.555***
Residual	498	.487

*P ≦ .05; **P ≦ .01; ***P ≦ .001

TABLE XLVI

LEAST SQUARE ANALYSIS OF VARIANCE FOR 70-DAY WEIGHT OF LAMBS BORN IN THE WINTER, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year	1	55.297
Class of Sire	1	67.206
Breed of Sire	2	50.220
Breed of Ewe	4	14.296
Sex	1	246.848***
Birth-Rearing Type	2	431.262***
Residual	220	17.976

$^{*}P \leq .05$; $^{**}P \leq .01$; $^{***}P \leq .001$

TABLE XLVII

LEAST SQUARE ANALYSIS OF VARIANCE FOR ADG OF LAMBS BORN IN THE WINTER, USED TO ESTIMATE LEAST SQUARE MEANS

Source	df	MS
Year (YR)	1	.26707***
Class of Sire (COS)	1	.02915*
Breed of Sire (BOS)	2	.00333
Breed of Ewe (BOE)	4	.00249
Sex	1	.30394***
Birth-Rearing Type (T)	2	.00642
COS x YR	1	.01634
COS x Sex	1	.02218*
Residual	148	.00481

*P $\leq$ .05; **P $\leq$ .01; ***P $\leq$ .001

TABLE XLVIII

MEAN SQUARES FOR OVERALL ANALYSIS TO CHECK FOR INTERACTION WITH SEASON OF BIRTH

Source	df	Birth Weight	df	70-Day Weight	df	ADG
Sea	2	244.164***	2	1021.849***	2	.17613***
YR	3	2.633	3	140.225**	3	.18244***
TOS	1	2.926	1	.187	1	.00697
BOS	2	.203	2	23.928	2	.02630*
Sea x TOS	2	.075	2	38.150	2	.00757
Sea x BOS	4	2.100	4	68.890*	4	.00352
S	33	.952	32	22.201	31	.00629
BOD	4	14.027***	4	209.943***	4	.00491
Sex	1	16.555***	1	982.683***	1	1.08289***
T	2	173.011***	2	2972.141***	2	.00364
Sea x BOE	8	.939	8	29.406	8	.00477
Sea x Sex	2	.827	2	16.414	2	.04480***
Sea x T	4	.812	4	1.627	4	.00354
Residual	1538	.505	950	15.678	803	.00296

Sea=Season YR=Year nested in Season TOS=Type of Sire

BOS=Breed of Sire S=Sire nested in TOS, BOS, and Year

BOE=Breed combination of Ewe T=Birth-Rearing Type

T=Birth-Rearing Type for 70-Day Weight and ADG

*P < .05; **P < .01; ***P < .001

VITA

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