REPRODUCTIVE PERFORMANCE OF DORSET X WESTERN EWES WHEN MATED TO DORSET OR BLACKFACE RAMS

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CHAPTER I

INTRODUCTION

A progressive commercial sheepman, whose prime purpose is producing market lambs, should certainly welcome any management practice that will increase the number of lambs that reach market and thus increase his profit. This management practice must be simple to initiate and easy to operate.

Animal breeding specialists have for the past few years been recommending a static three breed cross in all market species.

```
              Breed A x Breed B
                      ↓
     Breed C male x (AxB) female
                  ↓
                C x (AxB) lambs ⟶ to market
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At least one of the breeds from the original cross should be a breed known for prolificacy and mothering ability to accomplish the best results from the matings. The terminal cross sire should be a breed respected for meatiness and growth rate. Due to the fact that the crossbred female is being used and a third breed is being introduced as a terminal cross sire, theory indicates that this mating system should maintain maximum heterosis. There have been no experimental estimates of the advantage of using the third breed (a triple-cross) over using a ram of one of the original breeds (a backcross) for reproductive and fitness characteristics.

The purpose of this study, therefore, was to evaluate the advantage, if any, that was gained by using a three-breed cross over a backcross mating in the production of market lambs. The criteria used was the reproductive performance of the matings, and the fitness characteristics of the resulting market lambs.

CHAPTER II

LITERATURE REVIEW

It has been the objective of animal breeders over the past few years to urge commercial producers to exploit the phenomenon of "heterosis" in their livestock breeding programs. Heterosis is usually defined as the improvement in performance of the F_1 (the offspring of a parental cross) or F_2 (the offspring of a cross between two F_1 individuals) etc., over the mid-parent value when in the same environment. However, for the F_1 to have much value, it should surpass the best parent in overall performance. Heterosis is further defined as the opposite of inbreeding depression which is a decrease in the performance of a trait due to inbreeding.

Crosses used to produce F_1 offspring, hopefully with some heterotic advantage, are called outbreeding matings and include (from the mildest to the broadest form of cross):

1. Outcrossing--mating unrelated individuals within the same breed.
2. Crossing inbred lines from the same breed.
3. Crossbreeding--mating different breeds.
4. Crossing inbred lines from different breeds.
5. Species crosses.

That heterosis is a genetic phenomena has never been doubted. The recurrent problem is in learning the intimate mechanisms of heterosis. This has been a slow process and the mechanisms are still far from being fully understood. According to East and Hayes (1912), hybrid vigor (heterosis) of hybrids was first studied by Keolreuter in 1763. With the rediscovery of Mendel's Laws in 1900, renewed interest was shown in heterosis as a phase of quantitative inheritance. Since then, the most important application of genetics to agriculture has been the use of heterosis in animals and plants, prime examples being hybrid corn and the mule.

The phenomena is being exploited more and more in the recent years, however, there have been few studies undertaken to expose the underlying causes. One fact has come out of the few studies undertaken, that being that heterosis is not due to any single genetic situation.

It is clear that outbreeding in most forms promotes heterozygosis (East and Hayes, 1912; Shull, 1952; Hayes, 1952; and others). Early workers such as East and Hayes (1912) introduced the concept of heterozygosis along with linkage and interaction of alleles at the same locus (dominance or overdominance) as the primary causes of heterosis. More recent workers (Jones, 1945; Hull, 1945; Castle, 1946; Gustafsson, 1947; and others) emphasized the importance of interallelic action (epistasis) as being a major factor in heterosis.

Shull (1952) suggested that the concept of heterosis is the

> ...interpretation of increased vigor, size, fruitfullness, speed of development, resistance to disease and to insect pests, or to climatic vigors of any kind, manifested by crossbred organisms as compared with corresponding inbreds, as the specific results of unlikeness in the constitution of the uniting parental gametes.

Hayes (1952) considered heterosis as the "normal expression of a complex character" when the genes are in highly heterozygous condition, with dominance (or partial dominance) appearing to be of great importance in explaining the heterosis. He also suggested that in some cases extra vigor was correlated with the heterozygous condition and concluded that interallelic and intraallelic interactions are dependent on both internal and external environment.

The heterozygosity was utilized in the four different crossbreeding matings involved in this study. Two of the crosses utilized straightbred females. Straightbred individuals exhibit no heterosis as no outbreeding is involved in their makeup. All genes are from the same gene pool. These ewes when mated to purebred males of a different breed produce two-breed crossbred lambs which would be expected to exhibit maximum heterosis (100 percent) for traits suceptible to heterosis.

The mating systems to be compared in this study were a backcross and a triplecross. The heterosis estimates as shown by Falconer (1960) are presented in Table I. A backcross mating involves the use of a two-way crossbred female. This crossbred female should exhibit maximum heterosis (100 percent) for traits such as uterine environment, reproductive capabilities and mothering ability. This ewe when mated to a ram of one of the breeds in the composition of the ewe (backcross) produces lambs that are 75 percent one breed and 25 percent the other breed. The degree of heterozygosity in these lambs is less than the degree of heterozygosity in the ewe or other lambs that are $\frac{1}{2}$ one breed and $\frac{1}{2}$ another breed and, therefore, has less than maximum heterosis. It only contains 50 percent of maximum heterosis (Table I). The triplecross mating involves the use of the same two-way crossbred female that exhibits maximum heterosis, but instead of mating the ewe to a ram of one of the breeds composing the ewe, an entirely new breed of ram is used. This cross produces lambs that are 25 percent of each of the breeds making up the ewe's geneology and 50 percent of the ram's breeding. The lambs will exhibit maximum heterosis, so a triplecross mating system maintains the maximum heterosis achieved by the original two-way cross (Table I).

TABLE I

BREED COMPOSITION AND PERCENT OF MAXIMUM HETEROSIS EXPECTED FROM BACKCROSS AND TRIPLECROSS MATING SYSTEMS

Generation Number	Backcross % Blood A	Backcross % Blood B	Backcross Expected Heterosis Lamb	Backcross Expected Heterosis Ewe	Triplecross % Blood A	Triplecross % Blood B	Triplecross % Blood C	Triplecross Expected Heterosis Lamb	Triplecross Expected Heterosis Ewe
1	50	50*	100	0	50	50*	0	100	0
2	75*	25	50	100	25	25	50*	100	100

*Breed of sire used to produce offspring.

Since the backcross lambs lose about one half the heterosis gained by the two-breed cross to produce the ewe (leaving 50 percent heterosis), and the triplecross lambs maintain maximum heterosis, the triplecross mating system would be expected to outperform the backcross mating system to some degree because of the extra heterozygosity.

Falconer (1960) developed and presented the genetic basis of heterosis. He reported through mathematical expression that heterosis in the F_1 generation at any one loci equals dy^2, where: d = the degree of dominance (loci without dominance cause neither inbreeding depression nor heterosis) and $\bar{y}^2$ = the square of the difference in gene frequency between the two populations or lines being crossed. The greater the magnitude of the difference in gene frequencies, the greater will be the heterosis experienced.

Falconer (1960) also proposed that the joint effects of all loci are the sum of their separate contributions. Since dominance at different loci may be in opposite directions, the final result may be no heterosis despite dominance at individual loci. This may be the reason that some crosses do not perform as well as expected. This observation agrees with the work of Dobzhansky (1950) and Wallace and Vetukhiv (1955) who observed the F_1's of wild populations of Drosphila were often less fit than the parent populations.

Falconer further stated that heterosis in the F_2 generation (disregarding maternal effect) will be $\frac{1}{2}dy^2$ or one half the heterosis observed in the F_1 generation. Each subsequent mating of F_2 x F_2 to produce F_3 individuals or F_3 x F_3 to produce F_4 individuals will result in a decrease of half the heterosis observed in the previous filial cross (F). After just a few generations, the heterosis will have regressed back very close to the mid-parent value.

Most researchers agree that heterozygosity is involved in the explanation of heterosis (hybrid vigor). The different opinions arise in the application of this heterozygosity to cause heterosis. At present there are three accepted possible hypotheses explaining heterosis; dominance, overdominance and epistasis (interallelic interaction).

Crow (1952) reported that since the earliest attempts to explain hybrid vigor in Mendelian terms, dominance has been a hypothesis. The dominance hypothesis attributes the increased vigor of heterozygosity to the covering of deleterious recessive genes by their dominant alleles. Hull (1952), in supporting the view of Crow, claimed that any degree of dominance of the desired allele is essentially a heterotic interaction.

The following is an example of how dominance may be a cause of heterosis. Assume:

1. A_B_ animals gain 2.2 pounds per day.
2. A_bb, aaB_ animals gain 1.8 pounds per day.
3. aabb animals gain 1.6 pounds per day.
4. Environment has no effect on the expression of a gene.
5. There are equal gene effects for a to A and b to B.

Then:

Generation	Genotypes	Phenotype ADG (lbs/day)	Generation ADG (lbs/day)
P_1	AAbb X aaBB	1.8 1.8	1.8 (mid-parent value)
F_1	AaBb	2.2	2.2
F_2 (F_1 x F_1)	1 AABB 2 AABb 1 AAbb 2 AaBB 4 AaBb 2 Aabb 1 aaBB 2 aaBb 1 aabb	2.2 2.2 1.8 2.2 2.2 1.8 1.8 1.8 1.6	2.01

The average daily gain (ADG) of the F_1 generation was 0.4 pounds per day greater than the mid-parent average, a heterotic advantage due to dominance. The F_2 generation regressed half way back towards the parental average, therefore, the problem is to maintain heterosis once it has been achieved.

Overdominance has also been proposed as a hypothesis for heterosis as reported by Crow (1952). According to Crow (1952), the overdominance hypothesis assumes that there exists a very small portion of loci at which the heterozygote is superior to either homozygote. Hull (1946) defined overdominance as those times when a heterozygote may be more extreme than either homozygote ("more viable, more productive, or otherwise exceed both homozygotes in some positive or negative quality").

Hull (1952) claimed that overdominance has seemed to be the more likely factor on the basis of genetics of the traits he studied, although he does not claim that the other alternative (dominance) has been disproven. Lerner (1954) after a comprehensive review of the evidence concerning overdominance concluded that overdominance (heterosis) was very important with respect to fitness and characters closely associated with fitness.

The pygmy gene in mice is an example of overdominance due to pleiotropy (King, 1955). Homozygotes are sterile, meaning the genotype with the highest merit would be the heterozygote. The work of Briles, Allen and Miller (1957) indicates apparent overdominance due to linkage. They found strong heterotic effects for fitness due to heterozygosity in the B blood group system in an inbred chicken strain.

The following is a numerical example of how overdominance may be the cause of heterosis. Assume:

1. AABB and aabb animals gain 1.6 pounds per day.
2. Animals that are heterozygous at one gene pair and homozygous at the other gene pair will gain 1.9 pounds per day.
3. AaBb animals will gain 2.2 pounds per day.
4. There will be no environmental effect on the expression of a gene.
5. There are equal gene effects for a to A and b to B.

Then:

Generation	Genotype	Phenotype ADG (lbs/day)	Generation ADG (lbs/day)
P_1	AABB x aabb	1.6 1.6	1.6 mid-parent value)
F_1	AaBb	2.2	2.2
F_2 (F_1 x F_1)	1 AABB 2 AABb 1 AAbb 2 AaBB 4 AaBb 2 Aabb 1 aaBB 2 aaBb 1 aabb	1.6 1.9 1.6 1.9 2.2 1.9 1.6 1.9 1.6	1.9

The F_1 generation again shows maximum heterosis but the F_2 generation regressed half way back towards the midparent average. One half the heterosis gained in the F_1 generation is lost in the F_2 generation.

Epistasis (interallelic interaction) has been identified as another contributing factor to heterosis. Epistasis, unlike dominance and overdominance which have their alleles at the same loci (A and a), has its alleles at different loci (A and B).

As mentioned earlier, Jones (1945), Hull (1945), Castle (1946), Gustafsson (1947) have emphasized the importance of interallelic action (epistasis) in relation to heterosis. Mather (1955) went so far as to suggest that a large portion of the apparent overdominance (with respect to some traits in plants) could be attributed to epistatic interaction.

