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

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.

COMPARISON OF FINNISH LANDRACE CROSSBRED EWES WITH COLUMBIA, RAMBOUILLET, AND TARGHEE ON WESTERN RANGE

by

Robert David Lewis

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

of

Master of Science

in

Animal Science

MONTANA STATE UNIVERSITY
Bozeman, Montana

June 1984

APPROVAL

of a thesis submitted by

Robert David Lewis

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

6/11/84
Date

Peter M. Lewis
Chairperson, Graduate Committee

Approval for the Major Department

6-12-84
Date

Arthur E. Linton
Head, Major Department

Approved for the College of Graduate Studies

6-15-84
Date

M. B. Malone
Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the Library shall make it available to borrowers under the rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Director of Libraries when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Robert D. Lewis

Date June 12, 1984

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to Dr. P. J. Burfening and Dr. D. D. Kress for their guidance, encouragement, and patience throughout my graduate program. Appreciation is extended to Dr. M. D. Huffman and Dr. W. W. Kezar for their counsel and instruction.

Special thanks are expressed to Ms. D. M. Doede for her support and friendship which made the success of my graduate program possible, and to Mr. D. E. Trowbridge for his assistance with computer programming.

Thanks are extended to Dr. J. L. Van Horn, Mr. K. L. Coleman, and the staff of the Red Bluff Research Ranch for management and collection of data.

I wish to offer my sincere gratitude to my families, far and near, without whose dedication to my education my graduate program would neither have been attempted nor completed.

Lastly, I express my most special thanks and admiration to my wife Sarah.

TABLE OF CONTENTS

TABLE OF CONTENTS-Continued

LIST OF TABLES

LIST OF TABLES-Continued

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