

BUDGET ANALYSIS OF QUARTER-FINN AND WESTERN EWES IN
SPRING- AND FALL- LAMBING SYSTEMS

by

Bee Tolman

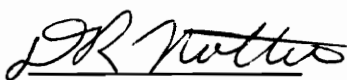
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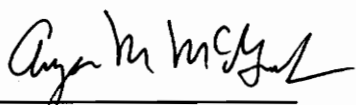
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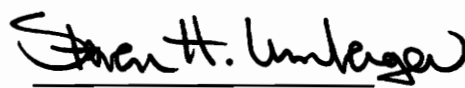
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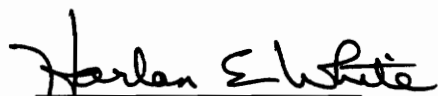
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Budget Analysis of Quarter-Finn and Western Ewes in Spring- and Fall-lambing Systems

ABSTRACT

Fifty-nine mature "Western" (Suffolk x Rambouillet) and 71 mature ¼-Finn (Suffolk x Finn-Rambouillet) ewes were bred to Suffolk-Hampshire rams to lamb in either spring (March) or fall (September). Effects of ewe breed type and lambing season on ewe fertility (ewes lambing/ewes exposed), prolificacy (lambs born/ewe lambing) and lambing date, and on lamb birth weight, 30-d survival, and average daily gain (ADG) to 55 d and to weaning were evaluated. Fertility was higher in spring than in fall (94 vs 64%, $P < .01$). Use of ¼-Finn ewes tended to increase fertility in fall lambing (69 vs 59%, $P < .25$) but not in spring (94 vs 93%). Use of ¼-Finn increased prolificacy by .36 lambs; fall lambing reduced prolificacy by .49 lambs. Lambs of Western ewes were born 5 d later ($P < .01$) and .6 lb heavier ($P < .001$) than lambs of ¼-Finn ewes. Lamb survival and ADG to 55 d and to weaning were not affected by ewe breed. Season affected ADG: fall-born lambs grew faster to 55 d ($P < .05$) and to weaning ($P < .001$) than spring-born lambs, attributable to differences in environmental factors. Effect of weaning on growth of spring-born lambs grazing summer pasture was analyzed. Spring lambs weaned at 90 d of age to graze independently grew more slowly and were older at market weight than lambs remaining with their dams on native perennial pastures (.24 vs .42 lb/d, $P < .001$; 201 vs 186 d of age, $P < .001$). Use of millet (*Pennisetum americanum* [L.] Leeke) as annual mid-summer forage and turnip (*Brassica rapa* L.) as annual late-fall forage were investigated. Dry ewes grazing millet lost weight in one yr, but averaged .23 lb/d gain in a second yr; weaned lambs grazing pearl millet averaged .32 lb/d gain over 2 yr. Lactating and dry ewes grazing turnip had average weight changes of -.37 and +.11 lb/d, respectively.

Budgets for production systems were constructed. Variable revenues and expenses for all combinations of ewe breed type, lambing season, weaning treatment, and annual forage use were integrated into an annual production system. The most profitable production systems were those that exhibited the greatest reproductive efficiency, required the least drylot time to finish lambs, and maximized use of perennial pastures.

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Chapter 1. Introduction

The value of any change in production traits in sheep, such as reproductive efficiency, growth, carcass characteristics, or wool production, should ultimately be assessed by its effect on the production system it is part of. Most production alternatives differ in cost and few occur in isolation; most changes have interactive effects on other production traits. Thus the long-term value of any change in performance should be assessed by its net effect the relationship between production costs and receipts (Dickerson, 1970). Perceived advantages or disadvantages to different management strategies may change when the options are integrated into a system and the consequence of each choice is assigned an economic value.

The experiment reported in this thesis was comprised of two parts. The first was a set of trials conducted at the Southwest Virginia Agricultural Experiment Station in Glade Spring, Virginia; these trials were designed to evaluate production of differing crossbred ewe types, lambing seasons, weaning treatments, and uses of annual forages. The second part consisted of compiling the trial results into complete production systems and then assigning economic values to those results to create budgets for each system.

Four production trials were conducted. The first evaluated the reproductive efficiency of Rambouillet x Suffolk ("Western") and ¼-Finn ewes lambing in either spring or fall. The second examined the effect of weaning on the growth of spring-born lambs grazing perennial bluegrass-clover pastures through summer, and the postweaning growth of fall-born lambs in drylot. The third trial investigated the production potential of millet, a warm-season annual grass, and tyfon, a brassica, as forages for summer grazing by dry ewes and weaned lambs. The last trial evaluated the production potential of turnips grazed by lactating and dry ewes in late fall.

Each production trial was analysed individually. The various combinations of ewe breed, lambing season, weaning treatment, and annual

forage use were then integrated into systems, and budgets were created for each. Gross margins of all systems, calculated by subtracting variable costs (purchased feed, forage, and non-feed costs) from revenues (lamb, wool, and cull sales), were compared to assess the economic efficiency of each system and the economic impact of different management decisions.

Chapter 2. Literature Review

The effect of $\frac{1}{4}$ -Finn breeding in crossbred ewes

Fertility

In most sheep production trials, fertility is defined as the percentage ewes lambing of ewes exposed to the ram. Finn-cross ewes compare well to their purebred or crossbred counterparts for this trait, and excel as ewe lambs. Thomas and Whiteman (1979a) compared fertility in 1, 2, and 3-year-old spring-lambing, crossbred ewes in Oklahoma, representing combinations of Finn (F), Dorset (D), and Rambouillet (R) breeding. They found that increasing F breeding from 0 to $\frac{1}{4}$ at the expense of R in the cross (therefore, the $\frac{1}{4}$ -F effect) resulted in an increase ($P < .01$) of 24.0% in fertility in ewes lambing at 1 year of age, but had no significant effect at 2 and 3 years of age.

Ewe breed effects on fertility were examined using 361 fall-bred ewes in Quebec (Fahmy and Dufour, 1988); ewes were DLS (a composite breed of $\frac{1}{2}$ -D, $\frac{1}{4}$ -Leicester, $\frac{1}{4}$ -Suffolk), F, and seven DLS x F combinations, from $\frac{1}{8}$ - to $\frac{7}{8}$ -F breeding. Conception rates in yearlings ranged from 61.5% for DLS to 89.0% for F; crosses were intermediate. However, genetic group x age interaction was significant: at later parities, conception rates were higher (average 94%) and similar across genetic groups.

Increased fertility in $\frac{1}{2}$ - or $\frac{1}{4}$ -F crossbred ewe lambs appears to be due largely to earlier sexual development of the Finnsheep breed (Maijala, 1984). In comparing three pure breeds (Suffolk, S; Targhee, T; and the "Minnesota 100", M) with F crosses involving those breeds, Oltenacu and Boylan (1981a) reported that the mean percentage of ewe lambs lambing at 12 months of age was 95.0, 92.0, 87.9, 79.2, and 72.0% for Finn, F_1 , F_2 , $\frac{1}{4}$ -Finn, and other purebred ewe lambs, respectively.

Differences in fertility among breeds or crosses can be affected by breeding season. In Nebraska trials examining reproductive performance of purebreds (R, D, and T) and $\frac{1}{2}$ -F crosses from those breeds, Fogerty et al.

(1989) found that the fertility of most $\frac{1}{2}$ -F crosses was higher ($P < .01$) than that of the pure breeds for January and May lambings, but not for September lambing. These results are averages of 4 years of production, however, and include fertility of ewe lambs, which would have tended to elevate the relative fertility of the F crosses in spring lambing. Also, the authors noted "a later onset of the breeding season for F and T compared with D and R ewes, and a later decline for F ewes."

In contrast, Notter and McClaugherty (1991) found no significant ewe breed effect when comparing fertility of "Western" (S x R) and $\frac{1}{4}$ -Finn ewes (SxFD or SxFR) lambing in November, January, and March. This result may be due to the range of breeding seasons in this study. The June breeding (for November lambing) would have been late enough to be past the peak of the Finn's extended breeding season (Maijala, 1984), and the October breeding (for March lambing) would have finished early enough not to give advantage to the Finn's extended breeding season. Thus the effect on fertility of $\frac{1}{4}$ -Finn genetics in the crossbred ewe would have been minimal.

Prolificacy

Maijala (1984) conducted an extensive review of 125 papers, synthesizing trial results that compared production traits of Finnsheep and Finn crosses with those of over 40 breeds used locally in 18 countries, including 8 U.S. states. He reported that, overall, a 1% increase in Finn genes resulted in a 1.4% increase in lambs born/ewe mated and a .7% increase in litter size at birth. One-quarter-F ewes produced 20% more lambs/ewe/year and 56% more lambs over 5 years of production than non-Finn ewes.

In their study of DLS and DLS x F ewes, Fahmy and Dufour (1988) found that DLS and $\frac{1}{4}$ -F ewes averaged 1.44 and 1.67 lambs at birth, respectively. There was a significant positive regression of litter size on increments of $\frac{1}{8}$ -F breeding, from 0-F to pure F ($b = 0.14$, $p < .01$).

Thomas and Whiteman (1979a) reported a positive but non-significant $\frac{1}{4}$ -F effect on prolificacy of spring-lambing ewes (.08 to .09 lambs/ewe), but also pointed out that an increase of 9 lambs/100 ewes lambing may be of economic importance. The $\frac{1}{4}$ -F effect, however, was greater in fall-

lambing ewes, increasing lamb drop by .20 lambs/ewe lambing ($P < .10$) in the first year and by .22 lambs ($P < .05$) in the second.

Notter and McClaugherty (1991) found that the difference in prolificacy between $\frac{1}{4}$ -F and Western ewes was fairly consistent across lambing seasons: $.20 \pm .13$, $.28 \pm .12$, and $.37 \pm .13$ lambs/ewe lambing for late fall, winter, and spring lambings, respectively.

When comparing spring-lambing $\frac{1}{4}$ -Finns to their purebred, non-Finn counterparts, Oltenacu and Boylan (1981a) found prolificacy to be significantly affected ($P < .05$) by both age and F breeding. Litter size/100 ewe lambs mated and per 100 yearlings lambing was 23.7 and 12.0 lambs greater, respectively, for $\frac{1}{4}$ -Finns than for purebreds. Litter size per 100 2-yr-olds mated and lambing was 12.3 and 31.1 lambs greater, respectively, for $\frac{1}{4}$ -Finns than for purebreds.

Birth weight

In his survey of papers on Finnsheep performance, Maijala (1984) found that a 1% decrease in proportion of Finn genes resulted in an average increase of .27% in lamb birth weight (BW).

Fahmy and Dufour (1988) reported that average BW of Suffolk-sired, spring-born lambs (not adjusted for sex or birth type) was 9.1 and 8.5 lb for lambs of DLS and $\frac{1}{4}$ -F ewes, respectively ($P < .05$). A negative linear regression of average BW on increasing increments of $\frac{1}{8}$ -F in the dams' breeding was found ($b = -0.42$, $P < .01$). In contrast, Notter et al. (1991) found that despite the greater prolificacy of the $\frac{1}{4}$ -F compared to Western (W) ewes, ewe breed effects on BW of Suffolk x Hampshire (SxH)-sired lambs over three lambing seasons were not significant: mean BW were $8.4 \pm .2$ lb for lambs from $\frac{1}{4}$ -F ewes, and $8.8 \pm .2$ lb for lambs from W ewes.

Notter et al. (1991) did find significant sex and birth type effects on BW. Mean sex difference was $.6 \pm .1$ lb, favoring ram lambs. Single lambs averaged $2.4 \pm .5$ lb heavier than twins, which averaged 4.4 ± 1.0 lb heavier than triplets. Furthermore, the ewe breed x birth type interaction was significant, as W ewes produced slightly heavier singles than did $\frac{1}{4}$ -F ewes ($10.7 \pm .3$ vs. $10.3 \pm .4$ lb), but $\frac{1}{4}$ -F ewes produced heavier twins ($8.4 \pm .2$ vs. $8.1 \pm .2$ lb) and triplets ($6.5 \pm .4$ vs. $5.9 \pm .8$ lb).

Lamb survival

In studies that consider baby lamb survival, there seems to be little consensus as to the point at which a lamb has officially "survived". Survival rates of lambs are thus assessed in many ways, i.e., lambs born alive/lambs born, lambs reared to 2 wks, lambs weaned/born, or lambs weaned/born alive.

Surprisingly, Maijala (1984) found that, in general, survival within a litter increased, in a fairly linear fashion, as percentage F breeding increased from $\frac{1}{4}$ -F to pure F ($b = .9\%$ per %F), in spite of larger litter sizes and smaller birth weights that accompanied increases in F breeding. (Here, survival was defined as lambs weaned/total lambs born.) In 37 studies within the U.S. alone, lambs of Finns and F-cross ewes had 5% higher survival than their non-F counterparts (Maijala, 1984).