Falconer (1960) raised a point that it may be assumed that epistatic interaction between loci in crosses of breeds of domestic animals or laboratory populations is negligible. However, he does not feel such an assumption is justified in the case of crosses between differentiated wild populations whose genetic differentiation is primarily the result of evolutionary adaptation to local environments.

A mathematical example of epistatic action follows. Assume:

1. It is an interaction whereby the capital gene from both loci must be present for either capital gene to have an effect. Therefore, animals of A_B_ genotype will gain two pounds per day.
2. All other animals will gain 1.6 pounds per day.
3. There are no environmental effects on the expression of a gene.
4. There are equal gene effects for a to A and b to B.

Then:

Generation	Genotype	Phenotype ADG (lbs/day)	Generation ADG (lbs/day)
P_1	AABB x aabb	2.0 1.6	1.8 (mid-parent value)
F_1	AaBb	2.0	2.0
F_2 (F_1 x F_1)	1 AABB 2 AABb 1 AAbb 2 AaBB 4 AaBb 2 Aabb 1 aaBB 2 aaBb 1 aabb	2.0 2.0 1.6 2.0 2.0 1.6 1.6 1.6 1.6	1.83

As in dominance and overdominance the F_1 has maximum heterosis and the F_2 generation regresses back towards the mean of the parents.

Knowing the causes of heterosis and how they work are not prerequisistes in raising a superior flock. This comes in the application of the genetic principles of heterosis. Experimental results on crossbreeding at the U. S. Range Livestock Station in Miles City, Montana and other stations have shown the advantages of heterosis and they have determined that traits expressed early in life and other traits of low heritability (less than 15%) are affected to the greatest degree by heterosis. As a result of these, and other studies, the present recommended mating system is the use of an F_1 crossbred female crossed with a purebred sire of a breed not in the original cross. The F_1 crossbred female herself exhibits maximum heterosis for the two breeds crossed to produce her. By then mating this female to a third breed, the heterosis shown in the resulting offspring will be greater (if positive heterosis is involved) than in an offspring from the crossbred female mated to a sire of one of the original breeds in the parental cross. All offspring should then be sent to market. The use of the third breed allows increased heterozygosity over a backcross, not only for improvement in superficial characteristics, but more importantly for a moderate improvement in type, rate of gain, feed efficiency, milking ability, reproduction, fitness, vigor and other traits.

Sang (1956) advised that traits of high heritability rarely show heterosis. For such traits if past progress under selection warrants its continued use stay with selection. Conversely, traits of low heritability generally display heterosis and utilization would allow the best results toward immediate gains.

Sidwell, Everson and Terrill (1962) conducted a study utilizing 3621 lambs from four groups of purebred sheep, seven groups of first cross lambs from the four pure breeds, six groups of three-way cross lambs and six groups of four-way cross lambs. Over all pure breeds and crosses they found that a higher percent of single lambs were born alive than multiple birth lambs. They reported that prolificacy and lamb livability were generally higher for crossbred than for purebred matings and that the increase continued upwards with increasing numbers of breeds involved in the cross. The average increases in percent lambs weaned of ewes bred were 2.1, 14.9 and 27.1 for the two, three and four breed crosses respectively, over the averages of the purebred parents.

Thrift and Whiteman (1969) reported a study involving the lifetime performance (10 years) of 120 Western ewes (predominantly

Rambouillet) and 120 Dorset X Western ewes. They found that crossbred ewes produced significantly more lambs (19 per 100 ewes lambing) and the number of lambs reared (alive at two weeks of age) was also increased significantly (22.6 per 100 ewes lambing) under a fall lambing schedule.

Hight and Jury (1969), in a comprehensive study on 7727 lambs born between 1959 and 1967, looked at some factors associated with lamb mortality. The lambs were from six flocks, two Romney and four generations of two breed rotational crosses between Border Leicester and Romney sheep. They found that survival rate (to weaning) increased from straightbred Romney to the second generation cross lambs and then declined with interbreeding in the third and fourth generations indicating that heterosis and/or maternal ability influenced lamb mortality. In their study, 44.6 percent of the single lambs died of dystocia and 15.1 percent from physiological starvation. Conversely only 16.0 percent of the multiple birth lambs died of dystocia while 41.7 percent died of starvation. They also reported that most lamb deaths occurred within three days of birth. In their study, the survival rate of multiple born lambs increased as birth weight increased, however, single born lambs had a survival rate that was maximum at average birth weights and decreased in both directions from the mean birth weight.

Sidwell and Miller (1971) compared five different breeds (Hampshire, Targhee, Suffolk, Dorset and a Columbia-Southdown-Corriedale strain) and all possible two-way crosses for prolificacy and livability. The study involved four years (1965 to 1968) and included from 20 to 70 ewes of each "pure" breed during each year. The 20 possible crosses utilized 7 to 15 ewes in each group each year. Fourteen of the 20 possible two-breed crosses showed positive heterosis for number of lambs born per 100 ewes lambing ranging from -13.4 lambs to a 28.0 lamb increase per 100 ewes lambing. For percentage of lambs born alive of total lambs born, 13 of the 20 crosses showed positive hybrid vigor. All but one two-way cross produced more lambs weaned of live lambs born over the purebreds. The crossbred matings produced an average of 94.0 percent lambs weaned of ewes bred compared to 78.8 percent for the average of the pure breeds. They concluded that two-way crosses considerably improved reproductive efficiency.

Smith and King (1964) utilizing a total of 34,800 litters of pigs reported that two-way cross matings produced 2.0 percent more pigs born and 5.0 percent more pigs at weaning over purebred matings. They also found that crossbred sows produced 5.0 percent more pigs born and 8.0 percent more pigs weaned over purebred matings.

In 1971, Parsons found that hybrids between inbred lines and other homozygotes in sheep tend to show an enhancement of heterosis in extreme environments over optimal environments. He proposed that such a phenomenon may be associated with temperature sensitive components and correlated enzymes.

Sang (1956) concluded from a review of literature that hybrid animals are more adaptable and, therefore, more fit because of a greater biochemical versatility. Biochemical reactions are controlled by genes. Hybridization introduces new recombinations of genes and, therefore, more kinds of enzyme systems. He advises to hybridize when the hybrid shows greater stability towards environmental variables.

CHAPTER III

MATERIALS AND METHODS

The two mating systems to be compared for this study were the backcross and triplecross matings. The backcross mating consisted of a two-way crossbred females ($\frac{1}{2}$ Dorset X $\frac{1}{2}$ Western) mated to Dorset rams. These ewes will hereafter be referred to as Dorset cross ewes. The triplecross consisted of the same ewe breed cross mated to a Blackface ram (Suffolk or Hampshire). Suffolk and Hampshire rams are generally considered to be very similar in most traits and for this study were grouped together as one breed of ram (Blackface).

There is an inherent problem from such a comparison, i.e., any differences found between mating systems may be due totally or partially to the differences between ram breeds. One mating system utilizes Dorset rams while the other utilizes Blackface rams, and, as a result, the ram breed effects will be confounded with mating system differences in the comparison. For this reason, another group of ewes was included in the study (Western ewes, predominantly Rambouillet). These ewes were mated simultaneously to the same rams (Dorset and Blackface) and used as a comparative control to allow evaluation of the mating systems without confounding of ram breed effects. Both the Dorset X Western and Blackface X Western matings were single cross outbreeding matings.

By using the control matings to correct for breed differences in rams, a clean advantage or disadvantage of a triplecross mating over a backcross mating can be seen and evaluated for each specific trait studied. With the data available the advantage can be found by three different methods.

Method 1. The Western ewes were used as a comparative control. For each trait concerned, the two ram breeds (Dorset and Blackface) were compared when mated to Western ewes. Since the females used were of the same breeding and averaged equal according to age, any difference should be due strictly to sire breed effect for the trait studied. The difference between the sire breeds could also be evaluated from matings of the rams to Dorset cross ewes. This value included differences due to mating system plus differences between ram breeds. By then subtracting the estimated difference in sire breeds found by matings to Western ewes, the remainder was the advantage due to the mating system alone as shown below.[1]

(DxW)-(BxW) = R (the difference due to ram breed effects)

(DxDC)-(BxDC) = X (the difference due to mating system + ram breed effects)

X - R = M (the difference due to mating system alone)

Method 2. Calculate the increase (or decrease) for each trait concerned from matings of Dorset cross ewes and Western ewes to each sire breed (Dorset or Blackface). The increase (or decrease) found for each trait and for each sire breed was a function of the heterosis (positive or negative) gained from the crossbred female over the straightbred (Western) female. By then subtracting these two differ-

[1]D = Dorset, W = Western, B = Blackface and DC = Dorset cross throughout this manuscript.

ences a value will be found which favors the backcross mating or the triplecross mating. The value will be the advantage (or disadvantage) of including a third breed in the mating system without the confounding of breed of ram.

(DxDC)-(DxW) = Y (the increase due to crossbred female using Dorset rams)

(BxDC)-(BxW) = Z (the increase due to crossbred female using Blackface rams)

Y - Z = M = the advantage due to the mating system alone

Method 3. Arranging the percentages for each specific trait into a 2x2 factorial treatment arrangement as shown below.

	Western ewes	Dorset cross ewes
Dorset rams	D x W*	D x DC
Blackface rams	B x W	B x DC

*the percentage or probability of an event for each specific trait.

The advantage for a mating system is then evaluated by looking at the interaction from the table. The interaction is [(DxW) + (BxDC)] - [(BxW) + (DxDC)] and the difference equals M (the advantage due to mating system).

All systems result in the same estimated advantage or disadvantage for mating systems (the M's are equal). This paper utilizes the third method of estimating the advantage of mating system to enable statistical analysis to be completed.

Ideally, to get a true estimate of heterosis (hybrid vigor) both types of crossbred ewes must be available for testing. This means that this study should not only be testing backcross matings with Dorset rams on Dorset cross ewes, but also with Blackface rams on Blackface cross ewes. Concurrently, the triplecross matings should be tested by using Dorset rams on Blackface cross ewes as well as Blackface sires on Dorset cross ewes. Both crosses should then be compared to purebreds of these breeds.

Such an experiment would be uneconomical to set up as it would have to involve a large number of animals over a long period of time to find a small difference between the two mating systems. The most economical and practical method to find the difference between the mating systems would be to evaluate available records from other studies. This method would only be acceptable if management prodecures remained constant from one year to the next. The sheep flock at Fort Reno is managed in such a manner. Using old records, it is still doubtful that all the needed crosses in large numbers are available for evaluation. Such was the case at the Fort Reno Livestock Station. Therefore, this study estimates the <u>advantage</u> of a specific triplecross over a specific backcross mating system for each trait, not the general situation involved.

Experimental Material

The data for this study consisted of 2501 ewe lambing records over a period of 12 years (1959 through 1970) at the Fort Reno Livestock Experiment Station near El Reno, Oklahoma. The ewes used were of two different breeds:

1. Western ewes which included primarily straightbred Rambouillet and 3/4 Rambouillet X $\frac{1}{4}$ Panama, but also a few Panama, $\frac{1}{2}$ Panama X $\frac{1}{2}$ Rambouillet, $\frac{1}{2}$ Rambouillet X $\frac{1}{2}$ Merino and $\frac{1}{2}$ Columbia X $\frac{1}{2}$ Rambouillet breed combinations.
2. One half Dorset ewes (Dorset cross ewes) which included $\frac{1}{2}$ Dorset X $\frac{1}{2}$ Rambouillet and $\frac{1}{2}$ Dorset X 1/8 Panama X 3/8 Rambouillet. Of the 2501 ewe records available, 1270 were Western ewe records and 1231 were Dorset cross ewes records.

Considering these two breeds of ewes and the breed of ram they conceived to, four different groups resulted upon which comparisons were drawn for this study. Their make-ups are shown in Table II. There were also two groups that were the result of either Western ewes (57) or Dorset cross ewes (76) conceiving to both breeds of rams (she lambed at least twins, each ram breed siring at least one lamb). The different mating systems cannot be compared from such conceptions and, therefore, these were disregarded from any results discussed in this paper.

