Comparison of Finnish Landrace crossbred ewes with Columbia, Rambouillet, and Targhee on western range

by Robert David Lewis

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal Science

Montana State University

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Abstract:
Effects of crossing 1/2 Finnish Landrace and 1/2 Rambouillet (FxR) rams with Columbia (C), Rambouillet (R), and Targhee (T) ewes on productivity traits under western range spring lambing management were evaluated. From 1975 to 1978, 563 whiteface (WF) ewes composed of C, R, and T, bred to either FxR or WF (of the same breed) rams produced 821 lambs. Ewes bred to FxR had similar levels of prolificacy and individual lamb weights at birth, 60 d, and 120 d (weaning) as those bred to WF rams. Lambs sired by FxR had 7.3% higher survivability to 60 d than those sired by WF (P<.01), resulting in 4.1 kg more lamb weaned per ewe lambing for ewes bred to FxR rams (P<.01).

From 1976 to 1982, 146 FxR-sired ewes (1/4Fx) and 143 WF-sired ewes were exposed to Suffolk rams to lamb beginning at T yr of age through to 6 yr of age, for a total of 1264 lambing opportunities. At 1 yr of age 1/4Fx ewes had higher fertility (P<.01) than WF ewes (37.7$ vs 1.3$). Prolificacy (lambs per ewe lambing) for 1/4Fx ewes was 1.10 lambs, and total kg of lamb weaned per 1/4Fx ewe exposed was 14.0 kg. No differences in fertility were found between mature (ages 2 to 6 yr) 1/4Fx and WF ewes. Prolificacy for mature 1/4Fx was .36 lambs higher than that for WF ewes (P<.01). Superiority of 1/4Fx ewes for litter size at 60 d and 120 d per ewe exposed was .24 and .22 lambs, respectively (P<.01).

Lambs from mature 1/4Fx dams were lighter at birth (P<.01), but not significantly different at 60 d and 120 d than those from mature WF dams. Survival to 60 d was 4.6% higher for lambs from 1/4Fx dams (P<.05), and 7.6$ higher for lambs from 1/4Fx dams when adjusted for birth weight (P<.01). Litter weights at 60 d and 120 d per ewe exposed were 3.9 kg and 4.3 kg heavier for 1/4Fx than WF ewes (P<.01). Fleeces from 1/4Fx ewes ages 1 to 6 were lighter and coarser than those from WF ewes (P<.01), but had similar staple lengths.

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by

Robert David Lewis

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of the requirements for the degree

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TABLE OF CONTENTS

	Page
LIST OF TABLES	vii
ABSTRACT	ix
1. INTRODUCTION	1
2. LITERATURE REVIEW	6
Fertility	6
Prolificacy	11
Survivability	15
Individual Progeny Weaning Weight Performance	19
Composite Reproductive Performance	23
Wool	26
3. MATERIALS AND METHODS	29
Populations	29
Management	31
Traits Studied	32
Statistical Methods	33
4. RESULTS AND DISCUSSION	36
Mature Ewe and Progeny Performance in Phase I	36
Breed Group of Sire Effects	36
Breed Group of Ewe Effects	42
Other Main Effects	42
Ewe Lamb and Progeny Performance in Phase II	36
Fertility and Prolificacy	43
Progeny Performance	44
Composite Traits	46
Mature Ewe and Progeny Performance in Phase II	47
Breed Group of Ewe Effects	47
Age of Ewe and Interaction Effects	58
Breed Group of Sire Effects	60
Other Main Effects	62

TABLE OF CONTENTS-Continued

	Page
Wool Production	62
Grease Fleece Weight	62
Fleece Grade	64
Staple Length	65
Discussion	66
REFERENCES CITED	68

LIST OF TABLES

Table		Page
1	Comparison of 1/2 and 1/4 Finn Crosses with Standard Breeds for Fertility in Ewe Lambs.....	10
2	Total Number of Phase I Ewes Lambing by Year and Age at Lambing.....	30
3	Total Number of Phase II Ewes Exposed in Previous Breeding Season by Year and Age at Lambing.....	30
4	Mean Squares from Analyses of Variance for Phase I Ewe Reproductive Traits per Ewe Lambing (1975 - 1978)....	37
5	Mean Squares from Analyses of Variance for Phase I Individual Progeny Traits (1975 - 1978).....	38
6	Least-Squares Means and Standard Errors for Phase I Ewe Reproductive Traits per Ewe Lambing (1975 - 1978)....	39
7	Least-Squares Means and Standard Errors for Phase I Progeny Traits (1975 - 1978).....	40
8	Mean Squares from Analyses of Variance for Phase II Ewe Production Traits (1976 - 1982).....	41
9	Least-Squares Means and Standard Errors for Phase II Fx Ewe Lamb Reproductive Traits (1976 - 1979).....	44
10	Mean Squares from Analyses of Variance for Phase II Individual Progeny Traits from Fx Ewe Lambs (1976 - 1979).....	45
11	Least-Squares Means and Standard Errors for Phase II Individual Progeny Traits from Fx Ewe Lambs (1976 - 1979).....	45
12	Least-Squares Means and Standard Errors for Phase II Fx Ewe Lamb Composite Reproductive Traits per Ewe Exposed (1976 - 1979).....	46

LIST OF TABLES-Continued

Table		Page
13	Least-Squares Means and Standard Errors for Fertility of Phase II Mature Ewes (1976 - 1982).....	48
14	Least-Squares Means and Standard Errors for Prolificacy of Phase II Mature Ewes (1976 - 1982).....	49
15	Mean Squares from Analyses of Variance for Phase II . Mature Ewe Progeny Traits (1977 - 1982).....	51
16	Least-Squares Means and Standard Errors for Individual Lamb Performance from Dams Ages 2 through 6 (1977 - 1982).....	52
17	Least-Squares Means and Standard Errors for Litter Size at 60 Days per Ewe Exposed (LS60, 1977 - 1982).....	54
18	Least-Squares Means and Standard Errors for Litter Weight at 60 Days per Ewe Exposed (LW60, 1977 - 1982).....	55
19	Least-Squares Means and Standard Errors for Phase II Litter Size at 120 Days per Ewe Exposed (LS120, 1977 - 1982).....	56
20	Least-Squares Means and Standard Errors for Phase II Litter Weight at 120 Days per Ewe Lambing (LW120, 1977 - 1982).....	57
21	Least-Squares Means and Standard Errors for Phase II Mature Ewe Production and Individual Lamb Performance by Breed Group of Sire (1976 - 1982).....	61
22	Mean Squares from Variance Analyses for Ewe Wool Production Traits (1976 - 1982).....	63
23	Least-Squares Means and Standard Errors for Phase II Wool Characters, Ages 1 to 6 (1976 - 1982).....	63

ABSTRACT

Effects of crossing 1/2 Finnish Landrace and 1/2 Rambouillet (FxR) rams with Columbia (C), Rambouillet (R), and Targhee (T) ewes on productivity traits under western range spring lambing management were evaluated. From 1975 to 1978, 563 whiteface (WF) ewes composed of C, R, and T, bred to either FxR or WF (of the same breed) rams produced 821 lambs. Ewes bred to FxR had similar levels of prolificacy and individual lamb weights at birth, 60 d, and 120 d (weaning) as those bred to WF rams. Lambs sired by FxR had 7.3% higher survivability to 60 d than those sired by WF ($P<.01$), resulting in 4.1 kg more lamb weaned per ewe lambing for ewes bred to FxR rams ($P<.01$).

From 1976 to 1982, 146 FxR-sired ewes (1/4Fx) and 143 WF-sired ewes were exposed to Suffolk rams to lamb beginning at 1 yr of age through to 6 yr of age, for a total of 1264 lambing opportunities. At 1 yr of age 1/4Fx ewes had higher fertility ($P<.01$) than WF ewes (37.7% vs 1.3%). Prolificacy (lambs per ewe lambing) for 1/4Fx ewes was 1.10 lambs, and total kg of lamb weaned per 1/4Fx ewe exposed was 14.0 kg. No differences in fertility were found between mature (ages 2 to 6 yr) 1/4Fx and WF ewes. Prolificacy for mature 1/4Fx was .36 lambs higher than that for WF ewes ($P<.01$). Superiority of 1/4Fx ewes for litter size at 60 d and 120 d per ewe exposed was .24 and .22 lambs, respectively ($P<.01$).

Lambs from mature 1/4Fx dams were lighter at birth ($P<.01$), but not significantly different at 60 d and 120 d than those from mature WF dams. Survival to 60 d was 4.6% higher for lambs from 1/4Fx dams ($P<.05$), and 7.6% higher for lambs from 1/4Fx dams when adjusted for birth weight ($P<.01$). Litter weights at 60 d and 120 d per ewe exposed were 3.9 kg and 4.3 kg heavier for 1/4Fx than WF ewes ($P<.01$). Fleeces from 1/4Fx ewes ages 1 to 6 were lighter and coarser than those from WF ewes ($P<.01$), but had similar staple lengths.

CHAPTER 1

INTRODUCTION

Reproductive efficiency of the ewe, total kilograms of lamb weaned per ewe in the flock (Sidwell and Miller, 1971a), is the most important factor affecting profitability in commercial sheep production systems in the United States (Dickerson and Glimp, 1975; Parker and Pope, 1983; Sidwell and Miller, 1971a). Litter size, number of lambs produced per parturition, is a major component of reproductive efficiency (Bradford, 1972a). Litter size in the Mountain region (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming), which comprises 36% of the total sheep population in the U.S., has increased by only .057 lambs per parturition (approximately 6%) from 1958 to 1981 (Parker, 1981). Such limited growth in any industry's most important economic trait demands attention from the research community.

Reproductive efficiency may be increased by improvements in management, nutrition, and genetics. Consideration of all of these areas in the western rangeland environment is beyond the scope of this paper; efforts will be concentrated on improvement through the use of genetics. New technologies loom on the horizon; yet, at the present, two methods are available to the commercial range sheep manager for genetic improvement: (1) selection among breeding animals based on individuals and/or relative performance and, (2) utilization of

genetic diversity between breeds in crossbreeding schemes (Dickerson, 1969; Turner, 1969).

Both of these techniques have been under study and in practice under different management systems around the world for many years (Nitter, 1978). Improvements in reproductive efficiency from selection strategies depend on the repeatability and heritability associated with the components under selection (Turner, 1969; Falconer, 1981). A partial list of components provided by Bradford (1972) includes: age at puberty, frequency of parturition (fertility and interval to first post-partum estrus), number of lambs produced per parturition (prolificacy), survival of the lambs, and length of reproductive life. As traditional management involves breeding ewes first as yearlings and subsequently on an annual basis, choices for selection strategies have focused on fertility and prolificacy.

In a review, Turner (1969) reported repeatability for fertility at .08 to .09, and heritability at 0 to .03. More recently, Clarke and Hohenboken (1983) found the heritability to be .02 in a crossbred population. Estimates of such low magnitude would suggest gains from selection to be slow. Shelton (1962) reported gains from culling open 2-yr-olds of .05 lambs per ewe bred per yr. Turner (1966) reported gains of only .005 and .059 in two flocks, concluding that selection for fertility (or against its converse, barrenness) is ineffectual.

Heritability estimates for prolificacy are also quite low in magnitude. In a review, Turner (1969) reported an average estimate to be .15; other values have been .06 to .16 in western fine wool sheep (Shelton and Menzies, 1970; Basuthakur et al., 1973), and .12 in

crossbreds (Clarke and Hohenboken, 1983). Repeatibility estimates reviewed by Turner fall both above and below the heritability estimates. Bradford (1972a) suggests that a negative environmental correlation might exist between consecutive records due to ewes who raised twins being in poorer condition at mating than ewes raising only 1 lamb. Again with such low estimates response to selection will be slow. Turner (1969) and Burfening (unpublished data) both reported an annual divergence between lines selected for high and low prolificacy of .023 lambs per ewe exposed. In the latter experiment no differences were found between high and control lines. Clarke (1972) reported on a New Zealand long-term selection experiment initiated in 1948. The high line, selected for multiple lambings, had an annual rate of improvement of .018 to .019 lambs per ewe per yr above the control line, selected for general appearance.

As a result of the slow gains due to selection, research has focused on utilization of genetic diversity between breeds in crossbreeding schemes for increasing reproductive efficiency. The Finnish Landrace (Finn) and the Romanov have surfaced as seemingly the most prolific breeds (Bradford, 1972a). Reports of direct comparisons between the two breeds are few. Goot et al., (1979) reported no significant differences in fertility and prolificacy between F1 progeny produced by Finn and Romanov rams crossed with Merino and Awassi ewes. However, differences did exist between progeny for wool traits. Romanov crosses had significantly lower wool grades and higher incidence of kemp fibers than the Finn crosses, resulting in a poorer quality fleece.

Pure Finns are noted for their early age at puberty and large litters. In Finland, Finn ewe lambs have an average 96.1% conception rate and have litter sizes of 1.80, 2.39, and 2.75 at 1, 2 and 3+ yr of age, respectively (Maijala and Osterberg, 1977).