In contrast to the results of Maijala's survey, Fahmy and Dufour (1988) reported a significant quadratic regression ($P < .05$) of preweaning mortality (spring-born lambs weaned at 70 d) on F breeding. As increments of F breeding increased by $\frac{1}{8}$ from 0-F to $\frac{1}{2}$ -F, lamb survival improved, and then as F-breeding increased to purebred F, survival declined. There was, however, no significant difference in survival between lambs of DLS and $\frac{1}{4}$ -F ewes: 3.0 vs. 2.8% lambs born dead/total born/ewe exposed, and 13.9 and 10.7% lambs dead before weaning/total born alive/ewe exposed, for DLS and $\frac{1}{4}$ -F ewes, respectively.

In Oklahoma, Thomas and Whiteman (1979a) found that the $\frac{1}{4}$ -F effect (when replacing $\frac{1}{4}$ -R) for lamb survival to 70-d weaning was negative but non-significant for all ewe ages (1 to 3 years), in both spring and fall lambing. The authors noted that with both $\frac{1}{4}$ -F and $\frac{1}{4}$ -D ewes, the sign of the breed effect on survival was opposite that of prolificacy, suggesting that an increase in prolificacy may have resulted in an increase in lamb mortality.

In Minnesota, Oltenacu and Boylan (1981a) found no difference between survival of spring-born lambs (weaned at 70 d) of $\frac{1}{4}$ -F ewes and their purebred counterparts, regardless of whether survival was defined as percentage born alive or percentage weaned of those born alive.

In contrast, in Virginia, progeny of $\frac{1}{4}$ -F yearling ewes had significantly higher survival to 70-d weaning than those of Western (W) yearlings ($94.7 \pm 4.3\%$ vs. $76.0 \pm 4.1\%$, respectively; Notter et al., 1991). As the dams aged, differences in lamb survival became non-significant. Adjustment of survival for birth type did not change significance levels, but did increase the survival advantage of lambs from $\frac{1}{4}$ -F ewes over those of W ewes.

Furthermore, Notter et al. (1991) reported that survival to 70 d was higher for twin-born lambs ($92.3 \pm 2.3\%$) than for either singles ($86.1 \pm 3.8\%$) or triplets ($76.7 \pm 7.0\%$). The relationship between survival and birth weight (unadjusted for birth type) was curvilinear, and survival was maximum at a BW of 9.7 lb. When adjusted for BW, survival was not affected by birth type ($P < .19$).

Lamb gain

Maijala's survey (1984) indicated that lamb growth to weaning was affected by Finn breeding in the dam. A 1% decrease in the proportion of Finn genes in *lambs* produced an average increase of .16% in weaning weight (WW), .20% in preweaning daily gain, .05% in slaughter weight, and .24% in postweaning gain. The author noted that the relative effects of Finn breeding on the growth and size of crossbred lambs are much smaller than those on the reproductive traits of dams.

For increasing $\frac{1}{8}$ -F increments, from DLS (0-F) to pure F, Fahmy and Dufour (1988) recorded a negative linear regression of average lamb WW on F breeding ($b = -1.0$, $P < .01$). However, there was no significant difference between WW of Suffolk-sired DLS and $\frac{1}{4}$ -F progeny (40.5 and 39.8 lb/lamb, respectively).

In Oklahoma, sex-adjusted 70-d WW was lowest for spring-lambing yearling ewe groups with the greatest prolificacy (Thomas and Whiteman, 1979a), resulting in the $\frac{1}{4}$ -F effect nearing significance (-3.3 lb WW/lamb, $P < .10$). However, in 2- and 3-yr-old ewes, the $\frac{1}{4}$ -F effect was positive, although not significant (0.4 ± 1.3 and $0.7 \pm .2.0$ lb/lamb, respectively). In 2 years of fall lambing, Thomas and Whiteman (1979b) found consistently lower WW in $\frac{1}{4}$ -F ewes, but also significant WW x year

interaction, as WW decreased in the year with significantly higher prolificacy.

Weaning weights can reflect birth weight or type, and may not reflect the lamb's ability to grow. Averaged over three lambing seasons (fall, winter, and spring) in Virginia, daily gains of SxH-sired lambs from $\frac{1}{4}$ -F ewes were not significantly greater than gains from lambs of Western (W) ewes: $.62 \pm .01$ vs. $.60 \pm .01$ lb/d preweaning, and $.55 \pm .01$ lb/d for both ewe breeds postweaning (Notter et al., 1991). Final slaughter weights and ages for lambs of $\frac{1}{4}$ -F and W dams were $111.8 \pm .7$ lb at 196 ± 2 d, and $112.4 \pm .7$ lb at 199 ± 2 d, respectively.

There was, however, significant ewe breed x lambing season interaction for postweaning gain and slaughter age (Notter et al., 1991). Under concentrate-feeding systems (i.e., for mid-winter feeding), progeny of $\frac{1}{4}$ -F ewes grew $.07 \pm .02$ lb/d faster postweaning and averaged 10 ± 6 d younger at slaughter than progeny of W ewes; differences in performance were small under forage-feeding systems.

Fahmy's study (1989) of spring-born market lambs from DLS x F ewes indicated no significant difference between lambs of DLS and $\frac{1}{4}$ -F ewes in either daily gain to 90 lb or age at slaughter: $.50$ lb/d at 193 d for DLS progeny, and $.50$ lb/d at 188 d for $\frac{1}{4}$ -F progeny, respectively.

Total lamb production

When comparing Finn crosses to other crossbred or purebred contemporary groups, total lamb production appears to be greatly influenced by conception rates and prolificacy, and to a much lesser extent by lamb growth rates. Maijala's review (1984) indicated that in six studies, $\frac{1}{4}$ -F ewes weaned 32% more lambs and 22% more weight per ewe mated in 5 years of production than did their non-Finn contemporaries.

The total weight of lamb weaned per ewe exposed for spring-lambing crossbred ewes in Oklahoma (Thomas and Whiteman, 1979a) was increased by $\frac{1}{4}$ -F breeding (7.7 lb, $P < .10$) in yearling ewes, and to a lesser extent in 2- and 3-yr-old ewes (2.2 and 2.0 lb, respectively). The authors noted that the productivity of commercial Rambouillet-cross ewe lambs appeared to be "greatly enhanced by infusion of $\frac{1}{4}$ -F germ plasm".

The ¼-F effect for the same crossbred types in a fall-lambing system resulted in reduced lb of lamb weaned (Thomas and Whiteman, 1979b): -5.5 ± 5.4 and -14.1 ± 5.6 lb weaned/ewe exposed in the first and second fall seasons. This was, however, a reflection of low conception rates (less than 60%) in late summer for the ¼-F ewes, compared to that of 1/2-R and 3/4-R ewes (70 to 85% conception).

In Quebec, Fahmy and Dufour (1988) found that ¼-F ewes weaned an average of 1.36 lambs weighing a total of 48.8 lb, while DLS ewes weaned 1.06 lambs weighing 39.8 lb (both significantly different, $P < .05$). This appears to be a reflection of the ¼-F's significantly greater conception rate and litter size at weaning. Regression of lb of lambs at weaning on increasing 1/8-F increments, from DLS (0-F) to purebred F, was positive though not significant ($b = 1.1$).

Economic returns per ewe lambing, of DLS and ¼-F ewes were determined by multiplying number of lambs weaned/ewe by lamb carcass value (Fahmy, 1989). Carcass value was figured as 200-d adjusted lamb weight x dressing percentage x the sum of price of each wholesale cut in a carcass. Carcass value ranged from \$169.10 (Canadian dollars) for Suffolk-sired lambs of DLS (0-F) ewes to \$158.40 for S-sired lambs of purebred F ewes, but did not differ significantly among dam groups. Carcasses of lambs from ¼-F ewes were valued at \$153.80. Returns per ewe and per lb of ewe weight ranged from \$207.30 and \$1.71/lb, respectively, for DLS ewes, to \$319.80 and \$2.90/lb for pure Finn ewes ($P < .01$). Returns for ¼-F ewes were \$223.20 and \$1.84/lb.

Ercanbrack and Knight (1989) estimated the average lifetime production per entering ewe over 7 yrs of production for purebred ewes (Rambouillet, Targhee, and Columbia) and the ½-F crosses and ¼-F backcrosses of those purebred types. All ewes were bred in November to Suffolk rams, were allowed to rear a maximum of two lambs (fostering occurred within breed type only), and were culled only for disability. Final production figures did not include orphaned lambs. Average final ewe ages and lifetime production (lambs weaned at 130 d and total weight of lamb weaned/ewe) were 4.92 yr, 3.77 lambs, and 304 lb, respectively, for

purebreds; 5.11 yr, 5.04 lambs, and 394 lb for $\frac{1}{4}$ -F ewes; and 5.12 yr, 5.52 lambs, and 420 lb for $\frac{1}{2}$ -F ewes.

Relative economic value was then estimated for the above ewes (Ercanbrack and Knight, 1989). Wool production was included and valued at 2.5 times the unit live-weight value of weaned lamb, but coarser wool grades were then discounted. Average lifetime fleece weights for $\frac{1}{4}$ - and $\frac{1}{2}$ -F ewes were 5 and 18% less, respectively, than those of purebreds, and were also discounted 18 and 25%, respectively, for lower wool grades. Final net values of production for $\frac{1}{4}$ -F and $\frac{1}{2}$ -F ewes were 15 and 17% higher, respectively, than those for purebreds.

Spring- and fall-lambing systems

A limited number of studies have been conducted on spring-breeding/fall-lambing performance of ewes. Most have been within the context of accelerated lambing systems (three lambings in 2 years, at 8-month intervals) rather than comparisons of annual out-of-season vs. annual in-season production systems. Depending on the region in which a study is conducted, and its climate and forage parameters, "fall" lambing may range from September to December. This variability in defining actual months of fall lambing, combined with variation in ewe breeds involved, has resulted in substantial differences in the consequent "success" or "failure" of fall-lambing systems.

Breeding season

In his review of genetic influences on out-of-season production, Notter (1992) found breed differences in the timing and duration of the breeding season, particularly in the typically anestrous spring and summer. The Dorset (D) is noted for its extended breeding season (i.e., late summer through late winter), while the Finnsheep (F) will start cycling later in autumn than the D but will continue cycling at least as long into the spring. The Rambouillet (R) will begin the estrous season earlier, in late summer, but will not cycle as far into the spring as the F. The British meat breeds (such

as Suffolk, S and Hampshire, H) have a comparatively short breeding season.

Maijala (1984) surveyed the effects of Finn genetics on seasonal ewe production, and reported that the proportion of $\frac{1}{2}$ -F ewes in estrus in March, April, and May was 43, 120, and 475 % greater, respectively, than non-Finn (O-F) ewe breeds to which they were compared. The percentage of $\frac{1}{2}$ -F ewes in estrus from July through December was 6% lower than that of non-F (O-F) ewes, and length of breeding season declined as percentage Finn-genes declined.

Seasonality of breeding is affected by age and is stronger in younger ewes (Notter and McClaugherty, 1991). Ewe lambs will tend to have a shorter estrous season than older ewes, and if born in fall are unlikely to exhibit puberty until the following fall (Notter, 1992). Therefore, most fall-born ewe lambs will not be part of an annual fall-lambing system until their second lambing, at approximately 24 months of age.

Fertility

The reproductive performance of grade ewes (from D, H, S, or Corriedale sires) in annual spring- and fall-lambing systems was compared in West Virginia (Barr et al., 1968). Occurrence of estrus and conception (here defined as percentage ewes lambing of ewes exhibiting estrus) was significantly lower ($P < .01$) for spring-exposed/fall-lambing ewes. Estrus and conception rates were 96.7 and 91.1%, respectively, for spring-lambing ewes, and 81.1 and 84.2% for fall-lambing ewes. The lower conception rate in fall-lambing ewes raises the possibility of increased failure to maintain pregnancy following out-of-season breeding.

The authors also noted a significant interaction ($P < .01$) between breed of ram and season (Barr et al., 1968). Estrus occurred in 85.2% of ewes exposed to D rams in spring, but in only 77.7% of ewes exposed to H rams. Thus successful out-of-season mating and reported conception rates can be affected by the breed of ram. This differential ability of ram breeds to stimulate ewes to cycle in the anestrus season was also demonstrated by Nugent et al. (1988). Western (SxR) ewes exposed to Dorset rams for

breeding from early June to early July had higher overall lambing rates than those exposed to Suffolk rams ($75 \pm 5\%$ vs. $54 \pm 6\%$).

Thomas and Whiteman (1979a,b) conducted two studies in Oklahoma with crossbred ewes representing combinations of F, D, and R breeding. They examined reproductive performance in spring (February-March) and fall (October-November) lambing, and the effect of increasing F breeding from 0 to $\frac{1}{4}$ at the expense of R in the cross (therefore, $\frac{1}{4}$ -F effect). Fertility (ewes lambing/ewes exposed) ranged from 77.5 to 96.0% in two spring-lambing seasons, and ranged from 58.7 to 87.1% in two fall-lambing seasons. The $\frac{1}{4}$ -F effect reduced fertility in fall-lambing ewes by 14.1 and 24.9% in the 2 years. This result is likely due to the mid- to late-summer (May-July) breeding season, which would have favored the crossbred ewes with more R and less F breeding.