Since this study involves observational data and was not a planned experiment, precautions had to be taken to discard any matings that would not allow an unbiased test of the question considered. Considerably more than 2501 lambing records were available for use, but in order to obtain the unbiased test desired, many small breeding groups were discarded from the study. Ewe mating records were not included in the study from breeding groups that did not meet the following specifications:

1. The ewes must be of the breed combinations described

previously.

2. Each ewe must have had an equal chance to mate and conceive to either a Blackface or a Dorset ram. Therefore, each breed group used in the study had to have a Blackface and a Dorset ram in the breeding group at the same time or rotated at equal intervals (usually daily) during the breeding season.

3. Any ewes that were being used in an experiment of a nature that might cause bias in this study were not considered, especially if they only included small numbers so chance would not equalize random differences.

4. Each breeding group used must have contained both breeds of ewes in approximately equal numbers.

TABLE II

COMPOSITIONS OF MATING SYSTEMS (GROUPS) STUDIED

Group	Ewe Breed	Ram Breed	Lamb Breeding
1	Western	Blackface*	Blackface X Western
2	Western	Dorset	Dorset X Western
3	Dorset cross	Blackface*	Triplecross
4	Dorset cross	Dorset cross	Backcross

*Suffolk or Hampshire

Since all ewe records were carefully scrutinized to only consider those ewe records that fit the specifications set up, the 2501 ewe mating records remaining should represent a group free of any bias that would render the results invalid. They should average equal over all considerations (ewe age, individual ram differences, pasture differences or any other variables that could cause discrepancies) that were not being studied. The ewes of Western and Dorset X Western breeding were in a project comparing the lifetime performance of the two breed groups of ewes. For this reason each breeding group consisted of both kinds of ewes in approximately equal numbers with different ages of ewes balanced. The rams were handled in such a manner that it was possible to utilize the ewes for this study. The breeding groups were exposed to Blackface and Dorset rams resulting in the mating systems to be compared for this study.

Table III shows the number of ewe records each year in each mating system for the duration of the study. There were 592 Dorset X Western matings, 621 Blackface X Western matings, 567 backcross matings and 588 triplecross matings available to make comparisons.

The 2501 ewe records were the result of conception to a total of 55 different rams (27 Dorset and 28 Blackface). As previously mentioned, rams were used in pairs or rotated at equal intervals (usually daily) so there should be an equal number of both Blackface and Dorset rams each breeding season. However, there was some variation from from equal numbers, the result of two problems:

1. Some rams were replaced for not being fertile (consistent rebreedings) but they did settle a few ewes and, therefore, were counted.

TABLE III

TOTAL NUMBERS OF EWES PER MATING SYSTEM PER YEAR

Year	Groups: Dorset ♂♂ X Western ♀♀	Blackface ♂♂ X Western ♀♀	Backcross Mating	Triple-cross Mating	Ewes conceived to both rams	Total
1959	18	27	25	30	13	113
1960	28	43	28	35	1	135
1961	87	32	41	22	13	195
1962	57	59	45	52	5	218
1963	61	70	48	45	8	232
1964	49	62	37	69	12	229
1965	61	64	81	54	10	270
1966	52	75	59	110	11	307
1967	40	83	51	70	13	257
1968	50	49	61	48	22	230
1969	69	34	66	36	17	222
1970	20	23	25	17	8	93
Totals	592	621	567	588	133	2501

2. From 1967 on, when all ewes were on a twice yearly lambing schedule, an effort was made to be sure that a fertile ram was with the ewes at all times. This involved using a battery of rams and rotating them often. Each ewe still had an equal chance to settle to a Blackface or Dorset ram, but there was a large number of rams used in relation to the number of ewes bred.

Managerial Procedures

The ewe mating records came from data on the existing flock at the Fort Reno Livestock Station. Most management procedures were alike for all years of the study, however, as new and better management practices became known some small procedures were changed. Any changes that were made did not affect the fact that each breeding group had rams allotted in pairs and both types of ewes were in each breeding group in approximately equal numbers. The following basic flock management practices were imposed on the ewes and their lambs each year of this study:

1. At breeding, ewes were stratified across all breeds and ages into small breeding groups (30 to 50 ewes). Ewes were exposed to rams evaluated as fertile from a gross semen check by electroejaculation. The rams were randomly allotted in pairs consisting of one Dorset and one Blackface (Hampshire or Suffolk) and were rotated daily or used together.
2. Following the breeding season the ewes were assembled into large flocks and maintained on mixed grass pasture.

3. In early fall, rams were again turned in with the ewes to mate with those ewes that did not conceive in the spring. Figure 1 shows the basic breeding seasons and subsequent lambing periods used before and during 1966. The major breeding period ran from May 20 until July 1 and the clean-up breeding period was from August 20 until September 20. The major lambing period then was from mid-October until late November. Starting in 1964, some of the ewes were placed on a twice yearly lambing schedule. Twenty-five of the 229 ewes used for this study during 1964, 121 of the 270 ewes used in 1965, 140 of the 307 ewes used in 1966 and all ewes used from 1967 to 1970 were on the twice yearly lambing schedule. Figure 2 shows the breeding and lambing seasons for these ewes. Spring breedings were from April 20 to June 20 with resulting fall lambing from mid-September to mid-November. Fall breeding included the period from October 20 until December 20 with subsequent lambing from mid-March to mid-May.
4. About four to six weeks prior to lambing (time depending on the pasture conditions) the ewes received supplemental grain.
5. Lambs were born in the lot and placed in lambing pens with their mothers at the central lambing barn. At this time, lamb data were collected and the lambs were identified with metal ear tags (with the mother's individual number). The lambs remained in this pen for about three

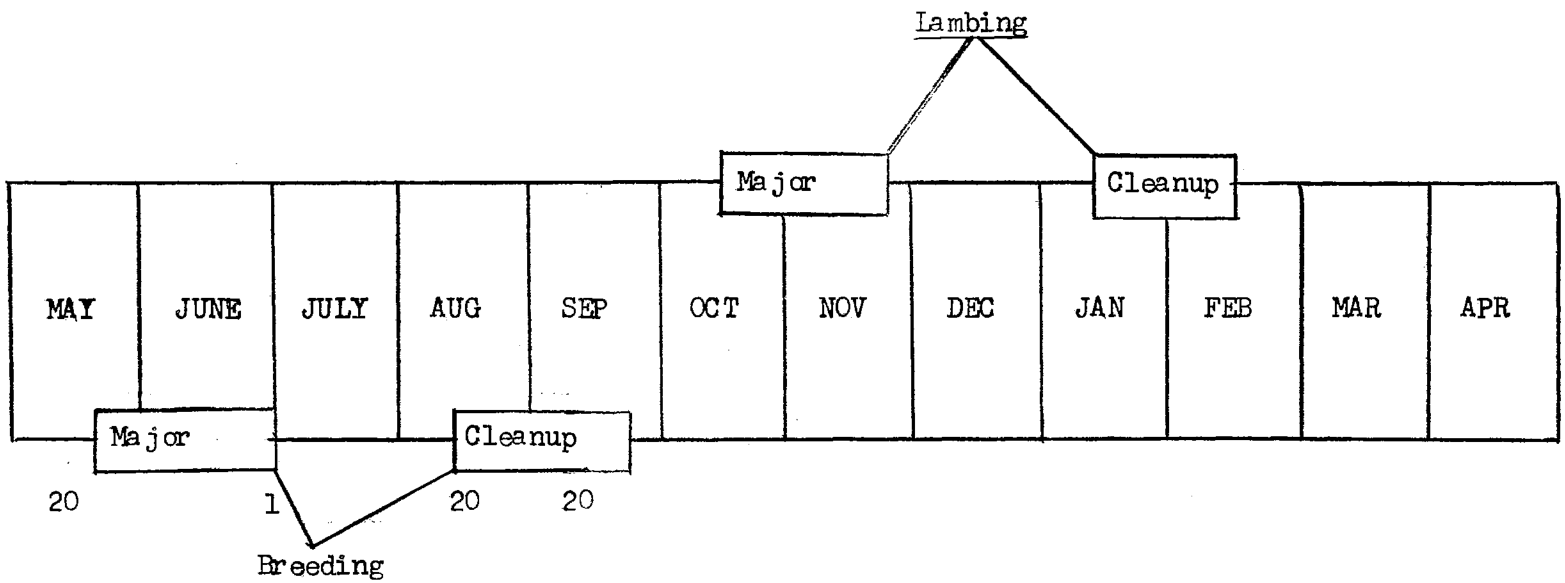

Figure 1. Major and Cleanup Breeding and Lambing Periods for the Ewes Used up to and Including 1966

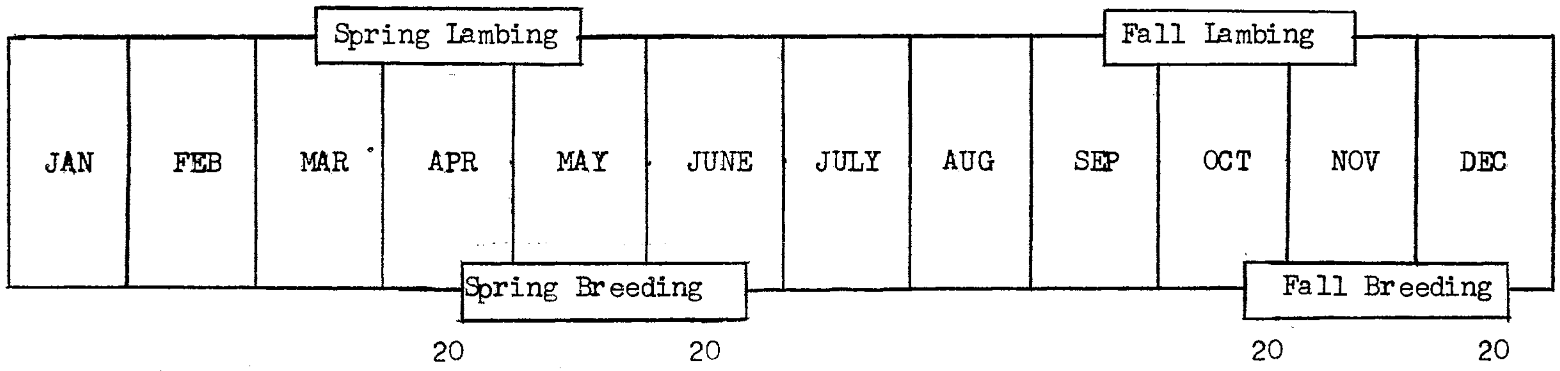

Figure 2. Breeding Periods and Subsequent Lambing Periods for the Ewes on a Twice Yearly Lambing Schedule

to four days. After the lambs were strong enough to stay at the mother's side, they were transferred to a larger area with approximately ten other ewes and their lambs.

6. As the lambs reached about ten days of age, the ewes and lambs were moved to a feeding area with the other ewes nursing lambs. Creep feed was available for the lambs. Fall lambing ewes and their lambs were allowed to graze on wheat pasture, but in an effort to reduce internal parasites, spring born lambs were not allowed out of the lot to graze with their mothers.
7. Upon weaning the ewes were maintained on mixed grass pasture with supplemental feed as needed to maintain desired condition.
8. All ewes were sheared in the spring.

Data Collection

All rams that were exposed to the breeding groups wore marking harnesses. With the aid of the markings and visual observations of estrual behavior, mating data were collected. This is not an entirely mistake-free method of obtaining mating data since no mark was found on some ewes that conceived, and it is also possible that no mating occurred on some of the ewes that were marked.

From the mating data collected, the conception date was computed by taking the lambing date and subtracting 147 days as the average gestation length of a ewe. Since a ram's sperm is generally considered to be viable from 12 to 24 hours after mating, and due to individual variation of gestation lengths between ewes, if a mating occurred within four days of the computed conception date and the face color of the lamb(s) matched that of the ram making the mating it was considered to be the mating that resulted in conception. The face color of the lamb was the only method of determining the breed of the sire, as all ewes were exposed to both breeds of rams. Lambs with black or spotted faces were considered to have Blackface rams as sires and lambs with white faces were considered to have Dorset rams as sires. If no mating occurred within four days of the estimated conception date the estimated date was used with the sire breed being determined by the lamb(s) face color. Conceptions for this study were categorized as follows:

1. Ewes that conceived to the first mating.
2. Ewes that had their first mating to a Dorset ram and did not conceive, then conceived to the second mating by either a Blackface or Dorset ram.