Under different management and environmental conditions in Britain, pure Finn ewe lambs had a similar conception rate, 93%; however, litter sizes were considerably higher at 2.0, 3.0, and 3.4 for ages 1, 2 and 3+ yr, respectively (Donald and Read, 1967). These results may be due to the importation of sheep more intensely selected for prolificacy rather than sheep more representative of the breed. Crossbred Finns in Britain have also shown superior prolificacy compared to three traditional crossbred groups. At ages 1, 2 and 3+ yr, female progeny from Finn sire and Scottish Blackface ewes had litter sizes of 1.5, 2.0, and 2.3, respectively, while the crossbred averages from Border Leicester, Clun Forest, and Dorset Horn sires were 1.1, 1.6, and 1.6, respectively (Donald et al., 1968).

Evaluation of Finn crosses (Fx) in the U.S. began in 1970 at the U.S. Meat and Animal Research Center, Clay Center, Nebraska. Under pasture conditions crosses were made using Finn and Rambouillet sires with seven breeds of ewes. At 1 yr of age Fx ewes had higher conception rates than Rambouillet crosses (Rx), 85% vs 66%, and higher than purebred average, 58%. At ages 1, 2, 3, and 4 yr litter sizes were higher for Fx than Rx, 1.55, 1.94, 2.03, and 2.25 vs 1.06, 1.38, 1.68, 1.51, respectively, and higher than purebred average, 1.08, 1.32, 1.52, 1.73, respectively. Overall reproductive performance for the Fx was 28% greater than the Rambouillet crosses (Dickerson, 1977).

Under western range conditions Fx superiority over the average of purebred Columbia, Rambouillet, and Targhees in conception rate at 1 yr of age was even more dramatic, 90.6% vs. 24.0%. Litter size was also significantly higher for Fx ewes, 1.53, 1.90, 2.25 vs. 1.06, 1.23, 1.53 at ages 1, 2, and 3+ yr, respectively (Ercanbrack and Knight, unpublished data).

The preliminary results cited above indicate that utilization of crossbreeding schemes involving Finn breeding may be an attractive alternative for improving reproductive efficiency under range conditions. The primary objective of this study is to compare reproductive efficiency and wool production of ewes composed of 1/4 Finn breeding with straightbred Columbia, Rambouillet, and Targhee ewes on western range. The secondary objective is to analyze breed of sire effects (Finn x Rambouillet vs. straightbred rams) on total kilograms of lamb weaned per ewe lambing.

CHAPTER 2

LITERATURE REVIEW

Fertility

In this paper, fertility is defined as the proportion of ewes lambing relative to ewes exposed to the ram (Nitter, 1978). In a review of Finn crossbred performance in numerous countries, Maijala and Osterberg (1977) found Finn breeding contributed to increased fertility only in ewe lambs (ewes lambing at approximately 1 yr of age). In Britain, Barker (1975) reported slightly negative, although non-significant, differences in fertility for mature ewes between Finn crosses and purebreds. These results are in agreement with studies conducted under semi-intensive management in the U.S. involving 1/4Finn crosses (1/4Fx) compared with Dorset x Rambouillet (Thomas and Whiteman, 1979), and 1/2Finn (1/2Fx) compared with Border Leicester crosses (Oltenacu and Boylan, 1981a). However, under western range conditions at Hopeland, California, 1/2Fx (x Whiteface) have demonstrated significantly higher fertility at ages 2 through 5 than 1/2Suffolk (x Whiteface), 98% vs. 88%, respectively (Dickerson, 1977). Ercanbrack and Knight (unpublished data) report similar results, although not significant, between 1/2Fx (x Whiteface) and Whiteface breeds ages 2 through 7 on western range.

Fertility in ewe lambs is largely a function of age at puberty (Nitter, 1978). Puberty may be defined as that point when reproduction

is first possible. Age at puberty is usually determined by observation of first behavioral estrus (Dickerson and Laster, 1975; Drymundsson, 1981). A list of factors affecting age at puberty would at least include breed, breed-cross, year, date of birth, weight at breeding, nutrition, daylight, and temperature (Laster et al., 1972; Drymundsson, 1981). Review of each of these areas is beyond the scope of this paper, efforts will be concentrated on breed and breed-cross effects.

Age at puberty in ewe lambs is not only of interest for the potential of reducing the number of non-productive ewes in a flock, but also for its effects on lifetime reproductive performance. On western range ewe lambs who display behavioral estrus during their first breeding season, but bred to lamb first at 2-yr-old, have been reported to be more productive at subsequent ages than lambs failing to cycle (Hulet et al., 1969; Burfening et al., 1972).

Several studies have reported small significant breed differences in ewe lambs obtaining puberty in their first breeding season (Hulet et al., 1969; Southan et al., 1971; Burfening et al., 1974). Due to wide variations in management and environment at various research sites, large differences exist between reported means among and between breeds (Drymundsson, 1981). Results in the literature may range from 0% in estrus during first breeding season for Merino ewe lambs in Australia (Watson and Gamble, 1961), and 24% for Columbia, Rambouillet, and Targhee ewe lambs on western range (Burfening et al., 1972), to 90.0% and 51.4% ewe lambs lambing at 12 mo of age for

Suffolk and Targhee under semi-intensive management (Oltenacu and Boylan, 1981a).

Studies involving pure Finns indicate consistently high fertility in ewe lambs in various environments. Maijala (1977) reports in Finland that over 90% of the Finn ewe lambs are bred to lamb at 1 yr of age, and lambs on a high level of nutrition breed at 5 mo. Similar indications of fertility were found in Scotland where 97% of the pure Finn ewe lambs exhibited estrus at 6 mo of age (Land et al., 1974). Reports of such large breed differences in age at puberty and fertility in ewe lambs has led researchers to ask "how" and "to what degree" will incorporation of Finn into standard breeds affect fertility in crossbred progeny.

In a study involving Finn crosses (Fx) and Rambouillet crosses (Rx) with seven standard breeds (Suffolk, Hampshire, Rambouillet, Dorset, Targhee, Corriedale, and Coarse Wool), Dickerson and Laster (1975) reported significantly lower age at puberty for Fx over Rx, 219 d and 238 d, respectively. In this study lambs were born either in February or April and exposed to vasectomized rams for about 10 wk prior to November 10th. No breed by date interaction was reported. Fx lambs were 4 kg lighter at puberty, but did not weigh significantly less than Rx at 230 d of age. The number of Fx lambs reaching puberty by November 10th greatly exceeded the Rx lambs, 70.2% vs 36.4%, respectively. While acknowledging high reports of fertility by Donald and Read (1967), Dickerson and Laster suggested heterosis played a larger role than average gene effects in the superiority of Fx lambs. This suggestion was based on data indicating 41% more 1/2Fx reached

puberty by November 10th than 3/4Fx (3/4Fx were not mentioned elsewhere in the study). Due to a lack of pure Finns, a heterosis estimate was available only for Rx: 8%, non-significant.

On the contrary, Cedillo and Hohenboken (1977) found no difference in percentage reaching puberty or average age at first estrus between Suffolk and Columbia ewe lambs sired by Finn rams vs those sire by Dorset, Targhee, Corriedale, and Coarse Wool rams. But, in this same study a large difference in fertility between Fx and standard crosses was observed, 72% and 38%, respectively.

While the little data available on the affect of Finn breeding on age at puberty is contradictory, much evidence exist supporting Fx superiority for fertility in ewe lambs over purebred standard breeds (see table 1). Unweighted averages of fertility for Fx (either 1/2 or 1/4) and standard purebreds, with which the Finns were crossed, are listed within the respective studies. Only in one study, Magid et al. (1981b), were Fx not reported significantly superior. This study compared ewe lambs sired by either Border Leicester or Finn rams; purebred comparisons were not reported.

Based on similar levels for fertility for pure Finns (81%) and Finn x Merino (76%), Land et al. (1974) concluded that the trait showed heterosis (87.7%) at least "superficially". In the only study involving pure Finns in the U.S., Oltenacu and Boylan (1981a) also reported similar levels of fertility between pure Finns (95.0%) and Finns crossed with Targhee, Minnesota 100, and Suffolk: 94.7, 94.1, and 87.0, respectively. Reported levels of fertility for the Targhee, Minnesota 100, and Suffolk were 51.4, 74.7, and 90.0, respectively;

TABLE 1. COMPARISON OF 1/2 AND 1/4 FINN CROSSES WITH STANDARD BREEDS FOR FERTILITY IN EWE LAMBS

Finn Breeding	Standard Breeds Involved in Crosses	Fertility (%) Fx	Std.	Reference
1/2	M100, Suffolk, Targhee	91.9	71.7	Oltenacu and Boylan (1981a)
1/2	Columbia, Rambouillet, Targhee	90.6	24.0	Ercanbrack and Knight (unpublished data)
1/2	Suffolk, Rambouillet, Targhee Corriedale, Dorset, Hampshire Coarse Wool	84	51	Laster et al., (1972)
1/2	Tasmanian Merino	81	5	Land et al. (1974)
1/2	Hampshire, Rambouillet, Targhee	78	78*	Magid et al. (1981b)
1/2	Dorset, Targhee, Corriedale Coarse Wool	72	38	Cedillo and Hohenboken (1977)
1/4	DorsetxRambouillet	80.5	56.5	Thomas and Whiteman (1979)
1/4	Columbia, Rambouillet, Targhee	76.1	24.0	Ercanbrack and Knight (unpublished data)
1/4	M100, Suffolk, Targhee	79.2	71.7	Oltenacu and Boylan (1981a)

* Estimate equals average of Finn and Border Leicester crosses. Authors reported no significant difference between Finn and Border Leicester cross ewe lambs; purebred estimates not reported.

estimates of heterosis were 29.5, 10.8, and -5.9, respectively. These results combined with those from Land et al. (1974) point to a strong link between increasing estimates of heterosis for Finn crosses and decreasing fertility in the purebreds incorporated in the cross.

Prolificacy

In addition to early age at puberty, pure Finns are most noted for exceptionally high prolificacy (litter size), number of lambs born (dead or alive) per ewe lambing. The average litter size for ewe lambs in Finland averages from 1.6 through 1.90 (Goot and Maijala, 1977; Maijala and Osterberg, 1977) is well above mature sheep of any standard breed in the U.S. Maijala and Osterberg (1977) report that the large litter sizes continue to increase with age up to 3 yrs of age, with averages of 2.39 and 2.75 for ages 2 and 3 yr. From age 3 onto at least 8 yr old the litter size remains constant.

Unweighted means of pure Finn performance in other European countries (not including Britain), under various management systems, agreed with the results in Finland, although there was a slight decline at 6 yr of age. Litter sizes were 1.84, 2.45, and 2.82 for ages 1, 2 and 3+ yr, respectively (Maijala and Osterberg, 1977). In Britain, Donald and Read (1967) reported similar results of increasing litter size to 3 yr of age, 2.0, 3.0, 3.3, 3.4, 3.4 for ewes ages 1, 2, 3, 4 and 5 yr, respectively. In the U.S., results for pure Finns are limited to one study reporting only the first 3 yr. Yet the data is in close agreement with those reported by Maijala and Osterberg (1977); average litter size was 156.8, 271.0, and 300.4 lambs born per

100 ewes exposed for ages 1, 2 and 3 yr, respectively (Oltenacu and Boylan, 1981a).

Of major concern to commercial sheep managers is how well this breed superiority is transmitted to progeny in crossbreeding schemes. The first Finn crossbreeding project in Britain demonstrated clear superiority for litter size of 1/2Fx over standard breeds. Fx ewes averaged 1.52, 2.02, and 2.30 lambs born per ewe lambing at 1, 2 and 3 yr of age; and, differences between Fx and standard breeds increased with age: .48, .55, and .79 at ages 1, 2 and 3 yr, respectively (Donald et al., 1968). A later study in Britain involving different breeds found the same pattern. But the differences were smaller and did not increase as dramatically with age. Fx minus standard breed (Border Leicester, Suffolk, and Clun Forest) average was .30, .32, .38 for ages 1, 2 and 3, respectively (Barker, 1975).

Several experiments conducted in the U.S. have found similar results to those in Britain. Laster et al. (1972) reported on ewe lambs from crosses involving seven breeds of dam and either Rambouillet or Finn sires. Fx ewes lambs had .58 more lambs per ewe lambing than Rx ewe lambs and .52 more than purebred. Cedillo et al. (1977) reported a difference of .44 between Fx and standard crosses (Dorset, Cheviot, and Romney crossed with Columbia and Suffolk) ewe lambs. In a more extensive study, Oltenacu and Boylan (1981a) found large and sharply increasing differences in litter size between Fx and the average of Minnesota 100 (M100), Suffolk, and Targhee purebreds: .51, .75, and .86 at ages 1, 2 and 3 yr, respectively.

Two studies under harsher conditions on the western range demonstrate that Fx superiority for prolificacy is not realized only in semi-intensive management schemes. At Hopland, California the average difference for ages 2 through 5 between 1/2Fx and white breeds was .60 (Dickerson, 1977). Ercanbrack and Knight (unpublished data) reported large differences between 1/2Fx and standard white-face breeds (Columbia, Targhee, and Rambouillet) on western range. Fx ewes exceeded the standard breeds by .47 at 1 yr of age. Subsequent breed group differences were nearly identical, .71 for ages 2 through 7 yr. Similarity between results under western range and semi-intensive management, are in agreement with conclusions drawn by Meyer and Bradford (1973). Finn x Targhee and Targhees both on high and low feed levels demonstrated no treatment x genotype interaction for fertility and prolificacy. The researchers concluded that feed levels are of little importance for evaluation of reproductive traits.