Iniguez et al. (1986) also reported a disadvantage to F breeding in a California fall-lambing system. Half-F ewes lambed approximately 3 weeks later and had significantly lower fertility ($P < .05$) than R and R x D ewes. Again, the late-summer breeding season in this trial would have favored R and R-cross ewes. Also in this study, as in the Thomas and Whiteman (1979b) study, the R breeding was derived from a population of R ewes that had been traditionally bred for fall-lambing in the southwestern U.S., and thus would have had the advantage of selection over generations for that lambing season. Furthermore, the breeding season was terminated in late September, possibly before some F-cross ewes had begun to cycle.

Given the resultant reduction in lamb weight weaned/ewe exposed, Iniguez et al. (1986) concluded that "50% Finn ewes are not suitable for a fall-lambing production system in California". Yet although this was termed a "fall-lambing" production system, average lambing date was January 1 for the R, D, and R x D ewes that excelled in this system. Thus this experiment may not have adequately evaluated the effect of the crossbred F type in a West Coast fall-lambing system.

Comparisons of fall- and spring-lambing production within an accelerated system may indicate trends in fertility, but should not be taken as absolute. In an accelerated lambing study, with January, April, and September lambing and 45-d weaning, Notter and Copenhaver (1980a)

found a significant interaction between time-since-lambing and season effects on fertility ($P < .001$). For April (out-of-season) breeding, ewes that had lambed 2 to 4 months before exposure (i.e., in January) had a 23% higher conception rate than ewes that had not lambed for at least 7 months.

Fogarty et al. (1984) reported a similar, but less pronounced, trend. In an accelerated lambing study in Nebraska, using purebreds (R, D, and Targhee, T) and $\frac{1}{2}$ -F crosses from those breeds, ewes exposed in spring with an 8-month lambing interval had a 3.8% higher conception rate than those with a 12-month lambing interval. However, season effect remained significant, as fertility averaged only 17% for September lambing, 57% for January lambing, and 72% for May lambing.

Fertility rates were not as low in a similar system in Virginia (Notter and McClaugherty, 1991). After adjusting to a constant 45-d breeding season and excluding yearlings, lambing rates for $\frac{1}{4}$ -F and Western (W) ewes lambing in early December, late January, and March were 78.6 ± 4.3 , 89.5 ± 4.1 , and $85.7 \pm 4.6\%$, respectively ($P < .10$). Lambing rates did not differ among ewe breeds.

Notter and Copenhagen (1980a) reported a significant difference in fertility between seasons ($P < .05$): 53 ± 3 , 90 ± 3 , and $79 \pm 4\%$ for September, January, and April lambings, respectively, in Virginia. This study also showed a significant F breed effect in out-of-season breeding, as the $69 \pm 5\%$ conception rate for $\frac{1}{2}$ -F ewes was 15% greater ($P < .05$) than that of $\frac{1}{4}$ -F ewes ($45 \pm 4\%$), which was in turn greater (though not significantly so) than that of W ewes ($38 \pm 7\%$).

Prolificacy, lamb birth weight, lamb survival

In comparisons of annual lambing systems, Barr et al. (1968) reported higher lambing percentages for ewes lambing in spring than in fall (1.83 vs. 1.54 lambs/ewe lambing; $P < .01$). Prolificacy was higher for ewes bred to Dorset rams than for ewes bred to Hampshire rams. Average birth weight (BW) was higher in spring-born than in fall-born lambs (9.8 vs. 9.4 lb; $P < .05$). Survival at birth and to 30 d was slightly greater for spring-born than for fall-born lambs, although there were no differences in survival due to breed, sex, or birth type.

Seasonal effects on prolificacy were not so pronounced in 2- and 3-yr-old ewes in Oklahoma. Lambs born/ewe lambing ranged from 1.51 to 1.72 in the spring, and from 1.27 to 1.73 in the fall (Thomas and Whiteman (1979a,b). The ¼-F effect on fall prolificacy was positive and tended towards significance (+.21 lambs/ewe; $P < .10$).

Notter and Copenhaver (1980a) reported significant season and breed group effects on prolificacy. Half-F, ¼-F, and W (O-F) ewes averaged $2.62 \pm .12$, $2.11 \pm .11$, and $1.85 \pm .19$ lambs/litter, respectively, in April and $1.87 \pm .10$, $1.50 \pm .11$, and $1.71 \pm .18$ lambs/litter in September. However, seasonal effects on BW and survival were also reported. After adjustment to mean litter size, BW was lower for September-born than for April-born lambs ($8.7 \pm .2$ vs $10.1 \pm .2$ lb). There was a litter size x season interaction ($P < .05$) for mortality within 24 hrs of birth, primarily reflecting the high mortality rate of fall-born triplets. This suggests a reduction in BW and vigor of lambs gestated through the heat of the summer.

Lamb growth

Barr et al. (1968) found that spring-born lambs grew faster to an adjusted 150-d wt than did fall-born lambs (.53 vs. .48 lb/d; $P < .01$), in spite of larger litter sizes. The authors did not indicate what feeding regimen was employed, or what environmental factors might have affected the relative performance of February- and October-born lambs in the study.

Notter and Copenhaver (1980b) measured preweaning (45-d weaning) and postweaning gains (to 100-lb slaughter weight) of concentrate-fed lambs on expanded-metal flooring. April-born lambs grew faster to 45 d than September-born lambs ($.67 \pm .01$ vs. $.59 \pm .01$ lb/d; $P < .05$). This difference was reversed for postweaning gain, as April-born lambs grew more slowly ($.49 \pm .01$ vs. $.57 \pm .01$ lb/d; $P < .001$), were lighter at 150 d (90.9 ± 1.1 vs. 95.0 ± 1.3 lb; $P < .05$), and took longer to reach slaughter weight (172 ± 3 vs. 160 ± 3 d; $P < .05$) than September-born lambs. These results presumably reflect effects of summer heat on spring-born lambs.

In most ewe and lamb production systems, management and feeding will differ between seasons. In their accelerated system, Notter et al. (1991) used feeding regimes typical of Southwest Virginia, such that spring-born lambs grazed with their dams on perennial pastures through the summer until slaughter, and fall-born lambs were fed to slaughter on high-concentrate diets. Therefore, lamb gains in this study might better represent the effect of different lambing seasons on lamb gain.

All lambs were creep-fed; no seasonal differences were found for preweaning gain (70-d wean, average $.61 \pm .01$ lb/d). However, for fall-born lambs fed concentrate diets after weaning, postweaning gain was consistently higher and slaughter age significantly younger than for spring-born lambs ($.75 \pm .01$ vs. $.38 \pm .01$ lb/d, and 156 ± 3 vs. 234 ± 2 d to 112-lb slaughter for fall- and spring-born lambs, respectively). It was noted that summer lambs were stressed by coccidia burden and limited forage availability due to drought.

Notter et al. (1991) also reported ewe breed x season interaction on postweaning gain and age at slaughter, as fall-born $\frac{1}{4}$ -F progeny, fed concentrate diets, grew $.07 \pm .02$ lb/d faster postweaning and averaged 10 ± 6 d younger at slaughter than did contemporary progeny of W ewes. There was, however, no breed effect on gain in the forage-based, spring lambing system.

Overall seasonal production

Because of poorer conception rates and litter sizes associated with fall lambing, final production in spring and fall lambing seasons may differ considerably. Notter and McClaugherty (1991) found that spring-lambing ewes had 1.54 lambs born per ewe exposed, while fall-lambing ewes had 1.29 lambs born/ewe exposed. Differences between spring-lambing and fall-lambing ewes were significant for number of lambs raised/ewe exposed (1.39 vs 1.08 [$\pm .08$], respectively) and approached significance for number of lambs marketed/ewe exposed (1.23 vs. 1.00 [$\pm .08$]; $P < .10$).

Barr et al. (1968) reported that the spring-lambing flock had 1.45 lambs available for sale per ewe exposed, while the fall-lambing flock had .96 sale lambs per ewe exposed. With the higher price for fall-born lambs

(\$29.00/cwt vs. \$23.37/cwt [1968 prices]), lamb income per ewe exposed was \$29.38 for spring-lambing ewes, and \$22.82 per ewe for fall-lambing ewes.

Production within a fall-lambing system may not be economically advantageous, given reduced reproductive efficiency of most ewe types when exposed to rams in the spring. Notter and Copenhaver's study (1980a), however, does indicate that the addition of F breeding into a fall-lambing system could increase productivity/ewe exposed, *if* the desired breeding season complements the Finn's particular estrous season. Thomas and Whiteman (1979b) suggested that "one-quarter Finnsheep ewes could be very desirable for fall-lambing if, through selection or management, the proportion of ewes lambing could be improved."

The effect of weaning on lamb growth

Introduction

The option of weaning lambs or the optimum age to do so is management-specific and should reflect time of lambing, season of marketing, and feed available to the weaned lamb. "Early weaning" has been defined as "the withdrawal of milk supply before the time when weaning would normally occur" (Brown, 1964). The definition of "early weaning" in the literature can refer to the removal of ewes in late lactation to save prime forage for finished lamb production, or to the removal of lambs as early as 3 to 6 wk of age in intensive management systems. In this study, however, we were primarily interested in the effect of weaning at approximately 12 to 14 wk (84 to 98 d) of age, the point at which spring-born lambs are beginning to graze summer pasture.

The primary reasons for weaning lambs at 12 to 14 wk are to reduce competition between lambs and ewes for better quality summer forage and to remove lambs from the primary source of internal parasite infestation, the ewes (Brown, 1964). These reasons are often further justified by the

assumption that at this age, milk is no longer a significant nutrient source for the lamb.

For the past 40 years, however, studies have shown either inferior performance by lambs weaned at this age (Jordan and Wedin, 1961; Watson, 1991), or little difference in performance between weaned and unweaned lambs at this age (Barnicoat et al., 1956; Pope et al, 1984).

Most researchers concur that an initial growth check occurs following weaning, reducing gains for a period of 1 to 4 wk, depending on lamb age and/or the diet following weaning (Brown, 1964; Gibb et al., 1981). Reduced growth at weaning may also be attributed to the immunosuppressive effects of emotional stress and internal parasites (Watson, 1991; Ali et al., 1984).

A review of literature indicates that the relative performance of early weaned lambs may vary with the severity and duration of the initial growth check, the ability of the lamb to regain pre-weaning rate of gain, and the ability of the lamb to withstand the challenge of internal parasite infection. The effect of weaning on lamb performance is thus less a reflection of age at weaning than a reflection of the entire weaning environment.

Post-weaning nutrition

Barnicoat et al. (1956) conducted extensive lactation trials with a Romney flock over five lactations. Lactation curves of ewes suckling singles and twins on high nutritional levels indicated that peak lactation occurred at 2 to 4 wk postpartum. A similar result was reported by Gibb et al. (1981). Milk yield peaked at approximately 60 and 80 oz/d for ewe suckling singles and twins, respectively; at 12 wk milk production dropped to 25 and 35 oz/d for ewes suckling singles and twins, respectively (Barnicoat et al., 1956). Nonetheless, the authors maintained that "lamb growth at 2 to 3 months of age was largely dependent on the amount of milk ingested".

That lambs could still be highly dependent on milk when its supply is waning may be explained by the work of Gibb et al. (1981), who measured the effect of milk and herbage intake of lambs before weaning, on herbage intakes and growth rates following weaning at ages between 6 and 14 wk.

Twin Scottish Halfbred x Dorset Down lambs were rotationally stocked with their dams on either high or low allowances (6 or 3 lb DM/cwt liveweight/d, respectively) of perennial ryegrass (*Lolium perenne* L.) pasture. Mean milk yields over 14 wk of lactation were 4.7 and 3.4 lb/d for ewes on high and low forage allowances, respectively.

Lambs were weaned at 6, 8, 10, or 14 wk onto separate ryegrass pastures with no intake restrictions. Measurements of lamb weight and herbage intake revealed that although intake increased following weaning, rate of daily gain dropped significantly in all lambs except those weaned at 14 wk from ewes on low forage allowances. The authors calculated that to maintain the same net energy intake for lamb daily gain after weaning, a reduction of milk organic matter (OM) intake of .1 lb/cwt liveweight (LW)/d would have to be matched by an increased herbage OM intake of .47 lb/cwt LW/d. Lambs weaned at 10 and 14 wk from ewes on high forage allowance (thus high milk yields) required increases of herbage OM of 2 and 1 lb/cwt LW, respectively, but only increased herbage OM by 1.3 and .3 lb/cwt LW, respectively. These herbage increases were inadequate for maintenance of pre-weaning daily gain. Lambs weaned at 10 and 14 wk from ewes on low forage allowance (thus lower milk yields) required less herbage to compensate for milk lost from the diet, and were able to maintain daily gain after weaning. Empty body weight at 25-wk slaughter increased significantly with weaning age: 40.2, 45.9, 46.6, and 52.5 ($\pm$ 3.2) lb for lambs weaned from high-yield dams at 6, 8, 10, and 14 wk, respectively. Slaughter weights of lambs from low-yield dams were lower but still significantly affected by weaning age.