3. Ewes that had their first mating to a Blackface ram and did not conceive, then conceived to the second mating by either a Blackface or Dorset ram.
4. A ewe that conceived to the third or a subsequent mating regardless of ram breed of previous matings.

Lamb crop percentages were of prime importance in this study. Therefore, the numbers of singles, twins and triplets for each of the four groups of ewes were calculated. From these figures total lamb crop percent (number of lambs per 100 ewes lambing) was also calculated.

Other observations taken were early lamb mortality, lamb vigor and birth difficulty. Early lamb mortality included stillborn lambs, lambs dying at birth and lambs dying before two weeks of age. Death losses were reported as a percentage of lambs born that did not survive to two weeks of age. After a lamb reaches two weeks of age most death losses would be considered due more to chance than any other factor so only losses up to two weeks of age were considered (Hight and Jury, 1969).

Lamb vigor was a subjective measurement of fitness made by the shepherd. The lambs at birth were evaluated and placed into one of three categories:

1. Lambs that were born stillborn or died during birth.
2. Lambs that were scored strong at birth. These lambs did not need help to get up and start nursing.
3. Lambs that were scored weak at birth. These were lambs that had to be helped to nurse and stay alive as they were too weak to fend for themselves.

A weak lamb many times was the result of a prolonged or difficult labor by the ewe. The incidence of unassisted births (expressed as a percentage of lambs born) was used as a basis of evaluating birth difficulty.

Gestation lengths were analyzed for the ewes in which a mating was recorded approximately 147 days prior to lambing (within four days), provided that mating was to a ram whose face color was the same as the lamb's face color.

Analysis

The traits studied by use of 2x2 factorial treatment arrangements were analyzed using a "t" test for differences in probabilities as explained in Chapter 16 of Snedecor and Cochran (1967). The 2x2 factorial table involves arranging the percentage or probability of an event for a specific trait and testing the interaction.

	Western ewes	Dorset cross ewes
Dorset rams	P_{11}*	P_{12}
Blackface rams	P_{21}	P_{22}

*the percentage or probability of an event for each specific trait

The test statistic is:

$$t = \frac{(P_{11} + P_{22}) - (P_{12} + P_{21})}{\sqrt{S^2_{P_{11}} + S^2_{P_{22}} + S^2_{P_{12}} + S^2_{P_{21}}}}$$

where:

1. $(P_{11} + P_{22}) - (P_{12} + P_{21})$ is the interaction being tested.
2. $S^2_{P_{ij}}$ is found by $\frac{P_{ij}\, q_{ij}}{n_{ij}}$
3. $q = 1 - P$
4. n = the number of observations for each mating system.

The "t" value is calculated by:

$$\frac{(P_{11} + P_{22}) - (P_{12} + P_{21})}{\sqrt{\frac{P_{11}\, q_{11}}{n_{11}} + \frac{P_{22}\, q_{22}}{n_{22}} + \frac{P_{12}\, q_{12}}{n_{12}} + \frac{P_{21}\, q_{21}}{n_{21}}}}$$

There are $(n_{11} - 1) + (n_{22} - 1) + (n_{12} - 1) + (n_{21} - 1)$ degrees of freedom associated with the test statistic.

CHAPTER IV

RESULTS AND DISCUSSION

The overall advantage (or disadvantage) of the triplecross mating over the backcross mating will be evaluated and discussed for each trait concerned.

Mating Records

It was an objective of this study to allow each ewe to have an equal chance to mate and conceive to a Blackface or Dorset ram. This was desirable to be able to draw accurate conclusions about the traits studied. It would be expected that one half of the ewes would have their first mating with a Dorset ram and one half would have their first mating with a Blackface ram. These matings were further broken into spring and fall breeding seasons, and the different ram breeds were compared for the two seasons.

The ewe records used over the 12 year period resulted from matings to 55 different rams (27 Dorset and 28 Blackface). The 27 Dorset rams constituted a total of 98 ram seasons (spring and fall breeding being considered different seasons). The 28 Blackface rams totaled 99 ram seasons. That meant that a ram could be used for both seasons in any one year or over a number of years. Any ram settling at least six ewes during a breeding season was considered a ram season, therefore, within any one breeding season there were many ram seasons.

When new rams were purchased they were usually yearling rams. The 27 Dorset rams used for this study averaged 60.7 months of age and the average age of the 28 Blackface rams was 62 months. Since the difference in average age was so small, there should be no effect on performance between the groups due to age of ram. McMeniman and Beasley (1970) found that over the entire breeding season mature rams and virgin rams had no significant difference in the number of matings performed.

The data on ewes mating in each breeding season are presented in Table IV. Dorset rams performed the first mating to 1169 (49.4 percent) of all ewes while 1199 (50.6 percent) had their first mating performed by Blackface rams. The records were almost half and half as to ram breed of first mating and are not significantly different, meaning that each ewe did have an equal chance to mate and conceive to either ram breed. To further break these figures down, 880 records were from fall breedings and 1488 records were from spring breedings. Among the ewes included in the fall breeding records 377 (42.8 percent) had their first mating to Dorset rams and 503 (57.2 percent) were first mated by Blackface rams. Of the 1488 spring breeding ewe records, 792 (53.2 percent) were first mated by Dorset rams and 696 (46.8 percent) were first mated by Blackface rams.

Significantly more ewes ($P<.025$) had their first mating performed by Dorset rams during the spring breeding seasons. In fall breeding seasons, significantly more ewes ($P<.005$) had their first mating to Blackface rams. The Dorset breed is considered an out of season breeding sheep and would be expected to mate with more ewes during spring breeding. Dorset rams are also quite heat susceptible and considering the high temperatures in Oklahoma, the Blackface rams would be expected to mate with more ewes for early fall breeding. The mating records totaled over all breeding seasons for the 12 year period show that the desired distribution of one half of these ewes having their first mating performed by each ram breed was achieved.

TABLE IV

THE NUMBER OF EWE RECORDS IN EACH BREEDING SEASON WHEN MATED TO THE DIFFERENT RAM BREEDS

Breeding Season	No. of Records	First Mating	
		Dorset rams	Blackface rams
Fall	880	377^a	503^b
Spring	1488	792^c	696^d
Totals	2368	1169	1199

Values within a row followed by different letters differ significantly, ab = ($P<.005$) and cd = ($P<.025$).

Conception Data

Conceptions for this study were subdivided into four groups and the results presented in Table V. The four groups were: conception at first mating, conception at second mating after the first service performed by a Dorset ram failed, conception at second mating after the first service performed by a Blackface ram failed and conception at third or subsequent mating regardless of breed of ram performing the first services.

TABLE V

TOTAL NUMBERS AND PERCENTAGES OF EWES CONCEIVING TO THE FIRST MATING FOR EACH BREEDING SEASON

First Mating By	Breeding Season	Total Number Available	Number Conceived	Percent Conceived
Dorset rams	Spring	792	663	83.82
Dorset rams	Fall	377	332	85.41
		1169	985	84.30
Blackface rams	Spring	696	591	84.91
Blackface rams	Fall	503	432	85.88
		1199	1023	85.30

A total of 2368 ewe records were available for consideration and 2008 (84.8 percent) resulted in conception to the first mating by one of the ram breeds. Dorset rams performed the first mating to 1169 of the ewes and 985 (84.3 percent) conceived to that first mating. The other 1199 ewes had their first service performed by Blackface rams and 1023 (85.3 percent) conceived to that first service (Table V). Conceptions to the first mating were not significantly different from spring and fall breeding for either of the ram breeds.

The 2368 ewe records consisted of 1213 Western ewe records and 1155 Dorset cross ewe records. Considering the conceptions of these records on an individual ram breed basis, Dorset rams settled 84.7 percent (504 out of 595) of the Western ewes at first mating and likewise settled 83.8 percent (481 out of 574) of the Dorset cross ewes at the first mating. Comparatively, Blackface rams performed the first mating to 618 of the Western ewes and settled 539 (87.2 percent) at that first mating. The Blackface rams settled 83.3 percent (484 out of 581) of the Dorset cross ewes as a result of the first mating. Table VI shows the 2x2 factorial treatment arrangement for conceptions to the first mating. The interaction shows a 3.0 percent advantage in conception at first mating for the backcross mating system over the triplecross mating system after adjustment for ram breed effects. This interaction for conception rate to first mating is not significant. The calculated t value is 1.014 ($P < .30$).

Conceptions to the four subdivisions for conception are presented in Table VII. As evaluated 2008 ewes conceived to the first mating. An additional 150 ewes conceived to the second mating after the first mating to a Dorset ram failed in conception. After failing to conceive to the first mating by a Blackface ram, 128 ewes conceived at the second mating. A total of 82 ewes mated three times or more before they conceived.

Mating data revealed that the ram breed of first mating was not significantly different over the 12 years of the study. After adjustment for ram breed effect a nonsignificant 3.0 percent advantage in conception rate to first mating was found in favor of the backcross mating system.

The total number of first matings to the different ram breeds depended upon the ratio of spring and fall breeding records, as ram breed of first mating was significantly different for the different breeding seasons. Conception rates to first mating did not vary for either ram breed between the two breeding seasons.

TABLE VI

2x2 TABLE FOR PERCENTAGES AND NUMBERS OF CONCEPTIONS TO FIRST MATING

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	504/595[1]	481/574
	84.71	83.80
Blackface ♂♂	539/618	484/581
	87.21	83.30

[1]The fractions represent the number of ewes that conceived to first service.

$$t = \frac{.030}{\sqrt{\frac{(.8471)(.1529)}{595} + \frac{(.8721)(.1279)}{618} + \frac{(.8380)(.1620)}{574} + \frac{(.8330)(.1670)}{581}}}$$

$$= \frac{.0300}{.0296} = 1.014$$

TABLE VII

THE NUMBER OF EWES THAT CONCEIVED TO THE DIFFERENT MATINGS UNDER EACH MATING SYSTEM

Group	Conception: At First Mating	Conception: At Second Mating[1]	Conception: At Second Mating[2]	Conception: At Third or Subsequent Mating[3]
Dorset ♂♂ X Western ♀♀	504	44	27	17
Blackface ♂♂ X Western ♀♀	539	31	35	16
Dorset ♂♂ X Dorset cross ♀♀	481	37	28	21
Blackface ♂♂ X Dorset cross ♀♀	484	38	38	28
Totals	2008	150	128	82

[1]The first mating was to a Dorset ram but conception failed.
[2]The first mating was to a Blackface ram but conception failed.
[3]Does not consider matings prior to conception.

Lambing Rate

Lambing rate is a reflection of the number of ewes lambing singles, twins and triplets and is a trait subject to heterosis, if the more highly heterozygous embryo has increased viability. The two mating systems utilizing Western ewes would not be expected to produce as many lambs per 100 ewes lambing as the mating systems utilizing Dorset cross ewes (Thrift and Whiteman, 1969), since the Western ewes are straightbred and would exhibit no heterosis for lambing rate. There should be maximum heterosis for embryo viability (lamb production) from matings of Western ewes to Blackface or Dorset rams, but the ewes themselves have no heterosis for this trait. Conversely, the Dorset X Western (Dorset cross) ewes exhibit maximum heterosis for prolificacy and when mated to Blackface rams (triplecross) maximum heterosis for embryo viability is achieved. The Dorset cross ewes from matings to Dorset rams (backcross) only have 50 percent of maximum heterosis for embryo viability, but the ewes still have maximum heterosis for lambing rate.