Results from studies involving 1/4Fx ewes at various ages show a reduction in prolificacy from 1/2Fx; however, 1/4Fx were still found to be superior to the purebreds. The smallest breed group difference, was reported by Thomas and Whiteman (1979) under semi-intensive management for ewe lambs. 1/4Fx average litter size was 1.17 compared to 1.08 for Rambouillet x Dorsets, a non-significant difference of .09. Also under semi-intensive management, 1/4Fx ewes, produced by backcrossing 1/2Fx with the standard breeds, were superior to the standard breeds. 1/4Fx ewe lambs significantly exceeded standards by .24; while litter sizes from 2 yr old 1/4Fx were .12 higher, although non-significant (Oltenacu and Boylan, 1981).

Ironically, under harsher western range management, overall breed means for both 1/4Fx and standard breeds were much higher than under semi-intensive management. In addition, differences between 1/4Fx and standard breeds were greater in magnitude. Across ages 2 to 5 yr at Hopland, litter sizes were .32 higher for 1/4Fx (Dickerson, 1977). The difference reported by Ercanbrack and Knight (unpublished data) for ewe lambs was half as great, .16, but significant. The amount by which 1/4Fx exceeded the standard breeds at later ages (2 though 7 yr) remained constant, .38 average.

Clearly, the Finn has the ability to transmit its superior prolificacy to crossbred progeny under varying management systems and at degrees of breeding as low as 1/4. The question now must be asked as to what genetic mechanism is this difference attributed - heterosis or additive gene effect?

In an experiment involving pure Finns, Merinos, and their reciprocal crosses, average prolificacy for ages 2 through 4 was 2.68, 1.00, and 1.70, respectively. Estimated heterosis, crossbred mean minus the parental mean as a proportion of the parental mean, was -7.6%. Therefore, no heterosis was present and the superiority could be attributed to additive gene effects (Land et al., 1974). The results of Oltenacu and Boylan (1981) are in strong agreement. Their data demonstrated heterosis (10.1%) at 1 yr of age, but non-significant. However, at ages 2 and 3 yr heterosis was zero. The mean of the 1/4Fx at 1 yr of age fell almost exactly half way between the mid-parent value and the standard breed average, 1.01 (1/4Fx) and 0.97

(mid-parent). However, at age 2 yr, the 1/4Fx were lower than the mid-parent value, but non-significant.

There do exist reports in the literature of positive heterosis for prolificacy (Turner, 1969; Sidwell and Miller, 1971a); however, most average about 3% and are non-significant (Nitter, 1978). The highest estimate this author reviewed, 30%, involved Fx ewes, but was non-significant (Hohenboken and Cochran, 1976). Therefore, while differences between Fx and standard breeds may vary with environment and age, the commercial producer may expect, in general, litter sizes to increase by the same proportion of Finn breeding due to additive gene effects.

Survivability

Utilization of Finn breeding to increase prolificacy may be unwarranted if corresponding large decreases in survivability from birth to weaning exist. Factors affecting survivability (or the converse, mortality) in lambs are numerous and often unaccountable. Any list of factors would include breed, birth weight of the lamb, nutrition (pre-partum and post-partum), litter size, age of ewe, sex, season, and management system (Bradford, 1972b; Jakubec, 1977). All of these factors are important to the commercial sheep producer; however, this review will concentrate on the genetic factors: birth weight, litter size, and breed.

Substantial effects of litter size on post-partum lamb mortality have been reported in the literature under various environments. Under adverse conditions twins have been found to have 68% higher mortality rates than singles (Smith, 1974). But, under more intensive management

in which mortality rates are lower, twins may have in excess of 80% higher mortality than singles (Sidwell et al., 1962; Sidwell and Miller, 1971a; Oltenacu and Boylan, 1981). The effect is even more dramatic for lambs born as triplets, over 50% and 200% higher mortality than twins and singles, respectively (Oltenacu and Boylan, 1981).

In a well-planned study under two environments (semi-intensive and open pasture), Purser and Young (1964) concluded that multiple births had no direct effect on survivability, but rather birth weight was the major factor. Lambs of equal birth weight, regardless of type of birth, had equal survival. Numerous studies have reported effects of litter size on individual birth weights; twins weighing on average 15 to 20% less than singles (Purser and Young, 1964; Bradford, 1972b; Sidwell and Miller, 1971b, Magid et al., 1981a), and triplets 30 to 35% less than singles (Rastogi et al., 1975; Magid et al., 1981a; Oltenacu and Boylan, 1981b)

As pure Finns have much higher litter sizes than most standard breeds, birth weights and survivability would be expected to be substantially lower. Maijala and Osterberg (1977) reported average birth weight of pure Finns across all ages, and at various locations, to be 2.57 kg. Although not an accurate comparison, birth weights in the U.S. average 4 to 5 kg (Sidwell and Miller, 1971b; Rastogi, 1975; Dickerson et al., 1975). Despite the much lower birth weights, Maijala and Osterberg (1977) reported mortality across all ages of dams and litter sizes, between birth and 2 wk of age, to be 10 to 15%. The effects of litter size and age of dam were significant. Mortality

rates of lambs from yearlings were twice as high as that from mature ewes at every litter size. Lambs born as quintuplets to yearlings had mortality rates in excess of 70%.

Donald and Read (1967) reported similar estimates for birth weight of pure Finn lambs in Britain. Average birth weight for singles and twins was 2.8 kg and 2.2 kg, respectively. Including lambs dead at birth, Finns had 38% mortality from birth to weaning. Despite semi-intensive management, mortality for lambs born alive from birth to weaning was 25%, averaged across all ages of dam and litter sizes. They attributed the high death losses to low birth weights.

Birth weights for pure Finn sheep in the U.S. are in close agreement with the results reported in Finland and Britain. Individual pure Finn lambs from ewes had an average birth weight of 2.60 kg, 1.00 (28%) kg less than the standard breeds (M100, Targhee, and Suffolk) across ages 1, 2 and 3 yr (Oltenacu and Boylan, 1981b). As these means are adjusted for type of birth and pure Finns had much larger litter sizes, the actual difference in means would be larger. The difference reported in this study may reflect the smaller mature weight of the Finn ewe, although Finn lambs are small relative to mature ewe size (Bradford, 1972b).

Incorporation of Finn breeding into standard breeds has also served to reduce birth weights at all ages. In Britain, 1/2Fx ewes were found to have consistently lower birth weights than purebreds at ages 1, 2 and 3 yr. Unadjusted for type of birth the difference was on average .5 kg (12%) less than purebred average (Donald et al., 1968; Barker, 1975).

Most of the estimates of differences in the U.S. fall between .3 and .9 kg less for the 1/2Fx than standard breeds (Dickerson et al., 1975; Magid et al., 1981; Oltenacu and Boylan, 1981, Cochran et al., 1982, Ercanbrack and Knight, unpublished data). But one report involving Finn x Panama (FP) and Panama (P) purebreds found Suffolk sired lambs from FP ewes to be significantly heavier at birth than lambs from P ewes by .89 kg (Dahmen et al., 1979). The study did not report if type of birth was included in the model. Estimates for 1/4Fx are intermediate between 1/2Fx and purebreds, ranging from .3 to .6 kg less than the purebreds (Oltenacu and Boylan, 1981; Cochran et al., 1982; Ercanbrack and Knight, unpublished data).

Based on the lower estimates of birth weight for lambs from Fx dams, one would expect survivability to be lower as well. But, despite significant differences in birth weight, this author found no estimates of significantly lower survivability in lambs from 1/2Fx or 1/4Fx ewes age 2 yr or older when type of birth was not included in the model (Donald et al., 1968; Barker, 1975; Dickerson, 1977; Thomas and Whiteman, 1979; Cochran et al., 1982). Only two studies reported significantly lower survivability for lambs from Fx yearling dams. Donald et al. (1969) and Barker (1975) both reported about 9% lower survivability for Fx than purebreds when weaned at about 90 d of age. Although statistically non-significant, similar results were reported by Dickerson (1977) and Thomas and Whiteman (1979). Conflicting, but statistically non-significant results were found by Ercanbrack and Knight (unpublished data) when lambs were reared on western range and weaned at approximately 120 d of age . Lambs from 1/2Fx yearling ewes

had 3% higher survivability than purebreds. These results may bias Fx survivability upwards due to the management procedure which credits a ewe with half a lamb when successfully reared by another ewe or artificially.

Estimates of survivability using models which include type of birth show increased survivability with increasing amounts of Finn breeding. Oltenacu and Boylan (1981a) found standard breeds and 1/4Fx to have similar survival rates for percent of total born to weaning; however, 1/2Fx and pure Finns exceeded standard breeds by 9% and 25%, respectively. However, Dickerson et al. (1975) reported even more dramatic differences; 1/2Fx exceeded both Rx and purebreds by more than 30%. In contrast, Hohenboken and Clarke (1981) found lower survival rates for lambs from 1/2Fx dams; although, due to their superior prolificacy, the Finn survivability was biased downwards as all lambs in excess of 2 were removed from the dam and counted as dead.

The literature reviewed suggest that no large breed differences exist between Finn crossbreds and standard breeds, or that any maternal heterosis is present. These conclusions agree with other reports in the literature that little to no heterosis has been found involving other standard breed crosses (Sidwell et al., 1962; Sidwell and Miller, 1971a; Rastogi et al., 1975; Hohenboken and Cochran, 1976; Nitter, 1978).

Individual Progeny Weaning Weight Performance

The last component of reproductive efficiency, individual lamb weaning weight performance, often receives the most attention from the producer; however, the total kilograms of lamb weaned is more a function of the total number of lambs weaned than the individual lamb weights (Sidwell and Miller, 1971a). A composite view of the previous sections of this review would clearly suggest the Finn contribution to total number of lambs weaned is important. Now the question becomes whether the gains realized in number weaned from crossbred Finns are negated or dampened by poor weaning weight performance.

Any list of the factors affecting the weaning weight of lambs would at least include breed, sex, type of birth/rearing, age of dam, age of lamb, nutrition, season, and management. Of the environmental factors, type of birth/rearing has the largest effect on weaning weight. All studies have shown a negative effect on weaning weight due to increasing type of birth/rearing (Bradford, 1972b). Bradford reports that weaning weights of twins reared as singles fall intermediate to weights of twins reared as twins and singles reared as singles, suggesting a permanent environmental effect due to type of birth. But, evidence put forth by Doney and Munro (1962) indicates differences in weaning weight are not due directly to type of birth but rather birth weight which is a function of litter size as discussed earlier. The researchers found no difference in weaning weight at 90 d of age between singles reared as singles and twins when reared as singles from 1 d of age when adjusted for birth weight.

Due to a large amount of variation in management no valid estimates are available for pure Finn individual weaning weights in Finland; however, in a review of experiments involving pure Finn sheep in Europe, Maijala and Osterberg (1977) reported an average of 18 kg at 90 d of age.

All studies reviewed by this author have shown reduced lamb weaning weights due to the incorporation of Finn breeding when means are unadjusted for type of birth/rearing. Barker (1975) found single and twin lambs from 1/2Fx dams lighter at 70 d of age than purebreds. The purebred superiority increased with age ranging from 1.1 kg for twins from yearlings to 3.4 for singles at ages 3 and 4 yr. Similar results have been reported in the U.S. under both semi-intensive management and western range. Lambs from Fx ewes were 1.3 to 2.7 kg less than purebreds at 70 to 105 d of age (Cedillo et al., 1977; Dickerson, 1977). But in contradiction to Barker (1975), when only singles were compared Dickerson found no breed differences existed. Also in contradiction, Magid et al. (1981) reported no breed differences between unadjusted weaning weights of lambs at 50 d of age from Fx and Border Leicester sired ewes. These results may indicate that the limitations of the maternal environment have not been exceeded at such an early weaning date.

Thomas and Whiteman (1979) also found unadjusted weights to be significantly lower for lambs from Fx ewes when compared with Dorset x Rambouillet. But, once the model included type of birth/rearing the weights were not significantly different. In agreement with these results, Oltenacu and Boylan (1981b) reported no difference between

lambs from pure Finns, 1/2Fx, and the three standard breeds (M100, Targhee, and Suffolk) when adjusted for type of birth/rearing. Lambs from 1/4Fx were significantly heavier than standard breeds, but only by 1.0 kg. Exclusion of the Suffolk breed from the standard breed and Fx means results in lambs from pure Finns, 1/2Fx, and 1/4Fx dams exceeding those from Targhee and M100 by 2.0, 1.4, and 2.3 kg, respectively.

This author found no unadjusted estimates of maternal heterosis for individual lamb weaning weight from studies involving Finn breeding in the literature. Estimates in the literature for maternal heterosis range from 0 to 8% in studies involving standard breeds, and are considered of minimal importance (Sidwell and Miller, 1971b; Hohenboken and Cochran, 1976; Jakubec, 1977; Nitter, 1978).

Most of the studies reviewed above have utilized a "meat" breed as the sire of the progeny from the Fx and purebred dams. As the resulting progeny are only 1/4Fx or 1/8Fx, depending on the Finn breeding in the dam, only small differences in individual weaning weights adjusted for type of birth are expected. The major cause for reductions in lamb weights remains litter size, and the associated less than optimum environment for lamb growth (Thomas and Whiteman, 1979). Therefore, reductions in individual lamb weaning weight performance are to be expected under any system of breeding, nutrition, or management which serves to increase prolificacy.