Consequently, Gibb et al. (1981) concluded that when adequate forage allowance for the lactating ewe produced a high milk yield, weaning before 14 wk of age resulted in a significant reduction in growth rate. This result occurred because herbage intake could not compensate for the nutritional loss of milk. With low milk yields, on the other hand, weaning after 8 wk might result in improved lamb daily gain. However, the authors cautioned that these results are applicable only to systems that wean lambs to high-quality, all-grass pastures. Pastures containing high proportions of

legume could provide greater intake and quality of herbage, and improve post-weaning performance.

The study by Gibb et al. (1981) may help explain other, seemingly contradictory, results concerning the effect of weaning age on grazing lamb performance. Barnicoat et al. (1956), for example, reported birth-to-20-wk weight gains of Romney x Southdown lambs weaned at 9, 12, or 16 wk: 63.9, 64.3, and 72.1 lb, respectively, for singles, and 58.7, 58.9, and 60.1 lb, respectively, for twins. These differences were not significant for age at weaning, except for single lambs weaned at 9 wk. The authors had noted earlier that forage for weaned lambs was a high-quality, ryegrass-white clover sward. In this case, forage quality was likely sufficient to replace the nutrient contribution of milk, except for the earliest-weaned singles, who had higher rates of growth than the twins. Similar results were cited by Brown (1964) in his review of studies on the effects of early weaning on lamb growth.

Barnicoat et al. (1956) also reported that the correlation (r) between milk intake and lamb gain fell from $r = .88$ at 10 to 24 d of lactation, to $r = .54$ at 24 to 52 d of lactation, and to $r = .05$ at 52 to 80 d of lactation. These results suggest that lambs in this study were able to obtain adequate nutrition from pasture after 8 to 9 wk of age.

In contrast, longer-term effects of weaning were demonstrated in a study of Dorset x Border Leicester-Merino lambs grazed on ryegrass and subterranean clover (*Trifolium subterraneum*) pastures and weaned at 14 or 23 wk of age (Groups A and B, respectively; Lee et al., 1990). From 14 to 23 wk of age, Group A lambs grew .03 lb/d slower than Group B (unweaned) lambs. From 23 wk to slaughter at 28 wk of age, the difference in rate of gain increased significantly, as Group A gained .16 lb/d less than Group B lambs, in spite of Group B being weaned at the start of this period. Across all sex groups (ewes, wethers, and entire rams) carcasses of lambs weaned at 14 wk were 3.96 ± 0.62 lb lighter ($P < .001$) than those weaned at 23 wk. These results suggest that at 14 wk of age, lamb gain was still somewhat dependent on milk supply, whereas by 23 wk of age lambs were largely independent of the ewes' milk.

Jordan and Marten (1968) compared daily gain of Hampshire and Columbia twin lambs, suckling or weaned, on alfalfa-brome (*Medicago sativa*; *Bromus* ssp.) summer pastures. Ewes and lambs were maintained in drylot with creep access, then in early May were rotationally-stocked on pasture with no creep until paddocks were depleted in mid-summer. Lambs were either 8 or 12 wk old when divided into weaned or unweaned treatment groups at the start of paddock grazing. Unweaned lambs gained .09 lb/d faster than weaned lambs. In addition, unweaned ewes and lambs required only 75% of the acreage required by weaned ewes and lambs. Older unweaned lambs and their dams may have been competing for forage by mid-summer, however: daily gains of weaned and unweaned lambs over the three years were .37 and .48 lb/d, respectively, for lambs started at 8 wk, and .31 and .40 lb/d, respectively, for lambs started at 12 wk.

Understanding the influence of nutrition, before and after weaning, on changes in daily gain gives more insight into research indicating that earlier-weaned lambs fed in drylot are less affected by weaning age. Pope et al. (1984), for instance, weaned western white-faced lambs at 72, 98, or 129 d. While daily gain to weaning did not differ between weaned groups, daily gain in feedlot was $.07 \pm .02$ lb greater for lambs weaned at 72 d than for lambs weaned at 98 or 129 d. Age at slaughter was significantly less for the earlier-weaned lambs: 181.4 ± 3.7 , 198.8 ± 4.3 , and 204.0 ± 3.9 d for lambs weaned at 72, 98, and 129 d, respectively. Similarly, Hinds et al. (1960) reported no significant difference in daily gain of single and twin lambs weaned at 6 or 9 wk of age and fed in drylot both before and after weaning. These drylot results suggest that post-weaning rations balanced to meet nutritional needs are adequate to maintain pre-weaning growth rates after lambs are 6 to 9 wk of age.

Internal parasites

The negative effects of parasitism on market lamb production on pasture are well documented (Brown, 1964), and are an additional consideration in decisions concerning grazing management of weaned or unweaned lambs.

The dam has both positive and negative contributions to the effects of internal parasites on grazing lambs. In his review of literature on early weaning of lambs, Brown (1964) noted that the ewe's milk contributes to the control of parasitism in the lamb by deferring grazing and reducing the number of parasites ingested. After 7 wk of age, lambs suckling dams with low milk yield ingest higher quantities of herbage than lambs suckling high-yielding dams ($P < .05$; Gibb et al., 1981). Single lambs, with greater milk ingestion than twins, tend to be less subjected to parasite burdens (Barnicoat et al., 1956; Brown, 1964), and with a better nutritional status, may be better equipped to withstand the effects of parasite infection.

The ewe, however, is also the primary source of internal parasite infection. Lewis et al. (1972) weaned Merino lambs at 3, 6, or 12 wk of age; lambs grazed before and after weaning on *Phalaris tuberosa*-white clover pastures. Lambs were not treated with anthelmintic and larval populations on pasture herbage were near zero before entry of weaned lambs. Fecal egg counts were made on lambs starting at 60 d of age and every 3 wk thereafter. Mean fecal egg counts (eggs per gram, epg) peaked for *Haemonchus contortus*, *Ostertagia* spp., and *Nematodirus* spp. at 84, 14, and 22 epg, respectively, for lambs weaned at 3 wk; 6, 10, and 60 epg for lambs weaned at 6 wk; and 3,730, 134, and 1,234 epg for lambs weaned at 12 wk. These results indicate that the lactating ewe was a primary source of parasite infection in grazing lambs. However, in spite of much greater parasite burdens, lambs weaned at 12 wk were significantly heavier at 17 and 37 wk of age than lambs weaned earlier. Additionally, stocking rates of ewes and lambs were tested at 4, 8, and 12 ewes/ac, but had no significant effect on either lamb fecal egg counts or lamb weights.

Lewis et al. (1972) also monitored a control group of lambs weaned at 3, 6, or 12 wk of age and treated with anthelmintic drench at weaning and every 3 wk thereafter. These lambs, however, were grazed on pastures with high residual levels of parasite infestation; egg counts revealed "substantial acquisition of infection" regardless of age at weaning (data not presented). Seventeen- and 37-wk weights of drenched lambs did not differ from the average 17- and 37-wk weights of undrenched lambs, emphasizing

the effect of contaminated herbage on level of parasite infection in grazing lambs.

The physiological effects of parasite infestation were examined by Watson (1991). Single Merino lambs were weaned at 8 wk of age or remained with their dams; all ewes and lambs grazed the same pasture. In the first year of the study, lambs acquired helminth infection naturally; in the second year lambs were given a single oral dose of 5,000 *H contortus* and 10,000 *T. colubriformis* larvae at 8 wks of age (concurrent with weaning). Lambs were immunized with ovalbumin or *B abortus* cells to test antibody reaction to heterologous infection, or with extracts of *H contortus*/*T colubriformis* larvae to test antibody reaction to homologous infection. Lamb weights of unweaned lambs were greater than those of weaned lambs at both 12 wk of age ($P < .01$) and at 15 wk ($P < .001$).

Fecal egg counts did not differ in the first year of moderate parasite contamination on pasture, but in the second year (experimental infection) peak mean egg counts were 24,000 and 12,000 epg for weaned and unweaned lambs, respectively at 12 wk of age ($P < .001$). By wk 13, however, fecal egg counts had stabilized at approximately 10,000 epg for both groups. Packed cell volumes for the weaned lambs was lower than for unweaned lambs at 13 wk ($P < .001$) and at 16 wk ($P < .05$).

Concentrations of anti-ovalbumin and *B abortus* antibody in serum did not significantly differ at any point between groups. However, following infection with *H contortus*/*T colubriformis* antigens at 8 wk, antibody responses occurred at 10 wk in unweaned lambs, but were delayed until 12 wk in weaned lambs; antibody profiles in weaned lambs were lower for both parasite extracts ($P < .001$). These results indicate that the impact of a single challenge dose of parasite antigen may be short-lived in terms of fecal egg count, but other effects on lamb health, as seen in packed cell volumes and antibody responses, may be of longer duration. The authors concluded that at 8 to 12 wk of age, suckled lambs had an earlier and stronger response to a parasite challenge than weaned lambs.

Lambs do develop resistance to parasite infection. Gibson and Parfitt (1972) orally dosed eight groups of three weaned lambs each with 2,000 larvae/d of *Trichostrongylus colubriformis* 5 days/week over a 36-wk period,

beginning when lambs were 8, 12, 16, 20, 24, 32, or 36 wk old. Fecal egg counts (FEC) and lamb weights were taken weekly, and worm burden was measured at autopsy at the end of 36 wk of larval dosing. In lambs dosed beginning at 8 or 12 wk, FEC rose throughout the 36-wk period to greater than 15,000 epg and worm counts at autopsy averaged 75,492. In lambs dosed first at 16 or 20 wk, FEC rose to a high plateau (10,000 to 15,000 epg) and worm counts at autopsy averaged 47,930. Half of the lambs in these groups showed evidence of an immune response, with declining FEC after 15 wk. In lambs dosed first at 24 or 28 wk, FEC rose to a plateau of 5,000 to 10,000 epg, and all lambs showed an immune response by 20 to 25 wk. Worm counts at autopsy averaged 17,261. Lambs dosed first at 32 or 36 wk had FEC plateauing at 5,000 epg within 30 to 35 wk, and worm counts averaging 15,288.

Lambs that developed no resistance (exposed at 8 and 12 wk) lost weight during infection. Lambs that developed a strong resistance (exposed at or after 20 wk) had a period of reduced weight gain but did not stop gaining weight. The ability to resist helminth infection thus appears to increase with age, although strong resistance does not develop until at least 16 wk of age, and even resistant lambs do suffer some effects from infestation.

Immune response to helminths appears to be species-specific. Merino wether lambs weaned at 4 mo of age exhibited resistance to *Ostertagia circumcincta* and *T. colubriformis* only after 8 mo of age, whereas the same lambs developed resistance to *H. contortus* as early as 4 mo of age (Barger, 1988).

Interestingly, resistance to *H. contortus* in these same Merino lambs was lost completely following treatment with anthelmintics (levamisole and oxfendazole at twice manufacturers' recommendations). Worm burdens of drenched lambs were greater ($P < .05$) than those of undrenched lambs. The authors noted that similar results had been presented in previous studies, wherein lambs whose "priming" parasite infections were removed by anthelmintic administration were as susceptible to challenge infections as unprimed lambs. Based on these studies, the authors recommended that anthelmintic treatment of lambs during an outbreak of haemonchosis "may

be particularly dangerous unless the treated lambs are moved immediately to a clean pasture."

Millet and warm-season grasses

Warm-season annual grasses that utilize the C₄ photosynthetic pathway can be used to offset the mid-summer dormancy of cool-season (C₃) grasses in temperate regions. Pearl millet (*Pennisetum americanum* (L.) Leeke) is one such warm-season annual grass that may fill the mid-summer slump in forage available to grazing livestock. To date, no studies have been published on the performance of sheep or lambs grazing pearl millet. Anticipated performance may be surmised from a review of studies on the forage quality of warm-season grasses in general, and on *in vitro* and *in vivo* metabolism-crate trials involving pearl millet in particular.

Yield

On an annual basis, warm-season (C₄) and cool-season (C₃) grasses can produce similar amounts of forage. In trials over 3 years in two Missouri locations, forage yields were compared for four species of warm-season grasses (bermudagrass [*Cynodon dactylon*], Caucasian bluestem [*Bothriochloa caucasia*], Indiangrass [*Sorghastrum nutans*], and switchgrass [*Panicum virgatum*]) and two cool-season species (tall fescue [*Festuca arundinacea*] and reed canarygrass [*Phalaris arundinacea*]). The warm-season grasses averaged 3.20 tons forage/ac, 95.9% of which was produced between June 1 and August 31, while the cool-season species averaged 2.61 tons forage/ac, nearly 60% of which was produced before June 1 (Rountree et al., 1974).

There are no published reports of the total forage production of pearl millet, with the exception of a grazing trial conducted by Wheeler and Hedges (1972) that included pearl millet in one year. Stand establishment was very poor (.9 plants/ft²), and although total available forage at the start of grazing was 1.17 tons DM/ac, 91% of that available forage was weeds.