There was only a very slight difference in lamb crop percentage from matings of Western ewes to the two ram breeds. Matings of Dorset sires to Western ewes resulted in a 12 year lamb drop averaging 140.03 lambs per 100 ewes lambing compared to 139.29 when using Blackface rams (Hampshire and Suffolk). The same Dorset sires mated to Dorset cross ewes (backcross) produced 148.85 lambs per 100 ewes lambing. The triplecross matings resulted in an average lambing rate of 153.06 lambs per 100 ewes lambing for the 12 years of this study. The figures for lambing rate are shown in Table VIII. Over the 12 years, after adjustment for ram breed effect, the triplecross mating system produced an average of 4.95 more lambs per 100 ewes lambing than did the backcross mating system. As shown by conception rate the 4.95 percent increase was not due to increased fertility, therefore it must be due to increased viability of the heterozygous embryo and fetus.

TABLE VIII

2x2 TABLE FOR LAMBING RATES AND NUMBERS OF EWES

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	592[1] 140.03	567 148.85
Blackface ♂♂	621 139.29	588 153.06

[1]The numbers shown are the number of ewes per mating system.

The ewe mating records were corrected for ewes bearing triplets, resulting in all mating records being based on ewes bearing singles and ewes bearing twins. The corrected numbers and percentages of ewes bearing twins are shown in Table IX. The test results in a t value of 1.217. This interaction was not significant ($P < .20$), although it approached significance.

As mentioned, the number of lambs per 100 ewes is a result of the number of ewes that lambed singles, twins and triplets. These results are shown in Table X and Figure 3. The same rams were mated to both Western and Dorset cross ewes but the percentage of ewes bearing singles, twins and triplets changed drastically from one breed of ewe to the other. When Dorsets were used as the sire breed, Western ewes and Dorset cross ewes lambed 60.6 percent singles, 38.7 percent twins, 0.7 percent triplets and 53.1 percent singles, 45.0 percent twins, 1.9 percent triplets, respectively. Concurrently, the Blackface rams when used as the sire breed produced 61.7 percent singles, 37.4 percent twins, 1.0 percent triplets and 50.3 percent singles, 46.3 percent twins, 3.4 percent triplets from matings to Western ewes and Dorset cross ewes, respectively. A 3.4 percent incidence of triplets (from the triplecross) is a fairly high frequency of triplets considering the breeds that composed the cross are not particularly noted for producing triplets. It is a value almost twice as large as any percentage from the three other crosses.

TABLE IX

2x2 TABLE FOR PERCENTAGES OF EWES BEARING TWINS CORRECTED FOR EWES BEARING TRIPLETS

	W ♀♀	DC ♀♀
D ♂♂	40.03	48.85
B ♂♂	39.29	53.06

TABLE X

THE NUMBERS AND PERCENTAGES FOR TYPES OF BIRTH PER MATING GROUP

Groups	No. of Ewes	Single Lambs		Twin Lambs		Triplet Lambs	
		No.	Percentage	No.	Percentage	No.	Percentage
D♂♂ X W♀♀	592	359	60.6	229	38.7	4	0.7
B♂♂ X W♀♀	621	383	61.7	232	37.4	6	1.0
D♂♂ X DC♀♀	567	301	53.1	255	45.0	11	1.9
B♂♂ X DC♀♀	588	296	50.3	272	46.3	20	3.4

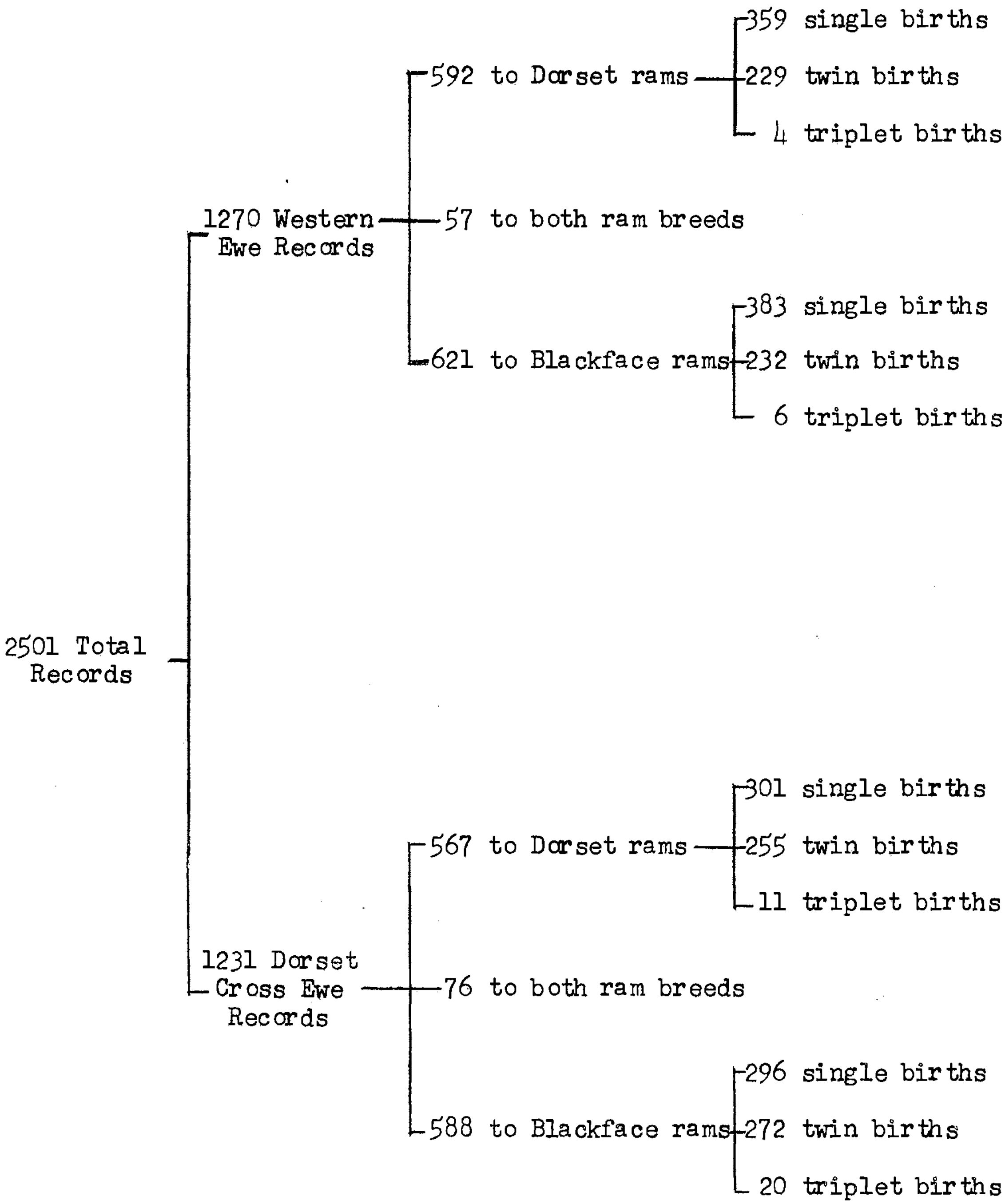

Figure 3. A Flow Pattern of Breed Groups and Resulting Lambs

As seen, the overall advantage as calculated for the 12 year period was 4.95 percent, however, Figure 4 shows that the advantage varied greatly from year to year. Sidwell et al (1962) using 2962 ewes found an increase of 10.3 percent (147.6 versus 137.3) lamb drop when comparing three breed crosses to purebreds. They found it an advantage to use extra breeds to increase lambing rate. The larger value found by Sidwell would be expected as these two studies were estimating different values. Sidwell compared triplecross matings to purebreds on an absolute basis, while this study compared triplecross to backcross matings using a comparative control.

Lamb Mortality

This study also evaluated the early death losses of lambs born to the different mating systems. Death losses among young lambs usually occur very early in life (Hight and Jury, 1969). The lambs born to the two-way cross mating systems (Dorset X Western and Blackface X Western) should exhibit maximum heterosis for factors contributing to lamb livability, but their mothers do not have any heterosis for mothering ability. The backcross matings utilize females with maximum heterosis, however, the lambs will have only 50 percent heterosis for the livability related factors. The triplecross matings use females with maximum heterosis and the lambs also exhibit maximum heterosis. It would then be expected that the triplecross lambs should have a better survival rate to two weeks of age than do the backcross lambs as they have increased hybrid vigor for fitness.

Lamb mortality figures are presented in Table XI. From matings of Western ewes and Dorset rams, 59 of the 829 (7.12 percent) resulting

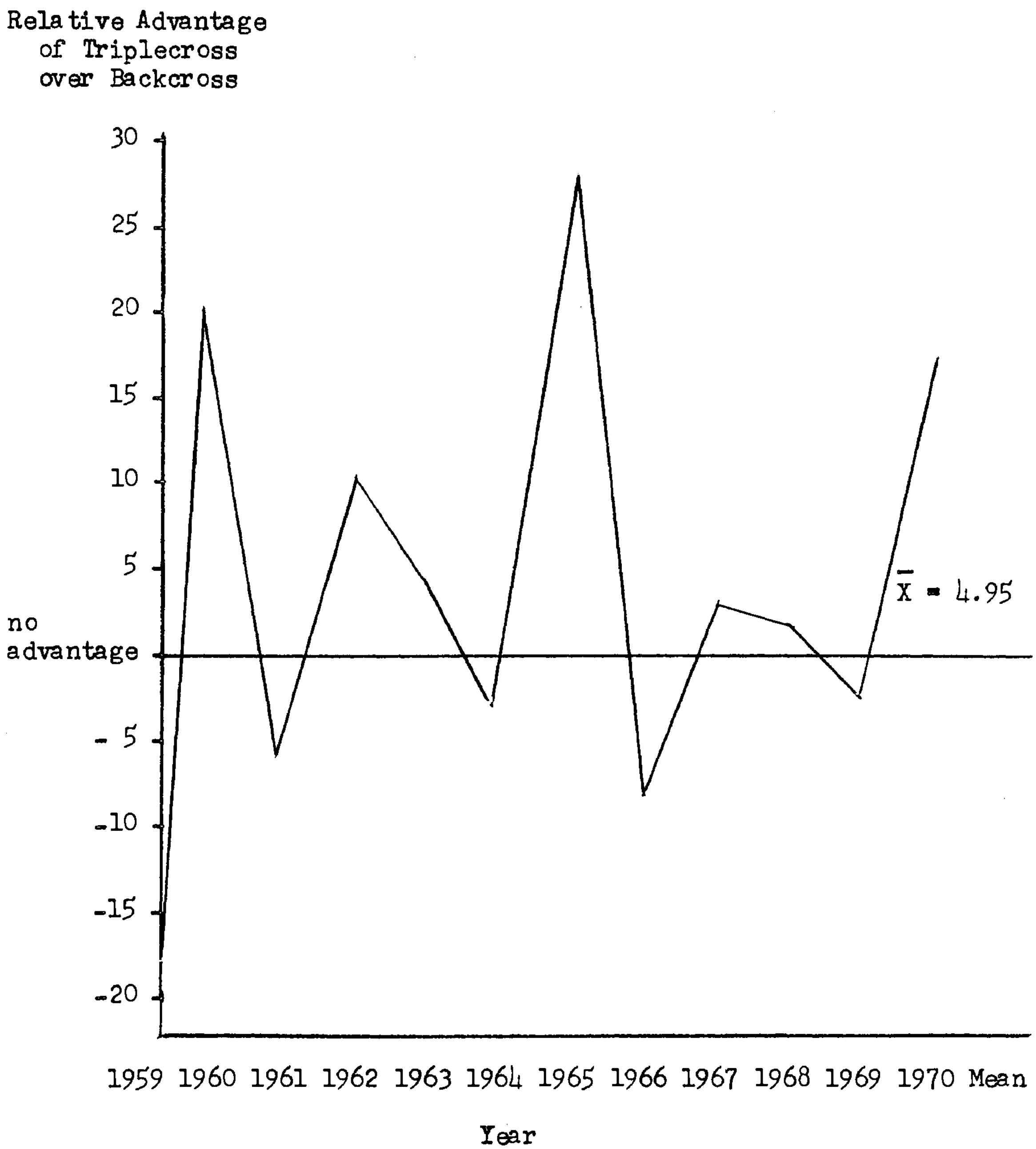

Figure 4. Yearly Variation in Advantage of Triplecross versus Backcross Mating for Lambing Rate

lambs were dead before two weeks of age with 18 dead at birth. The Blackface rams, when mated to Western ewes, produced 86 lambs dead by two weeks of age out of 865 lambs born (9.94 percent), 38 of which were dead at birth. Dorset rams mated to Dorset cross ewes resulted in 844 lambs with 67 (7.94 percent) being dead by two weeks of age (22 were dead at birth). There were 67 out of 900 lambs (7.44 percent) dead before two weeks of age from Blackface rams mated to Dorset cross ewes, with 32 of the lambs dead at birth. The interaction shows an advantage for the triplecross mating over the backcross mating system of 3.32 percent less death loss. This interaction is significant (P<.075) as the t value is 1.79, therefore, triplecross matings have significantly lower lamb mortality than the backcross matings after correcting for ram breed effects.