Composite Reproductive Performance

Increasing prolificacy and fertility are intermediate objectives for the commercial sheep producer. In the final analysis, evaluation of the contribution to reproductive performance of varying levels of Finn breeding with standard breeds must center on a composite of reproductive performance, the total kilograms of lamb weaned per ewe exposed at all ages.

Unfortunately, not all the components of the the above composite measurement are available in each study, nor is there agreement among systems of accreditation for rearing. Estimates of pure Finn performance are limited to an average of litter weights across Finland under various management systems. Maijala and Osterberg (1977) reported total kilograms per ewe lambing for 2-yr-old and older ewes of 29.1, 45.9, 62.8, 87.8, and 95.1 for litter sizes of 1, 2, 3, 4 and 5, respectively. Average litter weight at 150 d of age was 71 kg. As reported earlier, fertility for pure Finn sheep in Finland is exceptionally high; therefore, estimates based on a per ewe exposed basis would not be considerably lower. These results are gathered from small systems of intensive management where supplementation of lambs from large litters is regularly practiced.

On a per ewe lambing basis, Donald et al. (1968) reported only slight differences in total litter weight between pure Finns and standard breeds; however, at ages 2 and 3 yr pure Finns raised 5.9 kg and 9.5 kg more lamb, respectively. These results reflect smaller differences in prolificacy and higher lamb mortality rates for Finn

yearlings than standard breeds. Larger differences in prolificacy at later ages resulted in large differences in litter weight.

Under semi-intensive management in the U.S. pure Finns have greatly exceeded standard breeds (M100, Suffolk, and Targhee) for composite reproductive performance. Yearling Finns weaned at 70 d 10.7 kg (117%) more lamb than the standard breeds per ewe mated. Much of this difference could be attibuted to superiority of Finns for fertility at 1 yr of age. But, at 2 yr of age Finns exceeded standard breeds by 19.6 kg (104%); Finn superiority for prolificacy being the major factor. (Oltenacu and Boylan, 1981b). From a commercial producers viewpoint these results may be biased in favor of the Finns, as the weights of all lambs reared artificially were accredited to the ewe.

Crossbred performance in Britain was reported by Barker (1975) on a per ewe exposed basis. Fx advantage over purebreds in total weight weaned was significant only at 1 yr of age (+3.3 kg). At ages 2 and 3 yr the Fx advantage was slightly positive, but non-significant. Barker concluded that the Finn's contribution in increasing total kilograms of lamb weaned per ewe exposed is primarily by increasing fertility in ewe lambs.

This conclusion is in agreement with the results reported by Thomas and Whiteman (1979) for 1/4Fx ewes under semi-intensive management, and by Hohenboken and Cochran (1981) for 1/2Fx ewes under hill conditions. Thomas and Whiteman found total weight weaned at 70 d of age for 1/4Fx yearling ewes to exceeded Dorset x Rambouillet by 3.5 kg, while differences at 2 and 3 yr of age were only slightly positive

and non-significant. These results led to the conclusion that the major advantage of 1/4 Finn breeding is increased fertility in ewe lambs. Hohenboken and Clarke (1981) found a 10 kg superiority for lamb production from yearling 1/2Fx ewes over standard breeds, and no differences at later ages. But, under more favorible conditions on irrigated pasture 1/2Fx exceeded standards at all ages resulting in a cummulative difference of +36kg (27%) by age 5 yr. These results are reported on a per ewe entering the experiment basis, and would reflect hardiness of the ewe as well the reproductive traits discussed earlier. In addition, ewes received credit in this study only for the weight of lamb they actually reared themselves.

Under western range conditions, Ercanbrack and Knight (unpublished data) also found 1/2Fx and 1/4Fx to exceed purebreds at 1 yr of age for composite reproductive performance by 23.5 kg (452%) 13.8 kg (265%), respectively. The magnitude of the difference decreased from ages 2 to 6 yr with a slight increase at age 7 yr. Differences at all ages between Finn crosses and purebreds were highly significant. The cummulative advantage of 1/2Fx and 1/4Fx over ages 1 through 7 yr was 107.8 kg (50%) and 63.5 kg (30%), respectively. As mentioned earlier in this review, ewes were credited with half the weight of all their lambs reared artificially or by another ewe.

Due to varying systems of accreditation and analysis the verdict on the Finns contribution to crossbreeding schemes involving standard breeds is not clear. But, all the literature does point to a clear superiority of Finns and Fx for fertility in ewe lambs which results in increased kilograms of lamb weaned per ewe lamb exposed. In terms

of commercial sheep operations, utilization of Finn breeding will reduce the number of unproductive ewes in the flock.

Wool

This review has been primarily aimed at the potential contribution of the Finn breed towards increasing reproductive efficiency due to the large proportion of gross income derived from the sale of lamb compared to wool. Nevertheless, the quality and quantity of wool produced remains economically important to the western range producer, and should not be overlooked in evaluating any introduced breed.

In Finland the quantity and quality of wool are considered of secondary importance, and breeds other than the Finn are better adapted for the production of wool. Pure Finns in Finland produce on average 2.7 kg of grease wool per yr, have long staple lengths, and have a grade average around 3/8 blood (Maijala and Osterberg, 1977). Similar results were reported from Britain where pure Finns had fleece weights of 2.2 kg with 3/8 to 1/2 blood grades (Donald and Read, 1967).

In the U.S. Oltenacu and Boylan (1981b) reported average grease fleece weights for pure Finns of 2.0 kg and 2.2 kg for ages 1 and 2 yr, respectively, compared to standard breed averages (M100, Suffolk, and Targhee) of 3.2 kg and 3.4 kg. From these estimates pure Finns have approximately 35% lighter grease fleece weight. Wool grades for the pure Finn fell between 1/4 and 3/8 blood; grades for the purebred varied widely due to the breeds involved.

In the same study, 1/2Fx ewes had fleece weights slightly higher than the mid-parent value, demonstrating about 8% heterosis for the trait. Estimates of heterosis for grease fleece weight have been reported before ranging from 0 to 27%; however, Sidwell and Miller (1971c) concluded that more studies were required before establishing the existence of heterosis in wool traits.

The superiority over the mid-parent mean was maintained in the 1/4Fx as their average weights were the same as the 1/2Fx at both 1 and 2 yr of age. 1/2Fx wool grades were similar to pure Finns, while the 1/4Fx were no coarser than the standard breeds. Breed differences in quality and quantity were consistent across ages 1, 2, and 3 yr (limited data reported for age 3).

In a study involving ewes from Suffolk and Columbia dams crossed with either Finn, Dorset, Cheviot, or Romney sires, no crossbred differences existed for wool grade. Despite having similar staple lengths to Romenys, Fx ewes had significantly lighter weights (- .3 kg) than the crossbred average. Similarity in wool grades is to be expected as all the other sire breeds typically have grades averaging from 1/4 to 3/8.

In comparison with Columbia, Rambouillet, and Targhee breeds on western range, 1/2Fx and 1/4Fx had consistently lighter fleece weights at ages 1 through 7 yr than the whiteface breeds by 1.10 kg and .48 kg, respectively. Differences in grades were consistent across all ages, 1/2Fx were of lower grade with 1/4Fx intermediate (Ercanbrack and Knight, unpublished data). But, in a previous study involving the

same groups of sheep Drummond et al. (1982) found no differences in quality of yarns or fabrics produced by the three breed groups.

A study involving Panama and Finn x Panama ewes Dahmen et al. (1978) reported average Panama grease fleece weight to exceed the Fx by 1.1 kg and 1.5 kg at 1 and 2 yr of age. At 2 yr of age Fx ewes were found to have significantly smaller average fiber diameter (finer fleece), even though visual estimates had previously ranked the Fx lower in wool grade than the Panama.

CHAPTER 2

MATERIALS AND METHODS

Populations

From 1974 through 1977 at the Montana Agricultural Experiment Station, Red Bluff Research Ranch, Norris, Mt., approximately 240 western range ewes of ages 2 through 6 yr, composed of comparable numbers of Columbia (C), Rambouillet (R), and Targhee (T), were exposed to Finnish Landrace x Rambouillet rams (FxR). The (FxR) rams were obtained from the U. S. Sheep Experiment Station, Dubois, Idaho. In addition, approximately 360 straightbred, whiteface ewes (WF) ages of 2 through 6 yr, composed of C, R, and T in nearly equal numbers, were maintained as controls. No crosses were made between the three WF groups. Performance of the 563 ewes which lambed and of their 821 progeny was designated "Phase I" of this study (table 2).

All healthy female 1/4Fx lambs from Phase I were retained in the flock each year, totalling 146 for 4 yr. Each year approximately the same number of WF lambs as 1/4Fx lambs, representing all three breeds comparably, were selected randomly from the control group, totalling 143 for 4 yr. Phase II of this study involved the lamb and wool production of 289 ewes from the six breed groups, C, R, T, (FxR)xC, (FxR)xR, and (FxR)xT, for a total of 1264 spring lambing opportunities from 1976 to 1982 across ages 1 to 6 yr (Table 3). Beginning as ewe lambs, at approximately 7 mo of age, both 1/4Fx and WF ewes were

TABLE 2. TOTAL NUMBER OF PHASE I EWES LAMBING BY YEAR AND AGE AT LAMBING

	Age at lambing					
Year	2	3	4	5	6	Total
1975	18	26	23	20	--	87
1976	51	46	47	27	22	193
1977	51	57	33	32	17	190
1978	18	34	32	9	--	93
Total	138	163	135	88	39	563

TABLE 3. TOTAL NUMBER OF PHASE II EWES EXPOSED IN PREVIOUS BREEDING SEASON BY YEAR AND AGE IN YEARS AT LAMBING

	Age at lambing						
Year	1	2	3	4	5	6	Total
1976	42	--	--	--	--	--	42
1977	88	38	--	--	--	--	126
1978	80	84	35	--	--	--	199
1979	79	84	73	42	--	--	278
1980	--	73	77	65	39	--	254
1981	--	--	58	67	55	33	213
1982	--	--	--	51	56	45	152
TOTAL	289	279	243	225	150	78	1264

exposed to Suffolk rams throughout the breeding season for years 1976 to 1979. From 1980 to 1982 ewes were randomly divided into two groups and exposed to either FxT or Suffolk rams.

Management

All Phase I and II mature ewes (ages 2 through 6 yr) from each breed group were herded as one band on the range throughout the year with the exception of breeding and lambing seasons. Ewe lambs were managed separately from weaning until mid-April on aftermath hay meadows receiving an additional 150 g. of supplement (approximately 15% protein, 73% TDN) composed of barley (62.5%), wheatmill run (30%), cane molasses (6.25%), urea (1%), trace minerals (.25%), and Dicalcium Phosphate (.25%) with vitamins A and D added (.25%).

From the second week in November to the end of December, all ewes were bred in small pastures. Common "shed lambing" practices were followed at lambing, mid-April through May, except in 1976 and 1977 when 65 and 80 Phase I ewes lambed on open pasture. At this time lamb's identification, dam's identification, sex, birth date, birth weight (BWT), and type of birth were recorded; all lambs were docked and male lambs were castrated. Birth date and weight for the 205 Phase I lambs born on pasture were not recorded. Lambs were weighed twice subsequently, once in the middle of June (approximately 60 d of age, WT60) and again the last week in August at weaning (approximately 120 d of age, WT120). Ewes were shorn during the first week of April each year except in 1981 when shearing occurred in the last week of May. Ewes were removed from Phase II prior to breeding at six years of age,

or at earlier ages due to unsoundness such as mastitis, etc...; no ewes were removed based on performance.

The range site is characterized by a 25 to 35 cm precipitation zone, with sandy and silty soils, dominated by Idaho fescue and bluebunch wheatgrass, and classified in good condition. During the breeding season the ewes were flushed with first cutting grass hay and grain. During gestation ewes received .2 kg per head per day of the same supplement as the ewe lambs. Only under severe winter conditions when snow accumulation prevented grazing did the ewes receive hay (approximately 5 d per year). Starting April 1 each year the ewes received an additional 1/2 kg of barley per sheep. In the lambing pens first cutting hay was provided free choice. After the lambing period ewes were returned to the range.

Traits Studied

Traits associated with breed group differences in overall lamb production, total kilograms of lamb weaned per ewe exposed, and wool production were of primary interest. Components of lamb production measured in this study consisted of ewe fertility, ewe prolificacy, lamb survivability, and individual lamb weights. For the purposes of this experiment fertility was defined as the percentage of ewes lambing of those exposed for breeding. Ewe prolificacy was defined as the number of lambs born per ewe lambing. Survivability was measured at mid-lactation (S60), at approximately 60 d, and at weaning (S120), approximately 120 d of age. Survivability was defined as the percentage of lambs at the respective ages of those born, and coded 0

and 1 for dead and alive, respectively. Losses included stillbirths, lambs removed from the ewe to be reared artificially or by another ewe not in the study, and lambs that died prior to weighing. Composite traits for reproductive performance consisted of litter size and litter weight at mid-lactation (LS60 and LW60), and litter size and litter weight at weaning (LS120 and LW120). Composite traits were measured on a per ewe lambing basis in Phase I and on a per ewe exposed basis in Phase II.

Wool characteristics studied included kilograms of grease fleece weight, grade, and fiber length. Fleeces were graded based on the "blood" scale and then coded 1 through 5: Fine (1), 1/2 (2), 3/8 (3), 1/4 (4), and low 1/4 (5). Lengths were coded as Staple (1), French (2), and Clothing (3).