An experiment station report from Colby, Kansas (Schwulst and Robertson, 1980) showed that three varieties of pearl millet (Millex 23, Mil Hy 100, and Pearlex 24), planted in early June on irrigated pastures, were grazed from July 31 to August 28. Regrowth was grazed from August 31 to October 22. Grazing days/acre ranged from 1,357 to 1,884 for Millex 23 and Pearlex 24, respectively, and averaged 1,602 for all 3 varieties.

Chemical composition

Forage quality of warm-season grasses (as defined by protein, energy, and fiber content, digestibility, and intake) tends to be lower than that of cool-season grasses at similar stages of growth. In Pennsylvania, switchgrass (C_4), big bluestem (*Andropogon gerardi*, C_4), and fescue (C_3) hays harvested at the early head stage yielded 7.1, 8.1, and 11.3% CP on a dry matter (DM) basis (Vona et al., 1984). Missouri studies of clipped grasses indicated that two species of C_3 grasses averaged 2 to 12 percentage units higher in CP than four C_4 species (Rountree et al., 1974).

Studies also indicate that CP in warm-season grasses decline as either season or maturity progresses. An Indiana trial of pearl millet (Cherney et al., 1990) showed CP concentrations dropping from 12.8% at first cutting in August to 10.2% at second cutting in September. Both Vona et al. (1984) and Griffin et al. (1980) reported that delaying harvest (thus harvesting more mature plants, particularly past early head emergence) decreased CP between .5 and 1.5 percentage units.

Hollingsworth et al. (1991), however, found that pearl millet leaves contained higher CP concentration and higher *in vitro* organic matter digestibility (15.2% CP and 63.9% IVOMD) than pearl millet stems (11.0% CP and 59.3% IVOMD). Also, the extrusa of fistulated steers grazing millet was 14.7% CP and 63.3% IVOMD. This implies that grazing livestock might preferentially consume leaves and therefore actually have a higher CP intake than *in vitro* tests would indicate.

Warm-season grasses also tend to have a higher fiber content than cool-season grasses. Switchgrass, big bluestem, and fescue harvested at similar stages of growth (early head stage) in Pennsylvania yielded 74.3,

77.5, and 60.2% NDF, respectively (Vona et al., 1984). When the same three species were harvested at the same calendar date (July 14), NDF was 73.9, 71.9, and 64.3%, respectively (Griffin et al., 1980). Thus in mid-summer fescue had a higher fiber content relative to the warm-season grasses. The NDF fraction appears to change little, however, as the warm-season grass matures past the vegetative growth stage (Cherney et al., 1990; Griffin et al., 1980; Vona et al., 1984).

Griffin et al. (1980) found that big bluestem and switchgrass had significantly higher DE values than fescue (1.3, 1.3, and 1.16 Mcal/lb, respectively) when all were harvested on July 14. By July 29, calculated DE values for bluestem and switchgrass had declined to 1.11 and 1.13 Mcal/lb, respectively, suggesting that DE values declined as plants matured and lignification increased.

Digestibility

Digestibility of DM, NDF, and CP tend to be lower in warm-season grasses than in cool-season grasses. Rountree et al. (1974) compared *in vitro* dry matter digestibility (DMD) of two cool-season grass species and four warm-season species (specified above). At first harvest, IVDMD averaged 68.5% for cool-season grasses and 57.0% for warm-season grasses. When digestibilities were determined for the whole growing season, IVDMD declined to 64.5% and 52.6% for cool- and warm-season species, respectively. Griffin et al. (1980) also reported that digestibility of warm-season grasses declined an average of 6.5 percentage units as forage matured from mid- to late July.

In vivo digestibilities parallel *in vitro* results. DM, NDF, and CP digestibilities of grass hays fed to mature crossbred wethers in metabolism crates were 66.1, 64.8, and 66.8%, respectively, for fescue and 52.6, 54.0, and 49.0% for switchgrass (Vona et al., 1984).

Griffin et al. (1980), however, found DMD to be higher for big bluestem and switchgrass than for fescue, for both *in vitro* estimates and *in vivo* metabolism-crate trials with 90-lb wethers. The authors attributed this result to the fescue's lower NDF and higher bulk density (g/cm³ forage),

suggesting that those diet characteristics would increase the rate of rumenal passage, and thus lower total digestibility.

Griffin et al. (1980) also noted consistent differences between *in vitro* and *in vivo* digestibility estimates. On the average, *in vitro* digestibility estimates were 17 percentage units lower than *in vivo* estimates, and the difference was consistent for both warm-season and cool-season grass hays. The authors suggested that this difference may be because the first stage of the *in vitro* process allows only 48 h for fiber digestion. In the *in vivo* process, rate of passage would be slower with high-fiber diets, thereby increasing the time available for fiber digestion.

Intake

Intake may be a limiting factor in the potential use of warm-season grasses by sheep. Vona et al. (1984) reported that *ad libitum* dry matter intake (DMI) and digestible dry matter intake (DDMI) for mature wethers were 74.8 and 39.2% of body weight (BW), respectively, for switchgrass in the early head stage of growth, while DMI and DDMI for fescue at the same growth stage were 82.2 and 54.3% of BW, respectively. Furthermore, stage of maturity influenced both DMI and DDMI, as intake declined significantly between the late vegetative and early head growth stages of two species of warm-season grass hays tested (switchgrass and big bluestem; Vona et al., 1984). Griffin et al. (1980) found DMI to be positively correlated with DDM ($r=0.91$) and CP ($r=0.95$), and negatively correlated with NDF ($r=-0.84$). Similarly, Vona et al. (1984) reported total intake to be correlated with DDM ($r=0.60$).

Griffin et al. (1980) found that 90-lb wether lambs fed warm-season grass hays (2 species from 2 test locations) in metabolism crates had CP intakes of .18 lb/d, approximately half the recommendation for animals of that type (NRC, 1985). The authors suggested that although the lambs might not have experienced a protein deficiency at the tissue level for the short-term (i.e., mid-summer grazing) period, these low CP levels may result in sub-optimal levels of available N for rumen microbial activity, thereby further reducing microbial fiber digestion.

Physical structure of warm-season grasses

As outlined in review articles by Akin (1989) and Swakon and Moore (1980), the physical or structural nature of a forage plant can have an impact on the digestibility and consequent voluntary intake of that plant. Lignin especially can have an anti-quality role, and is histologically revealed as linkages of phenolic constituents to hemicellulosic carbohydrates (Akin, 1989). These linkages form physical barriers to degradation of plant tissues. For example, the mesophyll of cool-season (C_3) grasses is readily degraded in the rumen, whereas the mesophyll of warm-season (C_4) grasses is degraded more slowly, due to phenolic entities in the C_4 mesophyll cell walls.

The leaves of warm-season and cool-season grasses vary more in their anatomies than do the stems of those grasses. Compared with cool-season grass leaves, warm-season grass leaves have greater proportions of lignified parenchyma bundle sheath and cuticle-covered epidermis; less mesophyll area but also more tightly-packed mesophyll; and a higher-density vascular tissue, which frequently also has more phenolic entities in the cell walls (Akin, 1989). All these characteristics of warm-season grasses form structural barriers to digestion, first by increasing the mastication required to reduce forage pieces to digestible size, and then by restricting the access of the bacterial enzymes and protozoan colonies required to degrade forage particles in the rumen. Cherney et al. (1990) compared digestibilities of normal pearl millet and a low-lignin mutant variety when both were fed to 6-mo-old wether lambs in metabolism crates, and found that lignin and DMD were negatively correlated ($r = -0.71$). (However, as noted above, longer retention times of the warm-season fibers may lower intake but also improve digestibility.)

The longer rumen retention time required for the larger and more indigestible warm-season grass tissues may consequently reduce voluntary intake of those grasses. Swakon and Moore (1980) cited a study which showed that an increase in lignified tissue was related to decreases in both OM intake and digestibility ($r = -0.72$ and $r = -0.64$, respectively). Thus the higher percentage of indigestible or slowly-digestible fiber of warm-season

grasses may limit both nutrient digestibility and intake, and consequently limit the extent of their use as a livestock forage. To optimize nutrient intake by livestock, warm-season grasses must be managed to limit stand maturity and maintain high leaf proportion.

Alkaloids

Intake of pearl millet can be affected by alkaloids, secondary metabolites that originate from amino acid metabolism and contain basic nitrogen (Barnes and Gustine, 1973). Alkaloids have been associated with reduced palatability in other grass species, particularly reed canarygrass. Krejsa et al. (1984) tested 11 cultivars of pearl millet in the vegetative growth stage for alkaloid levels. Whole-plant alkaloid levels ranged from .0017 to .0101% of DM. Leaf blade alkaloid levels ranged from .0019 to .0132% of DM, while stem plus sheath levels were much lower and varied less, from .0012 to .0023% of DM.

Alkaloid content in drought-stressed pearl millet has been associated with reduced palatability. Rouquette et al. (1980) reported that cattle (*Bos taurus*) refused to consume pearl millet in drought-stressed fields in East Texas. Cattle were observed "biting the leaf-stem parts, chewing momentarily, and then expectorating the forage" without swallowing it. Other pearl millet fields that were readily grazed by cattle did not show visual drought stress. Tests on the pearl millet revealed a 46-fold difference in alkaloid concentration (from .0020 to .0460% of DM) between pearl millet from irrigated and non-irrigated fields. Furthermore, palatability appeared to improve dramatically following irrigation of drought-stressed stands.

A 5-day irrigation and N fertilization trial performed on Millex 24, a low-alkaloid pearl millet hybrid, resulted in leaf blade alkaloid concentrations of .0067% of DM in non-irrigated plants, .0037% of DM in irrigated plants, and .0049% of DM in plants that were non-irrigated for 2 d and then irrigated for 3 d (Krejsa et al., 1987). A positive relationship was found between increasing rates of N fertilization and total forage alkaloid concentrations ($r=0.72$).

Nitrates

Pearl millet also accumulates nitrates. Whole-plant nitrate concentrations ranged between .24 and .98% of DM in 11 pearl millet lines or cultivars (Krejsa et al., 1984). Mean nitrate concentrations were higher for stem plus sheath than for leaf blade (1.08 vs. .39% of DM). The researchers noted, however, that none of the total forage nitrate concentrations reached potentially toxic levels (described as 1.50% of DM in earlier studies). Toxicity potential would also be reduced if animals preferentially grazed pearl millet leaves over stems, as suggested by Cherney et al. (1990).

Krejsa et al. (1987) reported that total forage nitrate concentration was positively correlated with plant water status ($r=0.82$) and with N fertilization rate ($r=0.81$), but that nitrate concentrations of Millex 24 pearl millet only reached potentially toxic levels when plants were both irrigated and fertilized with at least 299 lb N/ac.

Brassicas

Brassicas as alternative forages

Forage availability in pasture-based sheep systems is often limited in mid-summer and in fall, as perennial cool-season grass and legume growth declines. These periods of insufficient forage may be relieved by reducing stocking rate, stockpiling forage, feeding stored feedstuffs, or by supplementing the permanent pastures with annual forages. Annuals may supplement perennial grass and legume growth in the summer or extend the growing season in the fall. The *Brassica* species have been used in Great Britain, New Zealand, and parts of the U.S., primarily as an autumn forage. Their value lies in their ability to provide a large amounts of highly digestible forage when the quality and quantity of permanent pasture are low or declining. Two brassica species that have been investigated for use in the eastern U.S. are turnip (*Brassica rapa* L. or *Brassica campestris*) and tyfon, a Chinese cabbage x stubble turnip hybrid (*B. pekinensis* (Lour.) Rupr. x *B. rapa* L.).

Grazing period and grazing days (GD)

Brassicas have primarily been used as a fall forage crop. Studies indicate that brassica forages can generally be grazed within 90 days after seeding, and will continue to grow and produce forage through the fall grazing season.

In Connecticut, Guillard and Allison (1984) clipped tyfon plots from October 12 to November 30 and reported peak DM yields on October 19, 84 d after the late-July seeding. Harvested foliage peaked at 5,400 lb/ac on October 19; root yields peaked at 1,800 lb/ac on November 23.

In 2 years of tyfon grazing studies in New Hampshire, Koch et al. (1987) seeded tyfon in late July and began grazing in late September or early October, an average of 72.5 days after seeding. Cut forage samples indicated that DM yield peaked in mid-November, approximately 120 days after seeding. Forage was stocked at thirty-six 66-lb lambs/ac and depleted by November 15 in the first year; in the second year stocking rate was reduced to 18 lambs/ac and tyfon was grazed until December 6.

In England, turnip was seeded in late July to mid-August and clipped from mid-October through late December; peak DM yields were registered at 117 d (3-yr average; Sheldrick and Lavender, 1981). Summer grazing of turnip in Montana was initiated on July 19, 58 d after seeding, and continued until September 20, (Thomas et al., 1990). DM yield peaked approximately 90 days after seeding.