TABLE XI

2x2 TABLE FOR NUMBERS AND PERCENTAGES OF EARLY DEATH LOSSES

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	59/829[1] 7.12	67/844 7.94
Blackface ♂♂	86/865 9.94	67/900 7.44

[1]The fractions represent the number of dead lambs of the total number born.

Lambs Reared

Lamb mortality when combined with lambing rate is expressed as the number of lambs reared to two weeks of age per 100 ewes lambing. An increase in heterozygosity of offspring would be expected to result in an increased number of lambs alive at two weeks of age per 100 ewes lambing. The triplecross matings in theory produce offspring with increased heterozygosity and, therefore, greater heterosis over the backcross matings.

Table XII shows the 2x2 table for number of lambs reared to two weeks of age per 100 ewes lambing. The control matings to Dorset rams produced 130.07 lambs reared per 100 ewes lambing while the Western ewes mated to Blackface rams reared 125.44 lambs per 100 ewes lambing. Backcross matings produced 137.04 lambs reared per 100 ewes lambing and triplecross matings resulted in 141.67 lambs alive at two weeks of age per 100 ewes lambing to be grown out for market.

TABLE XII

2x2 TABLE FOR NUMBER OF LAMBS SURVIVING TO TWO WEEKS OF AGE PER 100 EWES LAMBING

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	130.07	137.04
Blackface ♂♂	125.44	141.67

As calculated in Table IX the triplecross mating system over the 12 years averaged 4.95 more lambs born per 100 ewes lambing than the backcross mating system. When combining this lambing rate with death losses, the triplecross mating averaged 9.26 more lambs alive at two weeks of age per 100 ewes lambing over the backcross mating. The 9.26 percent advantage for the triplecross mating system represents a t value of 2.41 and is significant ($P < .025$). This 9.26 percent increase from the triplecross mating system is very important and is the result of increased embryo viability, increased viability of the fetus and increased livability and vigor of the newborn offspring, all from an increase in heterozygosity due to mating system.

Figure 5 shows the year to year variation in the relative advantage of the triplecross over the backcross mating system, leading to the overall 9.26 percent advantage for the triplecross mating system. The negative values in 1959 and 1961 and the positive value in 1970 may have been due in part to small numbers involved (Table III).

Lamb Vigor

Vigor is a fitness trait of the lambs that is difficult to measure because it involves a subjective measurement of the lamb's activity. Any classification beyond the lamb being alive or dead is dependent upon the discretion of the shepherd. The figures from the previous section regarding lambs alive at two weeks of age indicate that lambs born alive from the triplecross matings may be more rugged or have increased vigor. Each of the 3438 lambs born during the 12 years of this study were evaluated and classified as dead, strong or weak.

Figure 5. Yearly Variation in Advantage of Triplecross versus Backcross Mating for Lambs Alive at Two Weeks of Age Per 100 Ewes Lambing

Triplecross lambs would again be expected to outperform backcross lambs because they should exhibit maximum heterosis (100 percent) compared to 50 percent of maximum heterosis for backcross lambs. Both systems utilize the same crossbred ewes.

The percentage of lambs scored strong at birth to the mating systems are presented in Table XIII. Dorset rams mated to Western ewes produced 83.5 percent strong lambs compared to 78.9 percent strong lambs from Dorset cross ewes mated to Dorset rams (backcross). From matings involving Blackface rams, 81.2 percent of the lambs born to Dorset cross ewes were scored strong while 78.7 percent of the lambs from Western ewes were scored strong. These figures represent a 7.05 percent increase in strong lambs for a triplecross mating over a backcross mating after adjusting for ram breed effect, as shown by the interaction. A t test for the interaction reveals a t value of 2.61. This t value is significant ($P < .01$), therefore, these triplecross lambs are apparently more fit and vigorous at birth than are the backcross lambs.

Since there was a greater number of strong lambs from the triplecross mating there must be a decrease in at least one of the other two categories. The percentage of weak lambs decreased from 16.9 percent to 15.2 percent (Table XIV) and the percentage of dead lambs at birth decreased from 4.4 percent to 3.6 percent (Table XV) when comparing Western ewes and Dorset cross ewes, respectively. Concurrently, when comparing Dorset rams mated to Western ewes and Dorset cross ewes, respectively, the percentage of weak lambs increased from 14.4 percent to 18.5 percent. The percentage of dead lambs at birth also increased from 2.2 percent to 2.6 percent.

TABLE XIII

2x2 TABLE FOR NUMBER AND PERCENTAGE OF LAMBS SCORED STRONG AT BIRTH

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	692/829[1] 83.47	666/844 78.91
Blackface ♂♂	681/865 78.73	731/900 81.22

[1]The fraction represents the number of lambs born strong of the total number of lambs born.

TABLE XIV

2x2 TABLE FOR NUMBER AND PERCENTAGE OF LAMBS SCORED WEAK AT BIRTH

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	119/829 14.4	156/844 18.5
Blackface ♂♂	146/865 16.9	137/900 15.2

[1]The fraction represents the number of lambs born weak of the total number of lambs born.

TABLE XV

2x2 TABLE FOR NUMBER AND PERCENTAGE OF LAMBS DEAD[1] AT BIRTH

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	18/829[2]	22/844
	2.2	2.6
Blackface ♂♂	38/865	32/900
	4.4	3.6

[1]Stillborn and died during birth.
[2]The fraction represents the number of lambs born dead of the total number of lambs born.

Birth Difficulty

Birth difficulty was divided into two classifications, normal parturition and lambs that had to be pulled at birth. The classes were determined by whether or not the ewe completed the parturition process unassisted or if the shepherd had to render assistance.

A total of 1673 lambs were sired by Dorset rams and 153 were pulled (9.15 percent). Of the 1765 lambs sired by Blackface rams, 241 (13.65 percent) had to be pulled. The lambs by Dorset sires in this study averaged 8.77 pounds at birth, while those sired by Suffolk or Hampshire rams averaged 9.50 pounds, .73 pounds heavier than the Dorset sired lambs. This difference in birth weights may be a factor in greater incidence of pulled lambs among the Blackface sire groups. Buchi (1970) found that in most instances of difficult births, birth weights were above average.

The lambs of Dorset sire descent may be broken down into lambs born unassisted to Western ewes (92.52 percent) and lambs born unassisted to Dorset cross ewes (89.22 percent) as shown in Table XVI. Blackface X Western matings resulted in 86.94 percent of the lambs born unassisted. A total of 772 of the 900 triplecross lambs (85.78 percent) were born normally as is also shown in Table XVI. The interaction shows a 2.14 percent advantage for the triplecross mating system in the percentage of lambs born normally with no assistance from the shepherd. The t test for interaction represents a value of 0.99 which is not a significant t value ($P < .30$).

The Western ewes had significantly ($P < .05$) less birth difficulty, mainly because they were larger ewes and were thinner than the Dorset cross ewes.

TABLE XVI

2x2 TABLE FOR NUMBER AND PERCENTAGE OF LAMBS BORN UNASSISTED

	Western ♀♀	Dorset cross ♀♀
Dorset ♂♂	767/829[1] 92.52	753/844 89.22
Blackface ♂♂	752/865 86.94	772/900 85.78

[1]The fractions represent the number of lambs born normally of the total number of lambs born.

Gestation Lengths

Gestation lengths were considered on the basis of degree of heterozygosity of the fetus and comparing ewes bearing singles and ewes bearing twins.

The gestation lengths in which actual mating dates were established are presented in Table XVII. These gestation lengths have been broken down into the three categories of ewes bearing singles, twins or triplets for each mating group. Since there were so few ewes bearing triplets (24), their gestation lengths will not be used.

There were a total of 1112 ewes bearing fetus(es) exhibiting maximum heterosis and 327 ewes bearing fetus(es) exhibiting approximately 50 percent (backcross lambs) of maximum heterosis. The 1112 ewes had an average gestation length of 146.9 days compared to a 145.8 day gestation length for ewes bearing backcross lambs, 1.1 days shorter for the backcross lambs. The gestation lengths of 146.9 days and 145.8 days are not significantly different. There appears to be a trend in that the average gestation length decreased with an increased percentage of Dorset breeding in the pedigree and a decreased percentage of Western breeding in the pedigree.

TABLE XVII

GESTATION LENGTHS IN DAYS BY TYPE OF BIRTH AND MATING SYSTEM

Breeding Group	Total	Single Lambs		Twin Lambs		Triplet Lambs	
		No.	Average	No.	Average	No.	Average
D♂♂ X W♀♀	360	228	147.1	128	146.8	4	146.5
B♂♂ X W♀♀	389	231	147.5	153	147.5	5	147.6
D♂♂ X DC♀♀	333	168	145.9	159	145.7	6	145.8
B♂♂ X DC♀♀	381	188	146.3	184	146.2	9	146.4
Totals	1463	815	146.8	624	146.5	24	146.5

In three of the four groups, ewes bearing singles had gestation lengths slightly longer than ewes bearing twins. These were the Western ewes mated to Dorset rams (.34 days longer), Dorset cross ewes mated to Dorset rams (.21 days longer) and Dorset cross ewes mated to Blackface rams (.11 days longer). Western ewes mated to Blackface rams had equal gestation lengths when carrying either twins or a single lamb (147.5 days).

Overall gestation lengths for ewes bearing twins (624) averaged only 0.28 days shorter than ewes bearing singles (815). This small difference is of no economic importance and agrees with research conducted by Mahajan et al (1970) and Boshier et al (1969), in that the number of lambs carried has no significant effect on the gestation length. Mullaney and Lear (1969) did find a significant effect due to single or twin births, as did Honmode (1970).

The percentage of Dorset and Western breeding appears to be a better explanation of the difference in gestation lengths than does the degree of heterozygosity of the fetus. Increased Western breeding and decreased Dorset breeding resulted in longer gestation lengths while decreased Western breeding and increased Dorset breeding of the fetus resulted in shorter gestation lengths. Gestation lengths were not affected significantly by the number of lambs being carried by the ewe.

CHAPTER V

SUMMARY

The data from the 12 years of this study included 2501 ewe mating records of two different breed combinations. These were 1270 Western ewe records (predominantly Rambouillet) and 1231 Dorset cross ewe records (Dorset X Western). The purpose was to find the advantage, if any, of using Blackface rams as a third breed for a terminal cross sire (triplecross) in the production of market lambs, instead of a Dorset ram mated to the Dorset X Western ewe to produce backcross lambs for market. To enable separation of the ram breed effects from the mating system comparison, Western ewes were used in the study as a comparative control.

The two mating systems considered for evaluation (triplecross versus backcross) were compared for conception rate to the first mating, lambing rate as evaluated by number of lambs born per 100 ewes lambing, lamb mortality as measured by death losses before two weeks of age, lambs alive at two weeks of age per 100 ewes lambing, lamb vigor as evaluated by the percentage of lambs scored strong at birth, birth difficulty as shown by the occurence of pulled lambs and gestation lengths on the basis of degree of heterozygosity and number of lambs being born.

The interaction from a 2x2 factorial treatment arrangement displays a 3.0 percent advantage in conception to first mating for the backcross mating. This advantage was not a significant difference.

The triplecross matings resulted in 153.1 lambs per 100 ewes lambing compared to 148.9 lambs per 100 ewes lambing from the backcross matings tested. A 4.95 percent increase in lambing rate after adjusting for ram differences was observed in this study for the triplecross mating system over the backcross mating system. The 4.95 percent increase was not significant, however, it did approach significance ($P<.20$). In theory, there should be an advantage in lambing rate for the triplecross mating system and the 4.95 percent is an estimate of that difference. On the basis of the number of ewes involved in the study the 4.95 percent may be estimating a real difference even though significance was not found.