Statistical Methods

All data were analyzed according to the procedure described by Harvey (1975) for least squares analysis of data with unequal subclass numbers. The fixed-effects model for Phase I and II mature ewe reproductive performance included the factors breed group of ewe (B), breed group of lamb's sire (S), age of ewe at lambing (A), and year of lambing (Y). All possible two-way interactions between main effects were tested ($P<.10$) in preliminary analyses. Results indicated BxA to be the only interaction significant for any of the traits; BxA was included in all analyses, except LW60 and LW120 in Phase I. Composite traits for total kilograms reared to 60 and 120 d of age per ewe

exposed were not adjusted for sex, type of birth/rearing, and date of birth.

The basic fixed-effects model for Phase I and II individual lamb survival and weight traits for mature ewe progeny included the factors breed group of dam (B), breed group of sire (S), age of dam (A), year (Y), sex (X), and type of birth/rearing (BR). Preliminary analysis for significance ($P<.10$) of all possible two-way interactions indicated that BxY and SxY should be included in the fixed-effects models for Phase I, and that AxBR be included in the models for Phase II. Quadratic regression on birth weight was included in the models for each trait other than birth weight and survival from 60 to 120 d. In Phase I, 205 lambs, born on pasture, had no birth weight recorded, and consequently were not included in the analysis of individual progeny performance. (Analysis of composite traits, litter size and weight, for Phase I ewes included all 821 lambs born.) Quadratic regression on birth date was included in model for birth weight; linear regression on birth date was included in the fixed-effects models for 60 and 120 d weights. Additional analyses of all traits was conducted with type of birth/rearing main effect and regression on birth weight removed from the model.

As a result of only two ewe lambs out of 143 conceiving from the WF group, a separate analysis of variance for ewe lamb reproductive performance was conducted. The fixed-effects model for ewe lamb reproductive performance included breed group (B), year (Y), and BxY interaction. Fixed-effects model for ewe lamb individual progeny

traits included B, Y, X, type of birth/rearing, and regressions on birthdate (linear) and birthweight (quadratic).

The fixed-effects model for wool production traits included breed group of ewe's dam (D), breed group of ewe's sire (S), year (Y), and age of ewe (A). Preliminary analysis of all possible two-way interactions indicated that DxS, DxY, SxY, and SxA should be included in the fixed effects model.

Test of significance procedures described by Harvey (1975) for analysis of variance assume normal distributions of dependent variables. Distribuitons for ewe fertility and lamb survival are binomial; and also, prolificacy does not follow a normal distribution. Consequently, tests of significance for these traits may not accurately describe the populations.

CHAPTER 3

RESULTS AND DISCUSSION

Mature Ewe and Progeny Peformance in Phase I

Breed Group of Sire Effects

Mean squares from analysis of variance for Phase I are presented in tables 4 and 5. Least-squares means for ewe production and individual progeny performance by breed group of sire (S) are presented in tables 6 and 7. Ewes bred to FxR rams exhibited nearly identical levels of prolificacy, had larger, but not significant, litter sizes and weights at 60 d, and weaned more lambs ($P<.10$) and more total kilograms of lamb per ewe lambing ($P<.05$) than ewes bred to WF rams. Land et al. (1974) reported no differences in fertility or prolificacy between ewes bred to either Finn or Tasmanian Merino rams, even though ewes of the two breeds differ greatly in prolificacy. Furthermore, Bradford (1972b) indicates that differences in prolificacy are more a function of genotype of the dam rather than genotype of the offspring.

Birth weights of lambs sired by FxR were not significantly lighter. Magid et al. (1981) found pure Finn sires to produce crossbred lambs with lighter BWT than Border Leicester rams. Despite lighter BWT (non-significant), 1/4Fx lambs had better survivability ($P<.01$) from birth to 60 d than WF lambs; however, increased

TABLE 4. MEAN SQUARES FROM ANALYSES OF VARIANCE FOR PHASE I EWE REPRODUCTIVE TRAITS PER EWE LAMBING (1975 - 1978)[a]

Source	df	Prolificacy	LS60	LW60	LS120	LW120
Breed of dam (B)	2	.992*	1.680**	693**	1.664**	2444**
Breed of sire (S)	1	.008	.704	181	1.012+	1718*
Year (Y)	3	.166	.538**	483**	.601	784+
Age of dam (A)	4	3.606**	4.355**	1915**	4.125**	5257**
BxA	8	.421+	.439	---	.269	---
Error MS		.221	.283	95	.295	319
Error df		544	544	552	544	552

[a] LS60, litter size at 60 d; LW60, litter weight at 60 d; LS120, litter size at 120 d; LW120, litter weight at 120 d.

+ P<.10

* P<.05

** P<.01

TABLE 5. MEAN SQUARES FROM ANALYSES OF VARIANCE FOR PHASE I INDIVIDUAL PROGENY TRAITS TRAITS (1975 - 1978)[a]

Source	df	BWT	S60	WT60	S120	WT120
Breed of dam (B)	2	6.66**	.125**	45.85**	.025	171.8**
Breed of sire (S)	1	.44	.793*	.01	.035	1.3
Year (Y)	3	4.04**	.330**	65.31**	.067	244.1**
Age of dam (A)	4	6.09**	.476**	57.62**	.035	92.6**
Sex (X)	1	9.54**	1.214**	40.99*	.033	218.2**
Type of birth/ rearing (BR)[b]	1(2)	90.80**	.419+	455.30**	.095	732.6**
BxY	6	.84*	---	---	---	---
SxY	3	1.27*	---	---	---	---
Regressions						
BDT (linear)	1	23.626**	---	1262.09**	---	713.6**
BWT (linear)	1	---	2.897**	524.99**	---	933.3**
BWT (quad.)	1	---	---	4.65	---	19.5
Error MS		.38	.110	6.18	.056	12.5
Error df		592	601	499	502	489

[a] BDT, birth date; BWT, birth weight; S60, survival to 60; WT60, weight at 60 d; S120, survival to 120; WT120, weight at 120 d.

[b] degrees of freedom in parenthesis for WT60, S120, and WT120 models; rearing was coded 11 (single reared single), 21 (twin reared as single), and 22 (twin reared as twin). Triplets were coded as twins due to small numbers.

+ P<.10

* P<.05

** P<.01

TABLE 6. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE I EWE REPRODUCTIVE TRAITS PER EWE LAMBING (1975 - 1978)[a]

Effect	N	Prolificacy	LS60	LW60, kg	LS120	LW120, kg
Breed Group of Sire[b]		NS	NS	NS	+	*
FxR	220	1.50 ± .04	1.35 ± .04	26.8 ± 0.9	1.31 ± .04	48.1 ± 1.7
WF	343	1.49 ± .03	1.27 ± .04	25.4 ± 0.8	1.21 ± .04	44.0 ± 1.6
Breed Group of Dam		*	**	**	**	**
Columbia (C)	176	1.41 ± .04	1.24 ± .05	24.8 ± 1.1	1.19 ± .05	43.8 ± 1.9
Rambouillet (R)	194	1.50 ± .04	1.25 ± .05	24.9 ± 1.0	1.21 ± .05	43.7 ± 1.8
Targhee (T)	193	1.58 ± .04	1.44 ± .05	28.5 ± 1.0	1.39 ± .05	50.6 ± 1.8

[a] LS60, litter size at 60 d; LW60, litter weight at 60 d; LS120, litter size at 120 d; LW120, litter weight at 120 d.

[b] FxR, Finn x Rambouillet; WF, composite of Columbia, Rambouillet, and Targhee.

NS, non-significant (P>.10)

\+ P<.10

* P<.05

** P<.01

TABLE 7. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE I PROGENY TRAITS (1975 - 1978)[a]

	BWT		S60		WT60		S120		WT120	
Effect	N	Mean, kg	N	Mean, %	N	Mean, kg	N	Mean, %	N	Mean, kg
Breed Group of Ram[b]		NS		**		NS		NS		NS
FxR	290	4.56 ± .06	290	91.7 ± 2.6	251	21.6 ± .3	251	96.3 ± .1	246	37.1 ± .4
WF	326	4.64 ± .05	326	84.4 ± 2.6	265	21.6 ± .3	265	94.8 ± .1	259	37.0 ± .3
Breed Group of Dam		**		NS		**		NS		**
Columbia (C)	188	4.39 ± .06	188	91.1 ± 2.9	159	21.4 ± .3	159	95.0 ± 1.6	154	37.5 ± .4
Rambouillet (R)	203	4.53 ± .06	203	86.5 ± 3.0	170	21.0 ± .3	170	94.9 ± 1.5	166	35.8 ± .4
Targhee (T)	225	4.88 ± .06	225	86.6 ± 3.0	187	22.3 ± .3	187	96.8 ± 1.5	185	37.8 ± .4

[a] BWT, birth weight; S60, survival from birth to 60 d; WT60, weight at 60 d of age; S120, survival to 120 d; WT120, weight at 120 d of age.

[b] FxR, Finn x Rambouillet; WF, composite of Columbia, Rambouillet, and Targhee.

NS, non-significant (P>.10)

+ P<.10

* P<.05

** P<.01

TABLE 8. MEAN SQUARES FROM ANALYSES OF VARIANCE FOR PHASE II EWE PRODUCTION TRAITS (1976 - 1982)[a]

Source	df	Fertility	Prolificacy	LS60	LW60	LS120	LW120
Fx Ewe lambs:							
Breed group (B)	2	.044	.036	.088	36.2	.039	37
Years (Y)	3	1.305**	.063+	1.495**	732.9**	1.335**	1929**
BxY	6	.103	.183+	.312	135.4	.241	296
Error MS		.222	.090	.236	109.8	.204	255
Error df		134	43	134	134	134	134
Mature ewes:							
Breed group (B)	5	.086	3.925**	3.066**	1066.2**	2.597**	1597**
Years (Y)	5	.218*	.853**	2.776**	3633.5**	4.075**	8027**
Age (A)	4	.084	2.359**	1.537**	938.9**	1.291*	1878**
Sire (S)	1	1.527**	.625+	1.345+	3277.0**	2.040*	321
BxA	20	.144*	.198	.634+	250.4+	.885	365
Error MS		.084	.249	.419	162.3	.412	347
Error df		939	845	939	939	939	939

[a] LS60, litter size at 60 d; LW60, litter weight at 60 d; LS120, litter size at 120 d; LW120, litter weight at 120 d.

+ P<.10

* P<.05

** P<.01

survivability due to individual heterosis of crossbred lambs over purebred lambs is well documented in the literature (Dickerson et al., 1975; Dickerson and Glimp, 1975; Nitter, 1978). Lambs sired by FxR had virtually the same average weights as lambs sired by WF rams at both 60 d and 120 d; and, survivability from 60 to 120 d was only slightly higher for 1/4Fx lambs. Therefore, the 4 kg average superiority in litter weight of ewes sired by FxR rams ($P<.05$) was due primarily to improved survivability resulting from individual heterosis.

Breed Group of Ewe Effects

Variation due to B was largely due to higher levels of performance from T ewes for all traits except S60 and S120 (tables 6 and 7). Lambs from T ewes had heavier WT60 and WT120 than lambs from R ($P<.01$), but were similar to lambs from C ewes. But, the superiority in LW120 d per ewe lambing (6 kg, $P<.01$) over both C and R was due mostly to higher prolificacy.

Other Main Effects

Year (Y) affected LW60 ($P<.01$) and all progeny traits ($P<.05$) except S120 (table 4). Age of ewe (A) affected ($P<.01$) reproductive and weight traits as well as S60 ($P<.01$). Prolificacy and composite traits (litter size and weight) increased to 5 yr of age followed by a slight decline at age 6 yr. Largest differences occured between age 2 and subsequent ages. Ewes lambing at 5 yr of age weaned 20 kg more lamb at 120 d than 2-yr-old ewes ($P<.01$) due mostly to higher prolificacy (.47 lambs, $P<.01$). Birth weight increased steadily to age

6 yr; however, WT60 and WT120 were highest for lambs from 4-yr-old ewes and declined thereafter.

The only interactions affecting BWT were BxY and SxY (P<.05) and no trend was evident. Regression on birth date was highly significant for BWT (.03 kg/d), resulting perhaps from both differences in gestation lengths and a longer time on high plane of nutrition for ewes lambing late in the season.

Ewe Lamb and Progeny Peformance in Phase II

Fertility and Prolificacy

Early sexual developement is reflected in fertility at 7 months of age with lambing at 1 yr of age. Out of 143 exposures over 4 yr only two ewes from WF breed groups lambed at 1 yr of age, compared to 55 out of 146 from 1/4Fx breed groups over the same period (1.3% vs 37.7%, P<.01). Superiority of 1/4Fx ewes over WF breeds and breed crosses for early sexual development has been reported previously in the literature ranging from 7% to 24% fertility for ewe lambs under semi-intensive management (Thomas and Whiteman, 1979; Oltenacu and Boylan, 1981a), and up to 52% on western range (Ercanbrack and Knight, unpublished data). Year affected fertility (P<.01), but was not significant for prolificacy (table 8). Levels of fertility ranged from 16% in 1977 to 57% in 1976. Although B was not significant, Rambouillet crosses exceeded the other two breeds for both traits (table 9). BxY interaction approached significance for prolificacy. Ercanbrack and Knight (unpublished data) found Finn x Columbia ewe lambs to be inferior in fertility (P<.05), 77.7% vs. 85.9% and 86.5%,

for Finn x Rambouillet and Finn x Targhee, respectively; but they found no significant differences in prolificacy.