Mature, 125-lb ewes were flushed and bred on turnip in Indiana for three years (Outhouse et al., 1980). In the first year ewes grazed turnip from October 4 to December 2, stocked at 20 ewes/ac (59 days, 1,180 GD/ac). Poor moisture at seeding slowed turnip growth in the second year, and delayed the start of grazing until October 31. Ewes grazed until November 17, stocked at 34 ewes/ac (17 days, 578 GD/ac). In the third year of the trial, seeding rate was halved from that of previous years (to 1.25 lb seed/ac). Dry weather in September again delayed turnip grazing until mid-October, when ewes were stocked at 13 ewes/ac until the end of turnip grazing on November 14 (35 days, 473 GD/ac).

Dry matter (DM) yield and content

Turnip trials in Pennsylvania in November, seeded at 1.5 lb/ac, had whole-plant DM yields averaging 5,307 lb/ac when sampled 60 to 90 days after seeding (Jung et al., 1983). Orchardgrass plots at the same location yielded 1,158 lb/ac. Turnips in Scotland, seeded at 6.7 lb/ac and sampled pre-grazing in autumn, yielded 5,529 and 6,723 lb/ac in 2 years of study (Paterson et al., 1977).

DM intake in turnips, however, is likely to be limited by low DM content. The NRC (1985), for instance, estimates only 14 and 9% DM in turnip tops and roots, respectively, while late vegetative orchardgrass is estimated to contain 24% DM.

Tyfon seeded at 3.5 lb/ac, and grazed in early winter in Connecticut, yielded 6,156 lb/ac, while stockpiled plots of bluegrass-white clover yielded 3,339 lb/ac (Guillard et al., 1988). Tyfon DM content for the tops and roots was 6.9 and 8.9%, respectively, while DM content for the grass-legume pasture was 34.4%. Guillard and Allison (1984) reported that tyfon yields in Pennsylvania increased 19% between October 12 and November 23; most of the increase was due to dry matter accumulation in the roots. At a seeding rate of 10 lb/ac, mean yield was 5,800 lb/ac.

Autumn-grazed tyfon in New Hampshire, seeded at 3.4 lb/ac, only yielded an average of 2,186 lb/ac over 2 years (Koch et al., 1987). DM content for the tops averaged the same as that of the Connecticut trial, but root DM content was higher and increased throughout the grazing period (late September through late November), from 10.8% to 14.2%.

Digestibility

In-vitro dry matter digestibility (IVDMD) was reported at 95 and 90% for Sirius turnip (*B. rapa* L.) tops and roots, respectively, in Pennsylvania (Jung et al., 1984). Comparable IVDMD for orchardgrass was 60% (Jung et al., 1983). IVDMD for tyfon in three separate trials was greater than 85% (Guillard et al., 1988; Guillard and Allison, 1984; Koch et al., 1987), and tended to increase as the grazing period progressed. Comparable grass-legume plots in New Hampshire had digestibilities of 55% (Koch et al., 1987).

Nutrient content and quality decline

Forage quality of brassicas declines as the season progresses, as the plant matures and as more leaf area is depleted. Tests on aerial portions of continuously-stocked summer turnips indicated that *available* DM declined from 2,471 lb/ac in mid-July to 448 lb/ac in mid-September, as lambs preferentially selected leaf over stem through the grazing period (Thomas et al., 1990). Protein content began at 16% of DM content and declined to 12%, while NDF increased from 16.4 to 29.7% of DM. Sheldrick and Lavender (1981) clipped samples of two varieties of stubble turnip over 3 years and estimated metabolizable energy of turnip tops at approximately 1.26 Mcal/lb DM. Crude protein of above-ground samples of roots and tops declined only slightly from 18.75% of DM in late October to 17.50% in late December. During that period DM harvested increased from 2,315 to 2,894 lb/ac.

It should be noted that DM and nutrients that might be available to foraging animals are underestimated in studies such as Sheldrick and Lavender (1981) and Thomas (1990), which only consider clipped or aerial portions of turnip crops and fail to include the nutritional contribution of fully-grazed tubers. In a 3-yr trial of hand-clipped turnip, Sheldrick and Lavender (1981) found that the proportion of whole-plant DM found in the root ranged from 14% at the start of grazing in mid-October to 34% by the end of the grazing period in late December.

Crude protein levels of tyfon tops averaged 16.6% (DM basis) in Connecticut (Guillard and Allison, 1984) and 18.8% in New Hampshire (Koch et al., 1987); root CP averaged 9.0% and 12.5%, respectively for the two studies. In both trials CP levels declined over the course of the October-November grazing period.

Guillard et al. (1988) estimated digestible energy of tyfon foliage and roots, and stockpiled grass-legume herbage, in mid-December, to be 1.54, 1.65, and 1.19 Mcal/lb DM, respectively.

Fiber concentrations of brassicas are low (less than 16%; Guillard et al., 1988). This has prompted some researchers to recommend that grazing

livestock be supplemented with a dry, low-quality roughage to avoid diarrhea.

Lamb growth

The majority of research on the performance of sheep grazing brassicas has concerned lamb growth. Reported lamb daily gains on *Brassica* species have been inconsistent. Young *et al.* (1982) reported that 5-mo-old Dorset Down x Masham lambs, grazing from October through January in England, had average daily gains of .01 to .16 lb/d on a stubble turnip hybrid (*B. campestris*). Gains varied significantly with forage allowance: lamb gains were reduced when forage allowance was limited and lambs were thus forced to utilize a greater percentage of available forage. Because organic matter intake did not vary with forage allowance, these results indicate that gains can be affected by the animals' ability to preferentially select forage.

Targhee x Finnsheep lambs grazing Green Globe turnips (*B. rapa* L.) through the summer in Montana gained .30 to .66 lb/d (Thomas *et al.*, 1990); at a stocking rate of 8.9 lambs/ac, 664 lb of lamb were produced per acre.

Koch *et al.* (1987) compared Dorset lamb gains on tyfon to gains in drylot in the late fall. Lambs grazing tyfon averaged gains of .47 and .55 lb/d in each of two trial years, while lambs fed 1.5 lb of 18% alfalfa hay and 1.6 lb corn and oats/d, gained .43 and .41 lb/d in the 2 years. Tyfon lambs did, however, have access to orchardgrass not killed by paraquat application, estimated to contribute 12.4 and 10.3% of overall DM yield for the 2 years, respectively. Also, the researchers noted that drylot lambs were slow to adjust to concentrate rations after being moved from pasture. Lamb gains/ac and lamb days/ac on tyfon were 557 lb/ac and 783 d/ac, respectively, for the first year, and 450 lb/ac and 642 d/ac for the second year.

Weight change in mature ewes

Guillard *et al.* (1988) compared gains from mid-November to mid-December of mature ewes in mid-gestation on tyfon, to gains of similar

ewes on stockpiled bluegrass-white clover pasture. Ewes on tyfon were supplemented with .5 lb grass hay (12% CP) daily to supply approximately 10% of their DM intake requirements. Over a 34-d grazing period, ewes on tyfon gained .48 lb/d, while ewes on stockpiled pasture lost .396 lb/d. This may not be a particularly useful comparison, however, as ice and snow during the course of the trial limited the ewes' access to the grass-legume pasture, and favored access to the higher-standing tyfon foliage.

Weight gain of ewes grazing turnip and/or grass pasture during fall breeding was examined for 3 years in Indiana (Outhouse et al., 1980). In the first year a 59-d grazing period began October 4. Ewes on turnip were stocked at 20 ewes/ac and gained .18 lb/d, while ewes on fescue were stocked at 10 ewes/ac, supplemented with .5 lb corn/d for the last 14 days of the period, and gained only .02 lb/d. In the second year of the study, stocking rate on turnip was increased to 35 ewes/ac for a 17-d grazing period that began on October 31; ewes lost .15 lb/d. A second group of ewes was allowed equal access to turnip and fescue, but was stocked at only 16.5 ewes/ac, and lost .24 lb/d.

In the third year of turnip grazing, turnip was seeded at one-half the rate of the first 2 years (1.25 vs. 2.50 lb/ac), and ewes were stocked on turnip at 13.5 ewes/ac for a 35-d grazing period that began in late October. Ewes on turnip (unsupplemented) gained .13 lb/d, while ewes on turnip supplemented with .25 lb corn/d gained .18 lb/d. Control ewes on bluegrass pasture (10 ewes/ac), supplemented with .25 lb corn/d, gained .26 lb/d. These 3-yr results suggest that unsupplemented dry ewes, stocked at approximately 20 ewes/ac, can gain nearly .18 lb/d on fall turnip seeded at 2.5 lb/ac, thus requiring much less land than ewes grazing perennial grass pastures at the same time.

Transition period

Overall animal gains in many studies appear to be reduced during an initial period when animals are reluctant to graze the novel Brassica forage. Thomas et al. (1990) reported that for the first 2 weeks of a 9-week grazing trial, lambs preferred grass at the field edge, moving to graze Brassica leaves only when the supply of grass and pigweed had been depleted.

Similarly, lambs in an English trial (Young et al., 1982) all lost weight in the first 15-d period of the 2-month trial.

Dry ewes grazing turnips in Kansas in July were also initially reluctant to graze turnips (Schwulst and Banbury, 1979). The ewes consumed "every weed" before starting to graze the turnip tops, then consumed all the foliage, and then "experimentally nibbled the turnip roots for half a day" before starting full grazing of the tubers.

Guillard et al. (1988) enhanced tyfon forage utilization and ewe daily gains by feeding increasing amounts of harvested tyfon in drylot for 7 days before releasing the ewes to graze the tyfon paddocks.

Intake and forage allowance

As indicated above, animal performance may also be affected by daily forage allowances. When access to turnip DM was restricted to an intake of 4% of live body weight (LBW), lambs grew significantly slower than lambs allowed access to 6 and 8% of LBW (Young et al., 1982), although there was no difference in actual daily organic matter intake. This suggests that with limited access to forage, although intake is adequate and percentage of crop utilization increases, selectivity decreases and thus may lower animal performance. Paterson et al. (1977) also found that forage utilization of turnips increased but growth rate of lambs decreased with increased stocking rates.

There are few or no reports on actual forage DM intake of ewes grazing brassicas. The Agricultural Research Council (ARC, 1980) reviewed studies of DM intake of lactating ewes. Sheep do not reach maximum intake until peak milk yield has passed. Studies surveyed indicated that maximum DM intake peaks at 5 to 6 weeks post-parturition if ewes are consuming a pelleted diet and at 8 to 10 weeks post-parturition if ewes are on a long hay diet. Ewes suckling twins on pasture herbage diets will consume approximately 10% more DM than ewes suckling singles. The ARC reviewed six studies on DM intake of lactating ewes on pasture. Results ranged from 83 to 134 g DM/kg $W^{.75}$, and averaged 106 g DM/kg $W^{.75}$, which equals 6.25 lb DM/d for an 176 lb ewe suckling 1.5 lambs.

Antiquality constituents

Animal performance may be affected by antiquality constituents found in Brassica crops. For instance, glucosinolates found in brassicas release thiocyanate (SCN^-) when chewed; SCN^- inhibits thyroid uptake of iodine and causes goiter in ruminants (Guillard and Allison, 1989; Young et al., 1982). Guillard and Allison (1989) found SCN^- concentrations to be higher in *Brassica* root than in foliage, although concentrations varied by species and by cultivar.

Brassicas also contain S-methyl cysteine sulfoxide (SMCO) which appears to cause anemia in ruminants, including sheep (Smith and Greenhalgh, 1977; Young et al., 1982). Young et al. (1982), however, reported no correlation between lamb growth and high levels of SCN^- or SMCO, in spite of measurable low-grade anemia and goiter. This suggests that although these factors may modify growth, they are not necessarily the first or most important limiting factors. Possible subclinical effects of SMCO on lactation in diets that include brassicas may exist but have not been quantified.

Brassicas also accumulate nitrate-nitrogen (NO_3^- -N). Toxic doses for sheep have been indicated at .007% of BW. Guillard and Allison (1989) found that turnip and tyfon NO_3^- -N concentrations were significantly higher in autumn than in summer. For example, turnip leaves had concentrations of .0828% in the autumn vs. .0054% in the summer; root concentrations were .2065% in the autumn vs. .0589% in summer. Guillard and Allison (1989) reported that 175-lb sheep in previous trials consumed approximately 3.3 lb DM/d of fall-grown Brassica herbage. This would certainly suggest that toxicity values for NO_3^- -N would have been exceeded.

However, in a review of research on livestock nitrate toxicity, Wright and Davison (1964) question the real effect of ingestion of sub-lethal nitrate concentrations on livestock growth and milk production. The authors cite numerous studies, conducted in the 1950's and 1960's, indicating that neither rate of gain nor milk production were reduced in cattle or sheep

unless there was also a decline in feed consumption or a near-lethal nitrate dose. Furthermore, high concentrations of soluble carbohydrates in Brassica forages may dilute the potential nitrate toxicity by increasing nitrate reduction rates by rumen microbes (Wright and Davison, 1964; Guillard and Allison, 1989).