Considering the factorial design of the experiment, the triplecross lambs resulted in 3.32 percent fewer early death losses (before two weeks of age). This value approached significance ($P<.075$). When lamb survival was combined with lambing rate, there was a significant ($P<.025$) 9.26 percent increase in the number of lambs alive at two weeks of age from the triplecross mating system over the backcross mating system after correcting for ram differences. The Blackface rams involved in the mating system seem to result in a heterotic advantage for producing lambs to be raised for market due to increased viability of the embryo, fetus and newborn lamb.

After adjusting for ram breed, the triplecross mating system produced 7.05 percent more lambs classified as strong at birth, shown by the 2x2 factorial treatment analysis. This increase in vigor was a significant increase ($P<.01$). The triplecross matings resulted in 2.14 percent less difficult births (not significant) than the backcross matings.

The main question of this study was to consider if an advantage was gained by use of a triplecross mating system involving Blackface rams X Dorset cross ewes in place of a backcross mating system involving Dorset rams X Dorset cross ewes for reproductive and fitness traits. Some of the traits studied were not found to be significantly different, but all traits except conception rate to first mating show at least a trend for an advantage in favor of this triplecross as would be expected in view of the degree of heterosis involved.

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APPENDIX

TABLE XVIII

NUMBERS INVOLVED EACH YEAR IN REPRODUCTIVE AND FITNESS TRAITS FOR DORSET X WESTERN MATINGS

Year	No. Ewes	No. Lambs Born	No. Alive at 2 Weeks	Birth Difficulty Normal	Birth Difficulty Pulled	Lamb Vigor Strong	Lamb Vigor Weak	Lamb Vigor Dead
1959	18	20	20	18	2	20	0	0
1960	28	39	39	39	0	36	1	2
1961	87	107	99	105	2	104	2	1
1962	57	80	72	75	5	75	1	4
1963	61	84	77	82	2	77	5	2
1964	49	72	67	68	4	59	12	1
1965	64	86	79	80	6	72	14	0
1966	52	68	63	58	10	57	9	2
1967	40	62	58	59	3	40	21	1
1968	50	77	71	66	11	59	16	2
1969	69	104	98	92	12	71	30	3
1970	20	30	27	25	5	18	12	0
Totals	592	829	770	767	62	692	119	18
Percentages		140.0	130.1	92.5	7.5	83.5	14.4	2.2

TABLE XIX

NUMBERS INVOLVED EACH YEAR IN REPRODUCTIVE AND FITNESS TRAITS FOR BLACKFACE X WESTERN MATINGS

Year	No. Ewes	No. Lambs Born	No. Alive at 2 Weeks	Birth Difficulty		Lamb Vigor		
				Normal	Pulled	Strong	Weak	Dead
1959	27	36	35	33	3	34	2	0
1960	43	55	49	49	6	47	6	2
1961	32	37	34	35	2	35	0	2
1962	59	75	69	72	3	71	1	3
1963	70	94	79	88	6	81	9	4
1964	62	83	68	75	8	63	15	5
1965	64	80	70	60	20	63	10	7
1966	75	102	95	86	16	79	19	4
1967	83	136	126	125	11	97	35	4
1968	49	84	80	66	18	57	23	4
1969	34	47	43	36	11	35	11	1
1970	23	36	31	27	9	19	15	2
Totals	621	865	779	752	113	681	146	38
Percentages		139.3	125.4	86.9	13.1	78.7	16.9	4.4

TABLE XX

NUMBERS INVOLVED EACH YEAR IN REPRODUCTIVE AND FITNESS TRAITS FOR BACKCROSS MATINGS

Year	No. Ewes	No. Lambs Born	No. Alive at 2 Weeks	Birth Difficulty Normal	Pulled	Lamb Vigor Strong	Weak	Dead
1959	25	34	33	33	1	33	0	1
1960	28	39	32	37	2	35	3	1
1961	41	54	50	51	3	52	0	2
1962	45	59	57	57	2	58	0	1
1963	48	73	64	72	1	58	10	5
1964	37	60	57	59	1	57	1	2
1965	81	110	98	101	9	92	17	1
1966	59	98	89	80	18	72	25	1
1967	51	76	76	67	9	52	24	0
1968	61	98	96	77	21	64	33	1
1969	66	102	93	84	18	68	31	3
1970	25	41	32	35	6	25	12	4
Totals	567	844	777	753	91	666	156	22
Percentages		148.9	137.0	89.2	10.8	78.9	18.5	2.6

TABLE XXI

NUMBERS INVOLVED EACH YEAR IN REPRODUCTIVE AND FITNESS TRAITS FOR TRIPLECROSS MATINGS

Year	No. Ewes	No. Lambs Born	No. Alive at 2 Weeks	Birth Difficulty		Lamb Vigor		
				Normal	Pulled	Strong	Weak	Dead
1959	30	42	38	40	2	42	0	0
1960	35	52	49	51	1	49	2	1
1961	22	26	22	23	3	24	0	2
1962	52	67	62	63	4	61	2	4
1963	45	69	61	60	9	57	9	3
1964	69	101	97	98	3	89	9	3
1965	54	80	72	63	17	72	6	2
1966	110	178	166	155	23	133	36	9
1967	70	112	108	97	15	76	33	3
1968	48	86	83	65	21	72	13	1
1969	36	55	46	38	17	35	19	1
1970	17	32	29	19	13	21	8	3
Totals	588	900	833	772	128	731	137	32
Percentages		153.1	141.7	85.8	14.2	81.2	15.2	3.6

TABLE XXII

TOTAL NUMBER OF RAMS USED FOR THE TWO LAMBING SEASONS WITHIN EACH YEAR[1]

Year	Dorset Rams		Blackface Rams		# of
	Spring Lambing	Fall Lambing	Spring Lambing	Fall Lambing	Ewes
1959	0	4	0	4	113
1960	2	4	2	3	135
1961	0	5	0	5	195
1962	3	3	3	3	218
1963	2	4	2	4	232
1964[2]	5	6	5	6	229
1965	4	6	4	5	270
1966	4	12	4	10	307
1967[3]	5	4	7	10	257
1968	5	4	5	3	230
1969	5	4	4	2	222
1970	5	2	5	2	93
Total	40	58	41	57	2501

[1]The spring lambing of any one year is the result of breeding the year before but rams used in the previous years breeding are counted under the year of the resultant lambing.

[2]Some of the ewes started on 2X yearly lambing project.

[3]All ewes shown are on 2X yearly lambing project.

TABLE XXIII

INDIVIDUAL RAMS WITH THE NUMBER OF BREEDING SEASONS EACH WAS USED

	Individual Dorset Ram Number[1]	Number of Seasons Used	Individual Blackface Ram Number[1]	Number of Seasons Used
	1	9	7	2
	2	10	8	3
	3	14	9	7
	4	5	10	5
	5	3	11	8
	6	5	12-A	2
	7	2	13-A	2
	8	1	12-A	1
	12	7	13-B	1
	13	3	14	1
	14	2	15	7
	19	1	16	3
	21-A	1	17	7
	21-B	5	19	2
	22	4	20	2
	23	7	22	3
	27	3	23	2
	28	2	37	1
	29	1	38	2
	32	3	39	1
	33	3	40	1
	51	1	43	2
	52	1	45	7
	53	2	46	9
	80	1	47	7
	81	1	48	4
	82	1	49	5
			50	2
Total	27	98	28	99

[1]Rams of the same breed and with the same number are given letters to distinguish between them.

TABLE XXIV

INDIVIDUAL RAMS USED EACH SEASON AND EACH YEAR

Ram Breed	Breeding Season	Ram Individual Number[1] by Year											
		1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Dorset	Fall	--	19 21A	--	5 27 28	32 33	1 3 4 32 33	1 2 4	3 12 13	1 2 3 12 14	3 12 21B 22 23	3 12 21B 22 23	1 2 21B 22 23
Dorset	Spring	1 2 7 8	3 4 5 7	3 6 27 28 29	27 51 53	1 2 3 4	2 3 32 33 52 53	1 2 3 5 13	1 2 3 4 5 6 12 13 14 80 81 82	3 12 22 23	3 12 21B 23	1 2 21B 23	2 23

XXIV (Continued)

Ram Breed	Breeding Season	Ram Individual Number by Year											
		1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Blackface	Fall	--	12A 13A	--	22 40 43	49 50	38 45 46 48 49	8 9 11 45	9 11 46 47	9 15 16 45 46 47 49	10 11 17 19 20 45	9 11 17 46	11 12B 13B 15 46
Blackface	Spring	12H 13H 14 22	15 16 23	22 23 37 39 43	38 48 50	7 8 47 48	9 10 11 47 48 49	10 11 15 16 17	8 9 10 11 15 17 45 46 47 49	7 9 10 15 17 19 20 45 46 47	17 46 47	45 46	15 16

[1]Rams of the same breed and with the same number are given letters to distinguish between them.

TABLE XXV

NUMBERS OF EWES BY SEASON AND BY BREED, WHOSE FIRST MATING WAS TO THE DIFFERENT RAM BREEDS

Ewe Breed	Breeding Season	Ram Breed Dorset	Ram Breed Blackface
Western	Fall	202	294
Dorset Cross	Fall	175	209
Western	Spring	393	324
Dorset Cross	Spring	399	372
Totals		1169	1199

TABLE XXVI

NUMBER OF EWES EACH YEAR BY SEASON AND BY BREED THAT HAD THEIR FIRST MATING TO EACH RAM BREED

	Spring Breeding				Fall Breeding			
	Western ♀♀		Dorset cross ♀♀		Western ♀♀		Dorset cross ♀♀	
Year	D♂♂	B♂♂	D♂♂	B♂♂	D♂♂	B♂♂	D♂♂	B♂♂
1959	18	26	27	28	0	0	0	0
1960	20	24	26	37	6	21	0	0
1961	82	37	43	20	0	0	0	0
1962	29	27	23	36	34	26	20	18
1963	56	36	45	39	9	30	3	6
1964	38	42	36	47	12	19	4	19
1965	43	36	53	41	22	24	25	16
1966	28	49	47	70	27	23	24	28
1967	24	15	29	16	18	66	22	54
1968	10	13	24	12	32	44	34	39
1969	31	16	33	20	36	20	32	17
1970	14	2	13	6	6	21	11	12
Totals	393	324	399	372	202	294	175	209

TABLE XXVII

NUMBER OF EWES BY BREED AND BY YEAR THAT CONCEIVED TO BOTH BREEDS OF RAMS IN ONE SEASON

Year	Western Ewes	Dorset cross Ewes	Total
1959	2	11	13
1960	0	1	1
1961	6	7	13
1962	2	3	5
1963	4	4	8
1964	5	7	12
1965	4	6	10
1966	4	7	11
1967	6	7	13
1968	10	12	22
1969	10	7	17
1970	4	4	8
Total	57[1]	76[1]	133

[1]Significantly different ($P<.10$)

TABLE XXVIII

NUMBER AND PERCENT OF EWES CONCEIVING TO FIRST MATING UNDER EACH MATING SYSTEM

Groups	Number of Ewes	Number Conceived at First Mating	Conceived at First Mating, %
Dorset ♂♂ X Western ♀♀	595	504	84.71
Blackface ♂♂ X Western ♀♀	618	539	87.21
Dorset ♂♂ X Dorset cross ♀♀	574	481	83.80
Blackface ♂♂ X Dorset cross ♀♀	581	484	83.30

TABLE XXIX

THE NUMBER OF EWES THAT CONCEIVED TO THE DIFFERENT MATINGS FOR EACH RAM BREED

Ram Breed	Conception			
	At First Mating	At Second Mating[1]	At Second Mating[2]	At Third or Subsequent Mating[3]
Dorset	985	81	55	38
Blackface	1023	69	73	44

[1]The first mating was to a Dorset ram.
[2]The first mating was to a Blackface ram.