TABLE 9. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE II Fx EWE LAMB REPRODUCTIVE TRAITS (1976 - 1979)

	Fertility		Prolificacy	
Breed of dam	N	Mean, %	N	Mean
		NS		NS
Columbia (C)	42	41.7 ± 8.2	16	1.04 ± .10
Rambouillet (R)	50	45.5 ± 6.9	21	1.14 ± .07
Targhee (T)	54	39.2 ± 7.1	18	1.13 ± .07
Mean	146	42.1 ± 4.3	55	1.10 ± .05

NS, non-significant (P>.10)

Progeny Performance

Mean squares from analyses of variance and least-squares means by breed of ewe for individual progeny traits are presented in tables 10 and 11, respectively. Breed of ewe approached significance for BWT due to larger lambs from (FxR)xT ewes. These results are in agreement with results found in Phase I of this study, where straightbred T ewes produced larger lambs at birth than either R or C (P<.01, table 7). For both WT60 and WT120 B was not significant, contrary to Phase I where lambs from T ewes were heavier at both ages (P<.01). Dickerson (1977) reported that the superiority of purebred T lambs over R lambs was transmitted to crossbred lambs from T and R dams, although in neither case were differences significant.

Type of birth/rearing affected BWT (P<.01) and WT60 (P<.01), but did not significantly affect WT120. Nevertheless, lambs reared as singles were 5 kg heavier than twins. Quadratic regression on birth

weight influenced WT120 (P<.01), indicating perhaps that lambs with heavier BWT had poorer subsequent performance to weaning due perhaps to more difficult births.

TABLE 10. MEAN SQUARES FROM ANALYSES OF VARIANCE FOR PHASE II INDIVIDUAL PROGENY TRAITS FROM Fx EWE LAMBS (1976 - 1979)[a]

Source	df	BWT, kg	WT60, kg	WT120, kg
Breed of dam (B)	2	.853+	.048	10.3**
Year (Y)	3	.455	3.591	73.4**
Sex (X)	1	1.496*	.481	19.0+
Type of birth/ rearing (BR)[b]	1(2)	11.635**	13.045*	10.9
Regressions				
BDT (linear)	1	.215	62.437**	44.1**
BWT (linear)	1	---	21.746*	48.5**
BWT (quad.)	1	---	7.375	101.0**
Error MS		.359	3.745	6.4
Error df		52	41	38

[a] BWT, birth weight; WT60, weight at 60 d; WT120, weight at 120 d.
[b] degrees of freedom in parenthesis belong with models for WT60 and WT120.
+ P<.10
* P<.05
** P<.01

TABLE 11. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE II INDIVIDUAL PROGENY TRAITS FROM Fx EWE LAMBS (1976 - 1979)[a]

	BWT		WT60		WT120	
Breed of ewe[b]	N	Mean, kg	N	Mean, kg	N	Mean, kg
		+		NS		NS
(FxR) x C	17	3.73 ± .17	16	21.8 ± .5	15	36.1 ± .8
(FxR) x R	24	4.10 ± .14	21	21.8 ± .6	20	38.0 ± .9
(FxR) x T	20	4.15 ± .15	16	21.9 ± .5	15	37.5 ± .8
Mean	61	3.99 ± .10	53	21.8 ± .3	50	37.2 ± .6

[a] BWT, birth weight; WT60, weight at 60 d; WT120, weight at 120 d.
[b] C = Columbia, F = Finn, R = Rambouillet, T = Targhee.
NS, non-significant (P>.10)
+ P<.10

A limited amount of data prevented the utilization of least-squares methods for analysis of survivability. Out of 61 lambs born, 53 survived to approximately 60 d and 50 survived to approximately 120 d of age. Lambs from C ewes had the highest S60 rates (94%) followed by R (88%) and T (80%). One lamb from each breed group died between 60 and 120 d.

Composite Traits

Composite traits for 1/4Fx ewe lamb reproductive performance are reported in tables 8 and 12. Breed of ewe was non-significant for litter size and weight at both 60 d (mid-lactation) and 120 d (weaning) per ewe exposed, reflecting the lack of B effects for fertility, prolificacy, and individual lamb weights. Year affected all four composite traits ($P<.01$). In 1977 litter weight per ewe exposed was 17 kg lighter than the previous year.

TABLE 12. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE II Fx EWE LAMB COMPOSITE REPRODUCTIVE TRAITS PER EWE EXPOSED (1976 - 1979)[a]

Breed of dam	N	LS60	LW60	LS120	LW120
		NS	NS	NS	NS
Columbia (C)	42	.42 ± .08	9.5 ± 1.8	.40 ± .08	14.6 ± 2.8
Rambouillet (R)	50	.45 ± .07	9.4 ± 1.5	.40 ± .07	14.4 ± 2.4
Targhee (T)	54	.36 ± .07	7.8 ± 1.6	.35 ± .07	12.9 ± 2.4
Mean	146	.41 ± .04	8.9 ± .9	.38 ± .04	14.0 ± 1.5

[a] LS60, litter size at 60 d; LW60, litter weight at 60 d; LS120, litter size at 120 d; LW120, litter weight at 120 d.
NS, non-significant ($P>.10$)

Mature Ewe and Progeny Performance in Phase II

Breed Group of Ewe Effects

Means squares from analysis of variance for reproductive and composite traits of mature ewes (ages 2 through 6 yr) are presented in Table 8. Mean squares for weight and survivability of progeny from mature ewes is presented in Table 15.

While large differences in fertility existed between 1/4Fx and WF ewe lambs, B was not a significant source of variation in the model for fertility in mature ewes (table 13). Breed groups with 1/4Fx breeding had higher levels ($P<.01$) of prolificacy than WF breed groups, averaging at .36 more lambs per ewe lambing for ages 2 through 6 yr (table 14). Superiority of 1/4Fx for prolificacy was pronounced at all ages with no evident decline in superiority with increasing age of ewe (table 14). Dickerson (1977) and Ercanbrack and Knight (unpublished data) reported average 1/4Fx superiority over WF breeds on western range to be .24 (ages 2 through 5 yr) and .38 (ages 2 through 7 yr) lambs per ewe lambing, respectively; and the magnitude of the difference remained constant at all ages. Research involving 1/2Fx ewes has shown greater superiority in prolificacy than results for 1/4Fx, but no trend of increasing differences with increasing age (Donald et al., 1968; Land et al., 1974; Barker, 1975; Oltenacu and Boylan, 1981).

Birth weight for lambs from 1/4Fx mature dams were .63 kg lighter ($P<.01$) than lambs from WF dams (tables 15 and 16). Lighter BWT would be expected due to larger litter sizes; however, when type of birth

TABLE 13. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR FERTILITY OF PHASE II MATURE EWES (1976 - 1982)

Breed Group[a]	Age of ewe at time of lambing									
	2 yr		3 yr		4 yr		5 yr		6 yr	
	N	Mean, %	N	Mean, %	N	Mean, %	N	Mean, %	N	Mean, %
C	44	94.9 ± 5.0	37	90.7 ± 5.6	33	103.6 ± 6.2	20	96.8 ± 7.7	10	107.4 ±10.5
R	43	89.0 ± 5.1	38	102.6 ± 5.5	38	102.3 ± 5.7	22	98.3 ± 7.2	13	112.2 ± 9.5
T	51	91.2 ± 4.7	41	108.4 ± 5.1	41	98.9 ± 5.3	29	99.3 ± 6.6	15	94.4 ± 8.9
WF mean	138	91.7 ± 2.8	116	100.6 ± 3.1	112	101.6 ± 3.3	71	98.1 ± 4.1	38	104.7 ± 5.5
(FxR) x C	43	99.7 ± 5.3	34	96.5 ± 5.8	30	91.3 ± 6.5	18	95.8 ± 8.4	8	77.8 ±11.9
(FxR) x R	46	89.5 ± 5.2	42	105.8 ± 5.2	36	108.8 ± 5.6	29	87.5 ± 6.7	16	76.7 ± 9.4
(FxR) x T	52	101.1 ± 4.8	51	83.8 ± 4.9	47	90.3 ± 5.3	32	92.1 ± 6.6	16	96.5 ± 9.1
1/4Fx mean	141	96.8 ± 2.9	127	95.4 ± 3.0	113	96.8 ± 3.3	79	91.8 ± 4.1	40	83.7 ± 5.7
Mean	279	94.5 ± 2.3	243	97.8 ± 2.4	225	99.3 ± 2.5	150	94.8 ± 3.1	78	95.4 ± 4.1

[a] C, Columbia; R, Rambouillet; T, Targhee; F, Finn; breed of sire listed first.

Table 14. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PROLIFICACY OF PHASE II MATURE EWES (1976 - 1982).

Breed Group[a]	Age of ewe at time of lambing									
	2 yr		3 yr		4 yr		5 yr		6 yr	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
C	40	.99 ± .08	31	1.24 ± .10	32	1.39 ± .10	18	1.34 ± .13	10	1.50 ± .17
R	37	1.12 ± .09	36	1.16 ± .09	35	1.40 ± .09	19	1.50 ± .12	13	1.43 ± .15
T	43	1.14 ± .08	41	1.34 ± .09	39	1.45 ± .09	27	1.76 ± .11	14	1.75 ± .14
WF mean	120	1.08 ± .05	108	1.25 ± .05	106	1.41 ± .05	64	1.54 ± .07	37	1.56 ± .09
(FxR) x C	41	1.48 ± .09	31	1.65 ± .10	26	1.67 ± .10	16	1.81 ± .13	6	2.18 ± .21
(FxR) x R	38	1.44 ± .09	39	1.58 ± .09	35	1.79 ± .09	23	1.81 ± .11	13	1.80 ± .14
(FxR) x T	50	1.43 ± .08	41	1.72 ± .09	42	1.67 ± .09	30	1.73 ± .09	15	1.83 ± .14
1/4Fx mean	129	1.45 ± .05	111	1.65 ± .05	103	1.71 ± .05	69	1.78 ± .07	34	1.94 ± .09
Mean	249	1.27 ± .04	219	1.45 ± .04	209	1.56 ± .04	133	1.66 ± .06	71	1.75 ± .08

[a] C, Columbia; R, Rambouillet; T, Targhee; F, Finn; breed of sire listed first.

was included in the model BWT for lambs from 1/4Fx dams remained smaller by .34 kg (P<.01). Results were in agreement with Bradford (1972) who found BWT for Finn lambs to be small relative to mature ewe size after adjustment for type of birth. But results do not agree with Ercanbrack and Knight (unpublished data) who found no significant differences in BWT between 1/4Fx and and WF breeds when unadjusted for type of birth.

Despite lighter BWT, lambs from 1/4Fx dams had .6 and .7 kg heavier (non-significant) WT60 and WT120, respectively, than lambs from WF breeds (table 16). When type of birth/rearing was included in the model the differences increased to 1.3 and 1.5 kg for WT60 and WT120, respectively (P<.01). Oltenacu and Boylan (1981) found a significant adjusted weight superiority of 1.6 kg for lambs from 1/4Fx over WF breeds at approximately 70 d of age. Dickerson (1977) reported unadjusted lamb weights from 1/4Fx dams to be .4 kg heavier at 105 d of age than those from WF breeds (non-significant). In disagreement with these findings, Thomas and Whiteman (1979) found unadjusted lamb weaning weights from 1/4Fx dams to be 1.5 kg less than Dorset x Rambouillet, but when type of birth/rearing was included in the model no significant differences were evident. Amounts of Finn breeding in excess of 1/4 have lowered unadjusted weaning weights by 1.1 to 3.5 kg, and have had no significant effects when adjusted for type of birth/rearing (Donald et al., 1968; Barker, 1975; Dickerson, 1977).

Lambs from 1/4Fx dams had 7.6% (P<.01) greater S60 when quadratic regression on BWT was included in the model (table 16). Even though BWT were smaller for lambs with Finn breeding and smaller BWT cause

TABLE 15. MEAN SQUARES FROM ANALYSES OF VARIANCE FOR PHASE II MATURE EWE PROGENY TRAITS (1977 - 1982)[a]

Source	df	BWT, kg	S60	WT60, kg	S120	WT120, kg
Breed of dam (B)	5	3.88**	.384**	45.2**	.051	63.7**
Breed of sire (S)	1	19.35**	.204	55.8**	.105**	6.4
Year (Y)	5	5.41**	1.267**	407.4**	.280**	690.4**
Age of dam (A)	4	2.15**	.020	18.2*	.033	50.5**
Sex (X)	1	39.20**	.515*	3.8	.036	88.3**
Type of birth/ rearing (BR)	2(4)	95.49**	.273+	250.5**	.028	746.5**
A x BR	7	1.02	.170	11.1+	.063	27.5**
Regressions						
BDT (linear)	1	5.66**	--	1631.6**	--	991.5**
BDT (quad.)	1	2.30**	--	--	--	--
BWT (linear)	1	--	5.265**	1400.6**	--	1946.8**
BWT (quad.)	1	--	2.338**	72.4**	--	35.1+
Error MS		.48	.104	7.5	.047	13.7
Error df		1268	1268	1069	1072	952

[a] BWT, birth weight; S60, survival to 60 d; WT60, weight at 60 d; S120, survival to 120 d; WT120, weight at 120 d.