Effects of fertilization

Brassica crop yields and nutritional value can be influenced by fertilization. Jung et al. (1984) used a factorially-arranged set of treatments to evaluate effects of increasing levels of N and P (from 0 to 132, and from 0 to 53.4 lb/ac, respectively) applied to Sirius turnip (*B. rapa* L.) seeded at 1.25 lb/ac. Increased rates of N application (60 days after seeding) increased DM yield linearly from a mean of 2,089 lb/ac to 3,117 lb/ac. Increased rates of P positively influenced yield only when N application had increased yields to approximately 3,117 lb/ac. Increased N increased yields of foliage more than that of roots. Increasing N had a positive effect on CP of both roots and tops, while increasing P had a negative effect. CP ranged from 6.0% DM with no N or P inputs, to a peak of 25.0% DM with optimum N and P fertilizer combinations.

Tyfon foliage DM yield increased curvilinearly with increased N rates, while root yields declined (Guillard and Allison, 1988). Yield responses to greater than 49.9 lb N/ac were very small. Increased levels of N fertilization also decreased DM content, and increased CP and NO_3^- -N concentrations.

Sod suppression

Seedling establishment of *Brassica* species is compromised by unfavorable environmental conditions, such as high or low temperatures and weed competition. Weeds or surrounding sod (if seeding is no-till) must be suppressed during the period of initial seedling establishment. Jung et al. (1984) reported that grass yield in paraquat-treated (no-till) plots was twice as high as in glyphosate-treated plots. Turnip DM yield was consequently 75% higher in the glyphosate-treated plots.

Germination

The best germination for most Brassica species and cultivars appears to occur between temperatures of 50 and 95°F; germination is depressed sharply below 41°F and above 95°F (Wilson et al., 1992). Under controlled temperatures ranging from 35 to 122°F, turnip cultivars had the best germination rates of various *Brassica* species at 4 and 14 days, with a consistent 79% germination at 50 to 95°F. Tyfon had the worst rate, averaging 58% from 50 to 86°F, and dropping to 44% when temperatures reached 95°F.

Researchers note that lack of moisture at germination has a detrimental effect on crop establishment (Jung et al., 1983; Sheldrick and Lavender, 1981).

Economic analysis of sheep production systems

The majority of sheep production studies are concerned with comparisons of biological traits, such as reproductive performance, growth, carcass characteristics, or wool production. Some have added economic values to the comparisons to indicate a financial advantage attributed to a particular change in the production system. Few, however, have concerned themselves with the difference in cost, that inevitably accompanies a change in production. Dickerson (1970) suggested that the value of a change in performance, and consequently the biological objectives of a livestock production system, should be assessed by improvements in the *efficiency* of production, that is, the relationship of production cost to animal product.

Income and expense relationships

In deriving economic values for biological traits, Ponzoni (1988) stated that costs (Expenses) and revenues (Income) can be related in either of three ways: as profit (I-E), as return on investment (I/E), or as cost per unit of production (E/I). He proposed that ultimately the choice of

management strategy will be only negligibly affected by whether Income and Expense are related as a difference or as a ratio.

Yet the same product or system can be valued very differently according to what cost items are included or what unit of production is used as the basis of comparison. For example, using the ewe as the unit of production in the denominator (i.e., lamb income per ewe) ignores the impact that her weight or level of productivity would have on feed intake and cost (Hohenboken, 1986). Comparisons of production systems can be affected by breed type used, as environmental factors such as temperature or parasites can differentially affect breed types within the same system (Saoud and Hohenboken, 1984). Perceived efficiency can be affected by the inclusion or exclusion of variables (such as attrition rate, labor inputs, stocking rates) that might vary with breed or production level. Thus results and interpretations can be influenced by the choice of factors included in the analysis. Also, as many production traits have interactive effects, they would be best evaluated when integrated into a larger production system, where the effect of interaction can be assessed.

Hohenboken (1986) suggested that the most "valid" conclusions concerning the value of a production characteristic would incorporate the highest proportion of quantifiable costs. Thus gross margin per ewe (gross returns minus variable costs) would convey more information than simple revenue generated per ewe. Similarly, net revenue (gross returns minus variable and fixed costs) may be more informative than gross margin. But Hohenboken (1986) also noted that as more costs, particularly fixed costs, are included, the results become "more region, management system, and time specific"; conversely, simple biological results may be more applicable to a wider range of systems and for a longer period of time.

Revenues affecting production/economic efficiency

In a study of the production economics of 419 upland and lowland sheep flocks in Britain, Kilkenny and Read (1974) found that output/ewe (lambs weaned/ewe exposed) was the major factor affecting gross margin. Furthermore, the number of lambs born/ewe lambing was the largest source of variation in the number of lambs weaned and sold.

Flanagan et al. (1979) compared gross margins of Irish Galway and 3/4 Galway-1/4 Finn ewes for 2 years, and reported a 12.9% increase in gross margin/ewe lambing for each extra 0.1 lamb born/litter. This parallels Dickerson's (1970) suggestion that increased rate of reproduction (to the next unit, N) reduces total ewe costs per lamb by approximately $1/N$, assuming minimal increases in female feed costs as production increases.

When comparing the lifetime net revenue per ewe (lamb sales minus estimated feed and ewe purchase cost) of eight crossbred ewe types in irrigated- or hill-pasture management systems, Saoud and Hohenboken (1984) found that variation among ewes in gross income was more important than variation in costs in explaining differences in net revenue among ewes. Generally, within a crossbreed group or management system, the ewe with the highest gross income also had the highest net revenue, and vice-versa.

Thonney et al. (1979) used a computer program to simulate sheep production systems and to evaluate management alternatives. Management varied by lambing season (early to late spring), lambing percentage (125, 150, and 175%), and market age of slaughter lambs (20, 24, and 28 weeks). The costs associated with feed energy requirements, labor, equipment, facility overhead, and interest on operating capital were treated as model components. Lamb sales were the only revenue source that was a function of the management system. Fixed costs were combined and assigned a value, as were wool and cull ewe revenues. Profitability of a management system was expressed as net income (total returns minus total costs).

Simulation results indicated that within lambing seasons, net income increased as lambing percentage increased from 125% to 175% (Thonney et al., 1979). This was because of greater returns from lamb sales, and in spite of decreased market weights and increased feed, labor, and interest costs. Because market weights increased with market age, net income also increased with market age (20 to 28 weeks), although not linearly, because of costs associated with lengthened time maintaining lambs, i.e., feed, labor, and interest charges. The model did not, however, evaluate the

economic impact of interactions between lambing season, lamb drop percentage, and market age.

Valuing income sources

Value can be assigned to lamb and wool sales in a number of ways. Some studies have simply assigned the market values current during each of the years for which the studies were conducted (Barr et al., 1968; Flanagan et al., 1979).

With the simulated systems model, Thonney et al. (1979) determined market prices by selecting a base slaughter lamb price from the last year of the study, and combining the base price with average monthly fluctuations at major midwestern and western markets over the 3 previous years. In Oregon studies (Levine et al., 1978; Saoud and Hohenboken, 1984), lamb prices assigned were the 4-year averages of feeder lamb prices at local sales from mid-May to mid-June, and differentiated between the values of whitefaced and blackfaced lambs.

Wool sales have been inconsistently included as an income source in different studies. Levine et al. (1978) assigned wool prices by averaging 4 years of local wool pool prices, although incentive payments on wool and unshorn lamb were calculated using the ASCS payments for only the last year of the study.

In their 5-year evaluation of lifetime ewe production, Saoud and Hohenboken (1984) did not include wool income in the calculation of net revenue, showing that wool sales did not affect the relative ranking of crossbreed types or management systems. This was surprising, as the trial included the more prolific Finn-cross ewes: the incentive payments on unshorn lamb are awarded per hundredweight of lamb sold and would therefore increase with the number of lambs marketed per ewe or per acre. Similarly, although Thonney et al. (1979) did assign some constant wool credit on a per ewe basis, they did not consider wool incentive payments as revenue sources, in spite of increasing lambing percentages from 125 to 175%.

Replacement costs

Economic analysis studies have assigned ewe replacement costs to their respective systems in a variety of ways. For the purpose of simply comparing breed type and management system production, Levine et al. (1978) assumed all lambs were terminal, and charged no replacement costs to the system. But flock replacement costs in Kilkenny and Read's (1974) British survey averaged 34% of direct (variable) costs. Many economic evaluations assume no difference in attrition between among ewe groups and therefore assign a constant value to replacement costs. In their simulation model, Thonney et al. (1979) figured a constant 13% of all ewe lambs would be retained as replacements, based on estimated death loss and culling level of ewes.

A constant replacement rate may be accurate in some circumstances. Ercanbrack and Knight (1989) examined natural attrition, as measured by final age, in a study of spring-lambing ewes managed under Idaho range conditions. There was no significant difference in attrition between purebred ewe groups (Rambouillet, Targhee, Columbia), or between groups that differed significantly in level of lamb production (purebreds, $\frac{1}{2}$ -Finns, and $\frac{1}{4}$ -Finns).

Saoud and Hohenboken (1984), however, reported that the percentage of Suffolk-cross ewes that survived a 5-year trial in an Oregon hill pasture system was consistently lower than the percentage of surviving Columbia-cross ewes. There was no consistent breed type difference in ewe survival on the less rigorous irrigated pasture system. The authors thus included a constant ewe purchase cost in the production costs; then a ewe salvage value, based on actual market value, was granted to ewes still present at the end of the 5-year trial.

Labor costs

Labor as affected by management system is also inconsistently considered among economic evaluations. In Ireland, Flanagan et al. (1979) included 4 weeks of "casual labor" in the direct costs of both purebred and $\frac{1}{4}$ -Finn-Galway flocks. The similar labor inputs may have been because the

difference between 135 and 170% lamb drops in small flocks were not enough to warrant increased labor at lambing.

Saoud and Hohenboken (1984) did not include any labor costs in their determination of net revenue from different crossbred types and management environments. This decision was in spite of the significant differences in lambing percentages, as reported by Hohenboken and Clarke (1981). Average cumulative (5-year) lamb drop ranged from .79 lambs/Cheviot-cross to 1.64 lambs/Finn-cross ewe on irrigated pastures, and from .94 lambs/Romney-cross to 1.39 lambs/Finn-cross ewe on hill pastures.

Levine et al. (1978) did include "variable labor costs" along with supplemental feed costs, ewe depreciation, and interest costs in their estimation of net return per ewe. Net return was then multiplied by the stocking rate per acre for each breed type in the calculation of net return above variable costs per acre. Labor costs were derived from Oregon Extension Farm Management's Enterprise Cost Studies, and were not detailed in the publication.

Thonney et al. (1979) included labor as a model component in their simulation of production system economics. Lambing-time labor (allotted for lambing, castrating, docking, and data recording) was .55 hr/ewe in the January lambing, .50 hr/ewe in the February lambing, and .25 hr/ewe in the pasture lambings that began in March and April. Lambing labor also increased with lambing percentage: .45, .50, and .55 hr/ewe for 125, 150, and 175% lambing percentages, respectively.

The gross margins (fleece and carcass revenues minus undetailed variable costs) of half-Finns, Border Leicester halfbreds, and straight-bred Romneys were compared in New Zealand (Sorrenson and Scott, 1978). Gross margin of the ½-Finns averaged 18% and 55% higher than the Leicesters and Romneys, respectively. Additional labor costs for the management of ½-Finns at lambing time reduced the advantage to 15 and 51%, respectively, assuming the same stocking rate for all breeds.

Nitter (1987) cited a study that quantified labor costs associated with three different lambing management systems in Germany: intensive/housed and pasture-based, both with artificial rearing of triplets and orphans, and

traditional extensive migratory, with no artificial rearing and a high lamb mortality. Labor costs (in Deutschmarks, DM) per litter for the three systems were 12.5, 9.2, and 12.6 for single lambs, 31.2, 31.8, and 23.3 for twins, and 51.2, 59.0, and 29.8 DM for triplets, respectively. In this German case, real labor costs increased both with litter size and on a per-lamb basis with an increase in litter size. This differs from labor requirements estimated by Thonney et al. (1979), wherein lambing percentage increased at a faster rate than labor allotted for the greater number of lambs.

Feed and forage costs

Kilkenny and Read (1974) estimated that forage and concentrate costs accounted for 53% of the direct (variable) costs of production of the 419 sheep flocks surveyed in Britain. Comparisons were made between the most efficient one third of the flocks (in terms of gross margin/ac) and average flocks in the survey. Feed costs/ewe exposed for the top third were, on average, 12.5% lower than average flocks, largely because of less concentrates fed (12% difference), although the top third maintained 14% higher lamb revenues/ewe exposed.

To estimate feed costs of simulated production systems, Thonney et al. (1979) estimated digestible energy requirements for maintenance, gain, gestation, and lactation. Energy requirements of ewes and lambs were supplied and priced as combinations of alfalfa hay, barley, and corn (\$/lb), and irrigated grass pasture and turnips (\$/ac). When the profitability of differing lambing seasons was assessed, feed and overhead costs had a greater influence on net income than did other cost or return factors. Feed costs for lambing seasons starting in January, February, April, and May were \$3,874, \$3,836, \$3,232, and \$2,968, respectively, per 100-ewe flock. Feed costs declined as fewer supplemental feedstuffs were fed on pasture. It should be noted, however, that the authors did not vary lambing percentage with lambing season. Consequently, returns from lamb sales varied little and had little affect on perceived differences in seasonal profitability.