[3]Does not consider matings prior to conception.

TABLE XXX

CONCEPTIONS BY BREEDING SEASON AND YEAR FOR THE WESTERN EWES

Year	Breeding Season[4]	First Mating		Second Mating[1]		Second Mating[2]		Third or Subsequent Mating		Totals
		Do♂	Bo♂	Do♂	Bo♂	Do♂	Bo♂	Do♂	Bo♂	
1959	S	14	23	2	2	2	1	0	1	45
	F	0	0	0	0	0	0	0	0	0
1960	S	16	19	3	0	1	4	1	0	44
	F	5	20	1	0	1	0	0	0	27
1961	S	73	30	8	1	6	1	0	0	119
	F	0	0	0	0	0	0	0	0	0
1962	S	19	25	3	5	1	1	1	1	56
	F	32	25	1	1	0	1	0	0	60
1963	S	49	36	3	2	0	0	1	1	92
	F	8	28	0	1	0	1	0	1	39
1964	S	34	33	1	2	1	5	2	2	80
	F	9	19	0	1	0	0	2	0	31
1965	S	31	35	4	6	1	0	2	0	79
	F	19	20	2	1	1	2	1	0	46
1966	S	18	40	4	4	0	6	3	2	77
	F	19	22	7	1	1	0	0	0	50
1967	S	23	14	1	0	1	0	0	0	39
	F	13	56	1	3	1	6	0	4	84
1968	S	8	8	2	0	5	0	0	0	23
	F	30	34	0	0	3	5	2	2	76

XXX (Continued)

Year	Breeding Season[4]	First Mating D♂♂	First Mating B♂♂	Second Mating[1] D♂♂	Second Mating[1] B♂♂	Second Mating[2] D♂♂	Second Mating[2] B♂♂	Third or Subsequent Mating D♂♂	Third or Subsequent Mating B♂♂	Totals
1969	S	29	12	1	1	2	1	1	0	47
	F	35	20	0	0	0	0	1	0	56
1970	S	14	2	0	0	0	0	0	0	16
	F	6	18	0	0	0	1	0	2	27
Totals		504	539	44	31	27	35	17	16	1213

[1]The first mating was to a Dorset ram, but conception failed.
[2]The first mating was to a Blackface ram, but conception failed.
[3]Does not consider matings prior to conception.
[4]S = Spring, F = Fall.

TABLE XXXI

CONCEPTIONS BY BREEDING SEASON AND YEAR FOR THE DORSET CROSS EWES

Year	Breeding Season[4]	First Mating		Second Mating[1]		Second Mating[2]		Third or Subsequent Mating[3]		Totals
		D♂♂	B♂♂	D♂♂	B♂♂	D♂♂	B♂♂	D♂♂	B♂♂	
1959	S	20	22	3	4	1	4	1	0	55
	F	0	0	0	0	0	0	0	0	0
1960	S	21	31	2	3	4	1	1	0	63
	F	0	0	0	0	0	0	0	0	0
1961	S	37	19	2	3	1	0	1	0	63
	F	0	0	0	0	0	0	0	0	0
1962	S	17	22	4	0	2	4	2	8	59
	F	20	18	0	0	0	0	0	0	38
1963	S	44	36	1	0	0	1	0	2	84
	F	2	5	1	0	0	1	0	0	9
1964	S	31	43	1	2	1	2	1	2	83
	F	2	16	0	2	1	2	0	0	23
1965	S	51	38	2	0	2	0	1	0	94
	F	22	12	1	0	1	0	1	4	41
1966	S	33	56	0	10	2	8	1	7	117
	F	16	20	2	3	3	2	2	4	52
1967	S	20	13	6	2	0	1	3	0	45
	F	17	47	1	4	2	3	2	0	76
1968	S	23	11	1	0	1	0	0	0	36
	F	25	24	5	3	4	9	2	1	73

XXXI (Continued)

Year	Breeding Season[4]	First Mating		Second Mating[1]		Second Mating[2]		Third or Subsequent Mating[3]		Totals
		D♂♂	B♂♂	D♂♂	B♂♂	D♂♂	B♂♂	D♂♂	B♂♂	
1969	S	26	17	4	2	3	0	1	0	53
	F	31	17	0	0	0	0	1	0	49
1970	S	12	6	1	0	0	0	0	0	19
	F	11	11	0	0	0	0	1	0	23
Totals		481	484	37	38	28	38	21	28	1155

[1]The first mating was to a Dorset ram, but conception failed.
[2]The first mating was to a Blackface ram, but conception failed.
[3]Does not consider matings prior to conception.
[4]S = Spring, F = Fall.

TABLE XXXII

YEARLY LAMB CROP FOR EACH MATING GROUP (NUMBER OF LAMBS PER 100 EWES LAMBING)

Year	Group[1] D♂♂ X W♀♀	B♂♂ X W♀♀	D♂♂ X DC♀♀ (Backcross)	B♂♂ X DC♀♀ (Triplecross)
1959	111.1	133.3	136.0	140.0
1960	139.3	127.9	139.3	148.6
1961	123.0	115.6	131.7	118.2
1962	140.4	127.1	131.1	128.8
1963	137.7	134.3	152.1	153.3
1964	146.9	133.9	162.2	146.6
1965	141.0	125.0	135.8	148.1
1966	130.8	136.0	166.1	161.8
1967	155.0	163.9	149.0	160.0
1968	154.0	171.4	160.7	179.2
1969	150.7	138.2	167.2	152.8
1970	150.0	156.5	164.0	188.2
Mean	140.03	139.29	148.85	153.06

[1]D = Dorset
B = Blackface (Hampshire or Suffolk)
DC = Dorset Cross

TABLE XXXIII

YEAR BY YEAR ADVANTAGE OF TRIPLECROSS vs BACKCROSS MATING ON LAMBS BORN PER 100 EWES LAMBING

Year	Lamb increase for DC♀♀ over W♀♀ using D♂♂	Lamb increase for DC♀♀ over W♀♀ using B♂♂	Advantage of Triplecross over Backcross	Total No. of Ewes
1959	+24.9	+ 6.7	-18.2	113
1960	0.0	+20.7	+20.7	135
1961	+ 8.7	+ 2.6	- 6.1	195
1962	- 9.3	+ 1.7	+11.0	218
1963	+14.4	+19.0	+ 4.6	232
1964	+15.3	+12.5	- 2.8	229
1965	- 5.2	+23.1	+28.3	270
1966	+35.3	+25.8	- 9.5	307
1967	- 6.0	- 3.9	+ 2.1	257
1968	+ 6.7	+ 7.8	+ 1.1	230
1969	+16.5	+14.6	- 1.9	222
1970	+14.0	+31.7	+17.7	93
Mean	+ 8.82	+13.77	+ 4.95	

TABLE XXXIV

YEARLY DEATH LOSSES IN NUMBER AND PERCENTAGE
FOR EACH OF THE MATING SYSTEMS

	D♂♂ X W♀♀			B♂♂ X W♀♀			D♂♂ X DC♀♀			B♂♂ X DC♀♀		
Year	No. Lambs	No. Died	%	No. Lambs	No. Died	%	No. Lambs	No. Died	%	No. Lambs	No. Died	%
1959	20	0	0.0	36	1	2.8	34	1	2.9	42	4	9.5
1960	29	0	0.0	55	6	10.9	39	7	17.9	52	3	5.8
1961	107	8	7.5	37	3	8.1	54	4	7.4	26	4	15.4
1962	80	8	10.0	75	6	8.0	59	2	3.4	67	5	9.0
1963	84	7	8.3	94	15	16.0	73	9	12.3	69	8	11.6
1964	72	5	6.9	83	15	18.1	60	3	5.0	101	4	4.0
1965	86	7	8.1	80	10	12.5	110	12	10.9	80	8	10.0
1966	68	5	7.4	102	7	6.8	98	9	9.2	178	12	6.7
1967	62	4	6.5	136	10	7.4	76	0	0.0	112	4	3.6
1968	77	6	7.8	84	4	4.8	98	2	2.0	86	3	3.5
1969	104	6	5.8	47	4	8.5	102	9	8.8	55	9	16.4
1970	30	3	10.0	36	5	13.9	41	9	22.0	32	3	9.4
Total	829	59	7.12	865	86	9.94	844	67	7.94	900	67	7.44

TABLE XXXV

YEARLY LAMB CROP SURVIVING PAST THE FIRST TWO WEEKS FOR EACH MATING GROUP (NUMBER OF LAMBS PER 100 EWES LAMBING)

	Group[1]			
Year	D♂♂ X W♀♀	B♂♂ X W♀♀	D♂♂ X DC♀♀ (Backcross)	B♂♂ X DC♀♀ (Triplecross)
1959	111.1	129.6	132.0	126.7
1960	139.3	114.0	114.3	140.0
1961	113.8	106.3	122.0	100.0
1962	126.3	116.9	126.7	119.2
1963	126.2	112.9	133.3	135.6
1964	136.7	109.7	154.1	140.6
1965	129.5	109.4	121.0	133.3
1966	121.2	126.7	150.8	150.9
1967	145.0	151.8	149.0	154.3
1968	142.0	163.3	157.4	172.9
1969	142.0	126.5	140.9	127.8
1970	135.0	134.8	128.0	170.6
Mean	130.07	125.44	137.04	141.67

[1]D = Dorset
B = Blackface (Hampshire or Suffolk)
DC = Dorset Cross

TABLE XXXVI

YEAR BY YEAR ADVANTAGE OF TRIPLECROSS vs BACKCROSS MATING ON LAMBS SURVIVING PAST TWO WEEKS OF AGE PER 100 EWES LAMBING

Year	Total No. of Ewes	Lamb increase for DC♀♀ over W♀♀ using D♂♂	Lamb increase for DC♀♀ over W♀♀ using B♂♂	Advantage of Triplecross over Backcross
1959	113	+20.9	- 2.9	-23.8
1960	135	-25.0	+26.0	+51.0
1961	195	+ 8.2	- 6.3	-14.5
1962	218	+ 0.4	+ 2.3	+ 1.9
1963	232	+ 7.1	+22.7	+15.6
1964	229	+17.4	+30.9	+13.5
1965	270	- 8.5	+23.9	+32.4
1966	307	+29.6	+24.2	- 5.4
1967	257	+ 4.0	+ 2.5	- 1.5
1968	230	+15.4	+ 9.6	- 5.8
1969	222	- 1.1	+ 1.3	+ 2.4
1970	93	- 7.0	+35.8	+42.8
Mean		+ 6.97	+16.23	+ 9.26

TABLE XXXVII

NUMBER AND VIGOR OF LAMBS BORN TO THE DIFFERENT MATING SYSTEMS

Breed Cross		Total No. of Lambs	Lambs Born					
			Strong		Weak		Dead[1]	
Ram Breed	Ewe Breed		No.	%	No.	%	No.	%
Dorset	Western	829	692	83.47	119	14.36	18	2.17
Blackface	Western	865	681	78.73	146	16.88	38	4.39
Dorset	Dorset Cross	844	666	78.91	156	18.48	22	2.61
Blackface	Dorset Cross	900	731	81.22	137	15.22	32	3.56

[1]Lambs were stillborn or died during birth.

TABLE XXXVIII

DIFFICULTY OF BIRTHS OF THE MATING SYSTEMS

Groups	Normal Births		Pulled Lambs	
	Number	%	Number	%
Dorset ♂♂ X Western ♀♀	767	92.52	62	7.48
Blackface ♂♂ X Western ♀♀	752	86.94	113	13.06
Dorset ♂♂ X Dorset cross ♀♀	753	89.22	91	10.78
Blackface ♂♂ X Dorset cross ♀♀	772	85.78	128	14.22

TABLE XXXIX

AVERAGE GESTATION LENGTHS OF THE FOUR EWE GROUPS AND THE NUMBERS INVOLVED

Groups	Number of Ewe Records	Gestation Length (days)
Dorset ♂♂ X Western ♀♀	360	147.0
Blackface ♂♂ X Western ♀♀	389	147.5
Dorset ♂♂ X Dorset cross ♀♀	333	145.8
Blackface ♂♂ X Dorset cross ♀♀	381	146.3

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