\+ P<.10

* P<.05

** P<.01

TABLE 16. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR INDIVIDUAL LAMB PERFORMANCE FROM DAMS AGES 2 THROUGH 6 (1977 - 1982)[a]

	BWT		S60	WT60		S120	W120	
Breed of dam[b]	N	Mean, kg	Mean, %	N	Mean, kg	Mean, %	N	Mean, kg
		**	**		**	NS		**
Columbia (C)	158	4.14 ± .14	86.0 ± 3.6	125	20.2 ± .5	95.3 ± 3.7	117	33.1 ± .6
Rambouillet (R)	175	4.53 ± .13	86.6 ± 3.4	143	20.7 ± .6	87.4 ± 3.4	123	33.0 ± .8
Targhee (T)	229	4.37 ± .08	92.2 ± 3.2	199	21.5 ± .4	93.9 ± 5.6	180	34.7 ± .6
WF mean	562	4.35 ± .08	88.3 ± 2.0	467	20.8 ± .3	92.5 ± 2.6	420	33.6 ± .4
(FxR) x C	195	3.84 ± .08	97.6 ± 3.3	166	22.3 ± .4	92.6 ± 4.9	145	35.4 ± .6
(FxR) x R	249	4.08 ± .07	97.1 ± 3.0	224	22.1 ± .4	94.2 ± 3.2	199	34.8 ± .5
(FxR) x T	290	4.12 ± .07	92.9 ± 3.1	241	21.9 ± .4	87.5 ± 4.0	219	35.1 ± .5
1/4Fx mean	734	4.01 ± .04	95.9 ± 1.8	631	22.1 ± .2	91.8 ± 2.3	563	35.1 ± .3
Overall mean	1296	4.18 ± .03	92.1 ± 1.5	1098	21.5 ± .2	92.2 ± 2.2	983	34.4 ± .2

[a] BWT, birth weight; S60, survival to 60 d; WT60, weight at 60 d; S120, survival to 120 d; WT120, weight at 120 d.

[b] Crosses designated with letters, breed of sire first; F = Finn.

NS, non-significant (P>.10)

* P<.05

** P<.01

decreased survivability (Purser and Young, 1964), lambs from 1/4Fx dams had 4.6% ($P<.05$) greater S60 when the quadratic regression on BWT was removed from the model. Regressions on BWT were not significant and were not included in the model for S120. Breed of ewe effects were not significant; lambs from WF breeds having slightly better S120. Results in this study for S60 are in disagreement with previous studies which found lambs from 1/4Fx dams to have similar survivability with standard purebreds and crossbreds (Dickerson, 1977; Oltenacu and Boylan, 1981; Cochran et al., 1982; Ercanbrack and Knight, unpublished data).

Average LS60 (mid-lactation) per ewe exposed of 1/4Fx breed groups exceeded the WF breed average for ages 2 through 6 (table 17), resulting in an overall difference of .24 lambs per ewe exposed ($P<.01$). Largest differences occurred at age 2 yr where 1/4Fx ewes reared .46 more lambs. Superiority of 1/4Fx declined for 5 and 6-yr-old ewes primarily due to number of lambs reared by T ewes increasing with age. Targhee ewes exceeded R and C at all ages and 1/4Fx average at 5 and 6 yr of age, although not significantly. LS60 rather than individual lamb weights was mostly responsible for 1/4Fx superiority for LW60 per ewe exposed (table 18). Weights were not adjusted for sex, age of lamb, or type of birth/rearing. Averaged across ages 2 through 6 yr, 1/4Fx exceeded WF breeds by 3.9 kg ($P<.01$). The largest difference occurred at age 2 yr (8.2 kg), and the smallest at age 6 yr (1.4 kg).

TABLE 17. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR LITTER SIZE AT 60 DAYS PER EWE EXPOSED (LS60, 1977 - 1982)

	Age of ewe at time of lambing									
	2 yr		3 yr		4 yr		5 yr		6 yr	
Breed Group[a]	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Columbia (C)	44	.68 ± .10	37	.97 ± .11	33	1.14 ± .12	20	1.09 ± .15	10	1.20 ± .21
Rambouillet (R)	43	.79 ± .10	38	.94 ± .11	38	1.09 ± .11	22	1.12 ± .14	13	1.03 ± .19
Targhee (T)	51	.86 ± .10	41	1.19 ± .11	41	1.17 ± .11	29	1.47 ± .13	15	1.50 ± .17
WF mean	138	.77 ± .06	116	1.03 ± .06	112	1.13 ± .06	71	1.23 ± .08	38	1.24 ± .11
(FxR) x C	43	1.25 ± .11	34	1.32 ± .12	30	1.12 ± .13	18	1.58 ± .16	8	1.46 ± .24
(FxR) x R	46	1.17 ± .10	42	1.44 ± .11	36	1.58 ± .11	29	1.24 ± .13	16	1.30 ± .17
(FxR) x T	52	1.30 ± .10	51	1.25 ± .10	47	1.29 ± .10	32	1.33 ± .12	16	1.25 ± .17
1/4Fx mean	141	1.24 ± .06	127	1.34 ± .06	113	1.33 ± .06	79	1.38 ± .08	40	1.34 ± .11
Overall mean	279	1.01 ± .05	243	1.19 ± .05	225	1.23 ± .05	150	1.31 ± .06	78	1.29 ± .09

[a] Crosses designated with letters, breed of sire first, F = Finn.

TABLE 18. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR LITTER WEIGHT AT 60 DAYS PER EWE EXPOSED (LW60, 1977 - 1982)

	Age of ewe at time of lambing									
	2 yr		3 yr		4 yr		5 yr		6 yr	
Breed Group[a]	N	Mean, kg	N	Mean, kg	N	Mean, kg	N	Mean, kg	N	Mean, kg
Columbia (C)	44	13.7 ± 2.0	37	20.8 ± 2.2	33	25.4 ± 2.3	20	24.0 ± 3.0	10	25.0 ± 4.1
Rambouillet (R)	43	18.5 ± 2.0	38	21.8 ± 2.2	38	26.4 ± 2.2	22	21.3 ± 2.8	13	21.7 ± 3.7
Targhee (T)	51	18.9 ± 1.9	41	29.0 ± 2.1	41	27.7 ± 2.1	29	30.2 ± 2.5	15	31.6 ± 3.4
WF mean	138	17.0 ± 1.1	116	23.9 ± 1.3	112	26.5 ± 1.3	71	25.2 ± 1.6	38	26.1 ± 2.1
(FxR) x C	43	25.5 ± 2.0	34	27.3 ± 2.3	30	24.8 ± 2.5	18	29.9 ± 3.1	8	30.9 ± 4.6
(FxR) x R	46	23.1 ± 2.0	42	29.5 ± 2.1	36	32.5 ± 2.2	29	27.2 ± 2.5	16	27.1 ± 3.4
(FxR) x T	52	26.9 ± 1.9	51	25.8 ± 1.9	47	28.1 ± 2.0	32	30.8 ± 2.4	16	24.6 ± 3.4
1/4Fx mean	141	25.2 ± 1.1	127	27.5 ± 1.2	113	28.5 ± 1.3	79	29.3 ± 1.5	40	27.5 ± 2.1
Overall mean	279	21.1 ± 1.0	243	25.7 ± 1.1	225	27.5 ± 1.2	150	27.0 ± 1.4	78	26.8 ± 2.0

a Crosses designated with letters, breed of sire first; F = Finn.

TABLE 19. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE II LITTER SIZE AT 120 DAYS PER EWE EXPOSED (LS120, 1977 - 1982)

	Age of ewe at time of lambing									
	2 yr		3 yr		4 yr		5 yr		6 yr	
Breed Group[a]	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Columbia (C)	44	.69 ± .10	37	.91 ± .11	33	1.03 ± .12	20	1.03 ± .15	10	1.15 ± .21
Rambouillet (R)	43	.73 ± .10	38	.88 ± .11	38	1.05 ± .11	22	.93 ± .14	13	.91 ± .19
Targhee (T)	51	.84 ± .10	41	1.11 ± .11	41	1.11 ± .11	29	1.35 ± .13	15	1.32 ± .17
WF mean	138	.75 ± .06	116	.97 ± .06	112	1.06 ± .06	71	1.10 ± .07	38	1.13 ± .11
(FxR) x C	43	1.11 ± .10	34	1.22 ± .11	30	1.07 ± .12	18	1.33 ± .16	8	1.30 ± .23
(FxR) x R	46	1.06 ± .10	42	1.36 ± .11	36	1.44 ± .11	29	1.18 ± .13	16	1.20 ± .17
(FxR) x T	52	1.16 ± .10	51	1.17 ± .10	47	1.18 ± .10	32	1.28 ± .12	16	1.21 ± .17
1/4Fx mean	141	1.11 ± .06	127	1.25 ± .06	113	1.23 ± .06	79	1.26 ± .07	40	1.24 ± .11
Overall mean	279	.93 ± .05	243	1.11 ± .05	225	1.15 ± .05	150	1.18 ± .06	78	1.18 ± .09

a Crosses designated with letters, breed of sire first; F = Finn.

TABLE 20. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE II LITTER WEIGHT AT 120 DAYS PER EWE LAMBING (LW120, 1977 - 1982)

	Age of ewe at time of lambing									
	2 yr		3 yr		4 yr		5 yr		6 yr	
Breed Group[a]	N	Mean, kg	N	Mean, kg	N	Mean, kg	N	Mean, kg	N	Mean, kg
Columbia (C)	44	24.3 ± 2.8	37	30.5 ± 3.1	33	35.9 ± 3.3	20	37.2 ± 4.2	10	40.5 ± 5.8
Rambouillet (R)	43	26.8 ± 2.9	38	31.9 ± 3.1	38	38.5 ± 3.1	22	34.1 ± 4.0	13	34.3 ± 5.1
Targhee (T)	51	28.5 ± 2.7	41	41.0 ± 2.9	41	39.0 ± 3.0	29	46.7 ± 3.5	15	44.3 ± 4.8
WF mean	138	26.5 ± 1.6	116	34.5 ± 1.7	112	37.8 ± 1.8	71	39.3 ± 2.2	38	39.7 ± 3.0
(FxR) x C	43	36.7 ± 2.9	34	40.2 ± 3.2	30	37.2 ± 3.5	18	42.9 ± 4.4	8	41.2 ± 6.4
(FxR) x R	46	33.3 ± 2.8	42	42.9 ± 2.9	36	44.5 ± 3.1	29	39.8 ± 3.6	16	40.1 ± 4.7
(FxR) x T	52	38.0 ± 2.7	51	37.7 ± 2.7	47	39.1 ± 2.8	32	44.4 ± 3.3	16	39.5 ± 4.8
1/4Fx mean	141	36.0 ± 1.6	127	40.3 ± 1.7	113	40.3 ± 1.8	79	42.4 ± 2.1	40	40.3 ± 3.0
Overall mean	279	31.1 ± 1.4	243	37.4 ± 1.5	225	39.1 ± 1.6	150	40.9 ± 2.0	78	40.0 ± 2.8

a Crosses designated with letters, breed of sire first; F = Finn.

Trends established for LS60 and LW60 continued through weaning due primarily to no significant effect on S120 due to breed of ewe. Average mature 1/4Fx superiority for LS120 and LW120 per ewe exposed was .22 lambs ($P<.01$) and 4.3 kg ($P<.01$), respectively. These results represent an average increase, due to 1/4Fx breeding, in LS120 and LW120 of 22% and 12%, respectively. Ercanbrack and Knight (unpublished data) found incorporation of 1/4Fx breeding into the same WF breed groups as involved in this study to increase litter weight at weaning by 8.3 kg (24%) on average for ewes 2 to 7 yr of age. Other studies have reported only slight, non-significant 1/4Fx superiority for mature ewes (Dickerson, 1977; Thomas and Whiteman, 1979; Magid et al., 1981b).

Age of Ewe and Interaction Effects.

Although age of ewe (A) was not a significant source of variation in the model for fertility, the BxA interaction was important ($P<.01$). At 2 yr of age 1/4Fx breed groups had slightly higher fertility than WF breeds, but this difference was reversed at 3 yr of age. Superiority of WF ewes continued to increase at subsequent ages (table 13). In contrast, previous research has indicated no significant declines in Fx fertility at later ages, rather Fx fertility is nearly identical to standard breeds at all ages past 1 yr (Barker, 1975; Maijala and Osterberg, 1977; Thomas and Whiteman, 1979; Magid et al., 1981; Ercanbrack and Knight, unpublished data).

Age of ewe significantly affected prolificacy and composite traits (table 8). Average litter sizes at birth increased steadily from 2 to

6 yr of age, resulting in a difference of .5 lambs per ewe lambing between the two ages (P<.01, table 13). Effects due to A on composite traits for LS60 and LS120 per exposed resulted primary from A effects on prolificacy as A had no effect on fertility and S60 and S120. Breed of ewe x age of ewe interaction approached significance for LS60 (P<.10) due to combining fluctuations in prolificacy and S60 of 4-yr-old (FxR)xC and (FxR)xR, as well as a steady overall improvement of T ewe performance from age 2 to 6 yr. Breed of ewe x age of ewe effects on LW60 was due to LS60 rather than BxA effects on individual lamb weights. Analysis of combined 1/4Fx breed groups vs. WF breed groups indicates no BxA interaction.

Birth weight, adjusted for type of birth, also increased with each yr in age resulting in lambs from 6-yr-old ewes weighing on average .6 kg heavier than those from 2-yr-olds. Age of ewe also affected individual WT60 and WT120 (P<.01). Contrary to BWT, lamb weights increased with age of ewe up to 3 yr old then declined with increasing age. These results are in agreement with Dickerson et al. (1975) who found a strong curvilinear relationship between age of ewe with 4 and 10 wk lamb weights. Age of ewe affected LW60 and LW120 per ewe exposed (P<.01), and largely reflected differences between 2-yr-old and older ewes due to the conflicting effects of age on the components of litter weight in older ewes. Average LW60 and LW120 of 3 to 6-yr-old ewes exceeded 2-yr-olds by 6 and 8 kg, respectively (tables 18 and 20).

Age of ewe x type of birth/rearing affected WT120 (P<.01) and approached significance for WT60 (P<.10). Interaction effects were due

primarily to weight fluctuations for lambs born as triplets and reared as singles or twins. Lamb numbers in these categories were small. Effect of A on singles reared as singles and twins reared as twins was nearly identical.

Breed Group of Sire Effects

Due to utilization of FxT rams in addition to Suffolk rams commencing in the fall of 1980, breed of sire effects were included in all models for mature ewe reproductive and individual progeny traits (table 21). In Phase I, FxR-sired lambs did not show significantly heavier BWT, WT60, or WT120 than WF-sired lambs. But in comparison to Suffolks, FxT-sired lambs had lighter BWT ($P<.01$) and WT60 ($P<.01$), but only .5 kg lighter WT120. Oltenacu and Boylan (1981b) found Finn x Suffolk dams bred to Suffolk rams produced heavier BWT (+.3 kg, $P<.05$) but not significantly heavier weaning weights at 70 d of age than when bred to Finn rams. Dickerson et al. (1975) found Fx lambs to have lighter BWT (.8 kg) and lighter weaning weight at 70 d (1.4 Kg.) than Suffolk cross lambs.

Ewes exposed to FxT rams had higher fertility ($P<.01$) and higher prolificacy ($P<.10$) than ewes exposed to Suffolk rams, indicating superior fertilization rates and/or lower embyro mortality in ewes exposedto FxT rams. Due to confounding of SxY additional analyses of fertility and prolificacy were conducted including only the yr 1981 and 1982. Ewes sired by FxT rams in these two years had 13% higher fertitlity than Suffolk-sired ewes ($P<.01$), but were 9% less prolific ($P<.10$). Previous research by Land et al. (1974) found no differences

in fertility or prolificacy between ewes bred to either Finn or Tasmanian Merino rams. Litters sired by FxT were heavier at 60 d per ewe exposed (P<.01) than those sired by Suffolk primarily as result of superior fertility. Due to lower S60 (non-significant) and S120

TABLE 21. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE II MATURE EWE PRODUCTION AND INDIVIDUAL LAMB PERFORMANCE BY BREED GROUP OF SIRE (1976 - 1982)

	Finn x Targhee		Suffolk	
Trait	N	Mean	N	Mean
Ewe production				
Fertility, % **	171	103.0 ± .03	804	89.8 ± .01
Prolificacy +	169	1.49 ± .06	712	1.58 ± .04
Litter size at 60 +	171	1.26 ± .07	804	1.14 ± .03
Litter weight at 60, kg **	171	28.7 ± 1.3	804	22.6 ± .7
Litter size at 120 *	171	1.16 ± .07	804	1.06 ± .03
Litter weight at 120, kg NS	171	37.2 ± 1.9	804	35.3 ± 1.0
Lamb performance				
Birth weight **	234	3.87 ± .08	1062	4.28 ± .06
Survival to 60 NS	234	94.1 ± .3	1062	97.3 ± .2
Weight at 60 **	214	20.9 ± .4	884	21.7 ± .3
Survival to 120 NS	214	97.2 ± .3	884	99.7 ± .3
Weight at 120 NS	196	33.5 ± .6	787	33.8 ± .5

NS, non-significant (P>.10)
\+ P<.10
* P<.05
** P<.01

(non-significant) of FxT sired lambs, average FxT sired litter weights at 120 d was only 1.9 kg heavier (non-significant). Lower lamb viability due to increased Finn breeding found in this study is not in agreement with previous research. Dickerson et al. (1975) found Suffolk sired crossbred lambs to have 5% lower survivability (non-significant) than Finn sired crossbred lambs. Magid et al. (1981)

reported Finn sired to exceed Border Leicester sired crossbred lambs by 12% in survivability.

Other Main Effects

Year effects (Y) for fertility (P<.05), prolificacy (P<.01), and lamb weights (P<.01) contradict previous research which found Y effects for prolificacy and individual lamb performance traits, but no significant Y effects for fertility (Magid et al., 1981; Ercanbrack and Knight, unpublished data). Year effect were also found for LW60 (P<.01) and approached significance for LW120. Sex effects were significant for BWT, S60, and WT120 (table 14). Male lambs had .3 kg and .6 kg heavier BWT and WT120, respectively, than females; however, S60 was 4% lower for males. Similar results for birth and weaning weight have been reported in studies involving lambs from Fx ewes, but differences in survivability have been non-significant (Magid et al., 1981b; Oltenacu and Boylan, 1981a; Ercanbrack and Knight, unpublished data).

Wool Production

Grease Fleece Weight

Significant sources of variation for grease fleece weight (FLWT) of Phase II ewes ages 1 through 6 yr included breed of dam (B), breed group of sire (S), year (Y), age (A), and SxA interaction (table 22). Ewes sired by WF rams had .4 kg heavier FLWT than FxR-sired ewes (P<.01, table 23). These results are in close agreement with the study by Ercanbrack and Knight (unpublished data) which involved the same

dam breed groups and similar sire breed groups. In that study FLWTs of 1/4Fx ewes were .5 kg lighter (P<.05) than WF ewes for ages 1 through 7 yr. Larger difference were reported by Dickerson (1977) with similar

TABLE 22. MEAN SQUARES FROM VARIANCE ANALYSES FOR EWE WOOL PRODUCTION TRAITS (1976 - 1982)

Source	df	Grease weight	Fleece grade	Staple length
Breed of dam (B)	2	3.84*	51.95**	1.674*
Breed of sire (S)	1	21.68**	15.99**	.595
Years (Y)	6	66.29**	9.10**	21.971**
Age (A)	5	28.63**	12.87**	2.361**
BxS	2	2.39	22.16**	1.487*
BxY	12	.83	1.44*	.742*
SxY	6	2.10+	5.03**	1.241**
SxA	5	10.05**	1.13	.684
Remainder	1224	1.10	.75	.383

\+ P<.10
* P<.05
** P<.01

TABLE 23. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR PHASE II WOOL CHARACTERS, AGES 1 TO 6 (1976 - 1982)

Breed group[c]	N	Grease weight	Grade[a]	Length[b]
		Mean, kg	Mean	Mean
Columbia (C)	188	4.07 ± .12	2.75 ± .10	1.42 ± .07
Rambouillet (R)	199	3.80 ± .10	1.18 ± .09	1.16 ± .06
Targhee (T)	231	3.75 ± .09	1.74 ± .08	1.10 ± .05
WF mean	618	3.87 ± .07	1.89 ± .06	1.23 ± .04
(FxR) x C	175	3.63 ± .12	2.54 ± .10	1.35 ± .07
(FxR) x R	219	3.27 ± .09	1.79 ± .08	1.25 ± .06
(FxR) x T	252	3.51 ± .10	2.37 ± .08	1.28 ± .06
1/4Fx mean	646	3.47 ± .07	2.23 ± .06	1.29 ± .04

[a] Fleece grades coded 1 to 5: Fine (1), 1/2 blood (2), 3/8 blood (3), 1/4 blood (4), low 1/4 blood (5)
[b] Staple length coded 1 to 3: Staple (1), French (2), Clothing (3)
[c] Crosses designated by letters, breed of sire first, Finn (F)

breed groups. Average FLWT for WF ewes exceeded 1/4Fx ewes by 1.1 kg for ages 1 and 2 yr. Studies involving comparisons of 1/2Fx and 1/4Fx ewes with other breeds have shown Fx ewes to have FLWT ranging from 0 to 1.5 kg (average .5 kg) less than standard breeds (Cedillo et al., 1977; Dahmen et al., 1978; Magid et al., 1981b; Oltenacu and Boylan, 1981b).

No SxA effects were reported in the literature cited above; however, in this study, SxA was an important effect ($P<.01$). At 1 yr of age 1/4Fx ewes had .7 kg heavier FLWTs than WF ewes, and at 2 yr FLWTs were similar. WF superiority for FLWT increased to 5 yr of age, then showed a slight decline for 6-yr-old ewes. FLWT for 1/4Fx 2-yr-old ewes was similar to WF ewes ages 2 through 6 yr. Superiority of WF ewes for ages 2 through 6 yr largly reflected a decline in 1/4Fx FLWTs with age.

Effects due to breed of dam followed normal breed characteristics with C ewes having the heaviest FLWT and T and R being comparable. BxS, BxY, and SxY interactions were not significant ($P>.05$).

Fleece Grade

Fleeces from 1/4Fx were about 1/3 of a blood count coarser than those from WF ewes ($P<.01$, table 23). B also affected fleece grade in the expected manner with C ewes averaging in the 3/8 blood range, T in the 1/2 blood range, and R grading close to Fine. Fleeces from (FxR)xC ewes graded similarily to straightbred C, but were a half a blood count coarser than the finer wooled R and T. Results are in close agreement the study by Ercanbrack and Knight (unpublished data) which

involved the same dam breed groups. The resulting BxS interaction ($P<.01$) indicates crossbreeding with rams possessing characteristically coarser fleeces than dam breeds will lower fleece grades; however, crossbreeding with ewes of similar fleece grades has no effect. Cedillo et al. (1977) found no difference in fleece grades between ewes from Columbia and Suffolk dams crossed with either Dorset, Cheviot, Romney or Finn, all of which have approximately 3/8 blood fleece grades.

BxY and SxY were important ($P<.05$) in the model for fleece grades, but no trends were evident. Unlike FLWT, SxA was not a significant interaction for grades (table 22). But, age effects were present ($P<.01$), and due largely to differences between yearlings and mature ewes. These results are in agreement with previous research indicating affects due to age but no breed x age interactions (Dahmen et al., 1978; Ercanbrack and Knight, unpublished data).

Staple Length

In agreement with previous reports in the literature involving similar sire and dam breeds (Dahmen et al., 1978; Drummond et al., 1982), S did not significantly affect staple (fiber) length in this study. But in comparison of only R and T ewes sired by either FxR or WF rams, staple length was slightly longer for 1/4Fx ewes (table 23). C and (FxR)xC ewes had similar staple lengths resulting in a BxS interaction ($P<.05$). Staple length increased with age ($P<.01$), but showed no SxA interaction.

Discussion

Improved reproductive efficiency through incorporation of Finnish Landrace breeding with standard breeds in the U.S. under semi-intensive management systems has been well documented in the literature. Few reports, however, have been published evaluating the performance of Finn crosses under more harsh conditions on western range.

Results presented in this study indicate gains in total kilograms of lamb weaned may be realized through the addition of 1/4 Finn breeding into typical western whiteface ewes despite less than optimum nutrition and management. Based on unweighted average of LW120 from 1 through 6 yr of age, 1/4Fx ewes weaned 6 kg per ewe per yr more than WF ewes under the same conditions.

Lamb production superiority of 1/4Fx ewes was most evident at ages 1, 2 and 3 yr. Differences as ewe lambs, lambing at 1 yr of age, resulted entirely from increases in fertility (37.7% vs. 1.3%). Increased fertility as ewe lambs provided 1/4Fx ewes with a 14 kg production advantage before WF ewes lambed for the first time. Analysis by breed of dam showed increased levels of production in 1/4Fx ewe lambs to be independent of the WF breed involved in the cross.

Superior LW120 at ages 2 and 3 yr resulted from increased prolificacy rather than fertility as in ewe lambs. Although non-significant, estimates of fertility in mature ewes demonstrated 1/4Fx ewes to be actually inferior to WF ewes. Decreases in fertility in

mature 1/4Fx ewes may be a result of increased stress due to lambing at 1 yr of age; however, this study does not address this question. For ages 1 and 2 yr 1/4Fx ewes exceeded WF ewes by an average of .4 lambs per ewe lambing, resulting in an 8 kg superiority in LW120.

Analysis of Phase I was included in this study to estimate any change in total kilograms of lamb weaned due to the use of FxR rams to obtain 1/4Fx ewes for future production. The substitution of FxR for WF rams showed no effects on individual lamb weaning weights, and total kilograms of lamb weaned increased by 4 kg. Superiority in LW120 for ewes sired by FxR rams resulted primarily from heterosis increasing S60 for crossbred lambs.

Finnish Landrace are known for lighter coarser fleeces than WF ewes, and reductions in wool production and quality due to 1/4 Finn breeding were significant in this study. Lighter fleece weights of .4 kg per ewe per yr resulting in a net loss of 2.4 kg of wool over 6 yr, combined with a less attractive wool clip, due to coarser fleeces, reduces the overall gains from the utilization of 1/4Fx ewes.

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