Saoud and Hohenboken (1984) estimated ewe feed costs for Columbia- and Suffolk-cross ewes (sired by Cheviot, Dorset, Finn, or Romney rams) managed on either irrigated or hill pastures. Estimated ME requirements were based on ewe weight at breeding, the number of lambs gestated and reared, and annual ewe body weight change. Average cost (Mcal of ME) was calculated by partitioning annual feed intake into 89% pasture, 5.6% barley, and 5.4% legume hay. Hay and barley prices were derived from a 5-year average from state commodity data sheets; pasture cost was the price of hay/ton minus the estimated cost of hay making and handling.

Because feed requirements were based on ewe weight and adjusted for productivity (Saoud and Hohenboken, 1984), crossbreed types did differ in feed cost ($P < .05$). However, the difference in annual Mcal ME/ewe was only 13% per 22 lb body weight on a gestating, nonlactating ewe basis. But from a base of zero lamb production, bearing and weaning one, two, or three lambs required 55, 80, and 95% more energy/yr, respectively. There was also significant crossbreed type x management system interaction, as Finn-Suffolk and Romney-Suffolk ewes incurred more feed costs on irrigated than on hill pasture, and Cheviot-Columbia ewes incurred more feed costs on irrigated pasture.

Levine et al. (1978) determined pasture and feed intake by computer simulation for Columbia and Suffolk-type range ewes and their crossbred lambs on Oregon hill pastures. Intake was based on ME requirements for ewe and lamb weight, adjusted by stage of production. Cost of pasture was the net worth of pasture for hay production. A supplemental feed ration of 50% grass hay, 25% alfalfa, 5% molasses, and 20% grain mix was fed (hypothetically) from November to mid-March; cost assigned to this ration was a 4-yr average price paid by the University sheep operation. Suffolk ewes had greater net return above feed costs: total nutrient costs for Suffolk ewes were greater by \$3.22/ewe exposed than for Columbias, but were offset by a \$4.34/yr Suffolk advantage in gross income over Columbias.

Lambing season comparisons were made by Barr et al. (1968) in West Virginia, who recorded revenues (wool and market lamb sales) and expenses

(grain, hay, and worm drench costs) for 144 grade ewes bred to lamb in spring or fall for 3 years. Net income/ewe exposed was 77% less in the fall-lambing than in the spring-lambing system. Although market prices were higher for fall-born lambs, reduced conception and lambing percentage resulted in only 78.4 lb fall-born lamb sold/ewe exposed, compared to 126.2 lb spring-born lamb sold/ewe exposed. Additionally, ewes and lambs in the spring-lambing system consumed an average of 68 lb grain and 361 lb hay/ewe exposed, while fall-lambing consumption was 201 lb grain and 355 lb hay/ewe exposed.

However, in this West Virginia study, lambs born in the spring (March and April) were apparently not subject to any environmental stresses such as parasites ("lambs were sold before any drenching was needed"), heat, or dormant pastures, and the results of these frequent spring and summer disadvantages were not seen in the economic results. Coombs et al. (1990) noted that variability in production costs (in beef cattle stocker and finisher trials) were greater for high-forage than for highly-supplemented systems, due to the effects of variability of climate, forage, soil type, and management on production.

Production per unit area of land

Kilkenny and Read (1974) described stocking rate as a major factor in economic efficiency, because "land is normally the scarcest and most expensive resource". The authors suggested that in many cases stocking rate could be increased without adversely affecting either the number or the value of lambs per ewe, thereby increasing the liveweight of lamb produced per acre, and the return on capital. Gross margins/ewe for the top third and average of 306 British lowland flocks surveyed (Kilkenny and Read, 1974) were £12.01 and £9.47, respectively, a 27% difference in economic efficiency. Gross margins/ac, however, were £52.84 and £35.98 for top and average flocks, a 47% difference in efficiency. The greater advantage of the top flocks on a per-acre basis may be attributed to their superior stocking rates: 4.9 vs. 4.6 ewes/ac in summer and 4.4 vs. 3.8 ewes/ac annually, for top third vs. average flock, respectively.

Levine et al. (1978) reported a similar effect when comparing production efficiencies of Suffolk and Columbia ewes in Oregon. On a per-ewe basis, net return above variable costs was 18.9% greater for Suffolk ewes, but on a per-acre basis, net return was only 1.6% greater because of the lower stocking rate of heavier Suffolk ewes than of the lighter Columbia ewes. This illustrates that in many pastoral cases where land is the most limiting resource, profit per unit of land area may be more indicative of economic efficiency than profit per head (Hohenboken, 1986).

Levine et al. (1978) noted that evaluating systems on net return over variable costs per acre avoids having to determine a fixed per-ewe cost for grazed forage. This avoids the difficulty in accounting for and valuing variations in forage quantity and quality that occur with weather, past grazing use, and current grazing practices. Net return over variable costs/ac reflects "the components of income and expense that a producer would actually accrue" (Levine et al., 1978).

In an examination of various forage-based, *beef cattle* stocker and finisher production systems, Bagley et al. (1990) and Coombs et al. (1990) incorporated costs/ac into economic comparisons of cost of gain (\$/lb gain). Cattle were grazed on small grain, ryegrass, and clover mixtures from November through May, and on grain-supplemented bermudagrass, warm-season annuals, and grass-clover mixtures from June through October. Forage-related variable costs (fertilizer, seed, herbicide, insecticide, equipment and labor) were combined with grazing dates and stocking rates to compute the cost of forage (\$/ac grazing day). Per-acre and other variable costs (i.e., supplemental feeds, marketing costs, death loss) were then divided by seasonal gains (lb/d) to compute cost of gain (\$/lb) for the various production systems.

Chapter 3. Ewe Reproductive Performance, Baby Lamb Viability, and Preweaning Lamb Growth

INTRODUCTION

The management structure of a commercial sheep production operation is often determined by availability of resources such as forage, facilities, and labor. The choice of ewe breed type and time of lambing will clearly affect the use of those resources as well as the resulting production and profitability. The variety of sheep breeds available to Virginia producers allows selection of breeds that best fit a given set of resources. "Western" (Suffolk x Rambouillet) ewes have been a popular crossbred in Southwestern Virginia, well-suited to the traditional spring-lambing, pasture-based production systems. More recently, many producers have responded to reports of the benefits of incorporating Finnsheep breeding into a crossbreeding system (Oltenacu and Boylan, 1981; Ercanbrack and Knight, 1988; Fahmy, 1989; Notter and McClaugherty, 1990). There are, however, some lingering biases against the perceived inferior performance of lambs from Finn-cross ewes.

Fall lambing may be a way to offset some of the production difficulties encountered in spring-lambing systems: summer heat, predation, parasites, and low autumn market lamb prices. If ewes are successfully bred in spring to lamb in fall, some of these problems may be alleviated. However, fall production has been limited by fertility levels, as both estrus occurrence and litter size per ewe lambing are substantially below that of spring (Barr et al., 1968; Notter and Copenhaver, 1980a; Fogarty et al., 1984). Production differences between spring- and fall-lambing may be reduced through the use of ewe breeds that have higher out-of-season conception rates and/or higher prolificacy in fall lambing.

This portion of the study was designed to compare the preweaning production of two ewe breed types in two annual lambing seasons. Western and ¼-Finn ewes were bred to Suffolk x Hampshire rams to lamb

in March or September. Characteristics evaluated were percentage ewes lambing of ewes exposed to the ram, lambing date, litter size, lamb birth weight, baby lamb survival, and lamb daily gain to weaning, in order to assess the effect of ewe breed and lambing season on ewe reproductive efficiency, baby lamb viability, and lamb growth to weaning.

MATERIALS AND METHODS

Populations

This 3-year experiment, conducted at the Southwest Virginia Agricultural Experiment Station in Glade Spring, Virginia, initially involved 130 mature crossbred ewes: 59 $\frac{1}{4}$ -Suffolk, $\frac{1}{4}$ -Hampshire, $\frac{1}{2}$ -Rambouillet (Western, W) and 71 $\frac{1}{2}$ -Suffolk, $\frac{1}{4}$ -Rambouillet, $\frac{1}{4}$ -Finnish Landrace ($\frac{1}{4}$ -Finn, $\frac{1}{4}$ -F) ewes.

The ewes were born in 1980 and 1981, and thus were 4 and 5 years old at the start of the trial in 1985. The origin and previous performance of these ewes was described by Notter and McClaugherty (1991).

The ewes were evenly and randomly divided into two breeding groups, the first to be bred in the fall to lamb in spring, the second to be bred in the spring to lamb in fall. Numbers of ewes and breeding dates for each year are detailed in Table 3.1.

The study began with the breeding of the first spring-lambing group (September 1984), and ended when the last of the lambs born in fall 1987 were marketed (February 1988). Hence a total of six lambing seasons are evaluated: spring and fall of 1985, 1986, and 1987, hereafter referred to as Yr1, Yr2, and Yr3, respectively. All ewes were bred to Suffolk x Hampshire rams throughout the study. No culling was performed on the basis of performance; removal of ewes from the flock was due only to unsoundness or death.

Management of spring-lambing ewes

The spring-lambing ewes were exposed as a single group to rams beginning the first week of October. Duration of breeding was 90 d in Yr1,

and 60 d in Yrs 2 and 3 (Table 3.1). During breeding, ewes were maintained on perennial, cool-season pastures, which were primarily Kentucky bluegrass (*Poa pratensis* L.) with some white clover (*Trifolium repens*) and orchardgrass (*Dactylis glomerata* L.). Ewes then grazed stockpiled fescue (*Festuca arundinacea* Schreb.) until January, and were fed hay while on pasture through mid-winter until lambing. During the last 6 weeks of gestation, ewes were supplemented with .75 lb corn/hd/d. Lambing took place in drylot; ewes were fed hay and 1.5 lb of corn/hd/d after parturition.

Ewes and lambs were moved to winter rye (*Secale cereale*) pastures in mid-March, at which point corn supplementation ceased. Lambs were given access to creep while ewes grazed rye. Ewes and lambs were moved to bluegrass-white clover pastures as they became available in mid-April; creep feeding of lambs was discontinued at this time. In Yrs 1 and 2, ewes and lambs were continuously stocked on perennial pasture from mid-April to early June; in Yr3 they were rotationally stocked through 1-acre paddocks of improved pasture. Lambs were weighed at approximately 57 and 90 d of age (Table 3.1).

Management of fall-lambing ewes

The fall-lambing ewes were exposed as a single group for a period of 60 d beginning the first week of April (Table 3.1). Rams were enclosed in a light-proof barn and primed with short-day cycles in February and March in Yrs 2 and 3, to simulate daylength typical of fall breeding. Ewes were flushed with .5 lb corn/hd/d from March 10 to April 15. Ewes were maintained on pasture throughout gestation; no grain supplements were provided during gestation or lactation.

In late August, ewes were moved to alfalfa pastures for lambing. In Yrs 1 and 2, ewes remained on alfalfa until turnip grazing was available in mid-October. Lambs were weaned in late November as turnip forage became depleted. In Yr3, ewes and lambs remained on alfalfa pastures throughout lactation until weaning. Lambs in Yrs 1 and 2 did not have access to creep until ewes were moved to turnip. Lambs in year 3 were given access to creep throughout lactation.

Lambs were weighed at approximately 56 d and again at weaning at approximately 70 d of age (Table 3.1). At weaning, lambs were moved directly to drylot and ewes were put on stockpiled fescue pastures for winter grazing.

Traits Studied

Traits that indicate ewe reproductive efficiency, lamb viability, and pre-weaning lamb gain were of primary interest in this portion of the study. The component traits examined were ewe fertility, prolificacy and lambing date, and lamb birth weight, survival from birth to 30 days of age, early daily gain, and daily gain to weaning.

Ewe fertility was defined as percentage ewes lambing of ewes exposed. Ewe prolificacy was the average number of lambs born per ewe lambing. Lambing date was analyzed relative to other ewes lambing in the same lambing season.

Lamb survival reflected early lamb losses (i.e., those dead at birth or before 30 d of age). Ewes were given the opportunity to raise all lambs born; grafting occurred only if a ewe's entire litter died at or shortly after birth, or if a ewe was clearly not able to suckle her entire litter.

Early daily gain was determined from birth to approximately 55 d of age, except in spring of Yr1, when no weights were taken before weaning. Daily gain was also measured from birth until approximately 90 and 70 d for the spring- and fall-born lambs, respectively (Table 3.1).

Statistical Analysis

This portion of the study was set up in a two-by-two factorial arrangement within each year. The effects of the ¼-Finn vs. Western crossbred types and spring- vs. fall-lambing systems on ewe productivity, lamb viability, and lamb growth were evaluated.

Chi-square analysis was conducted using the frequency procedure of the Statistical Analysis System (SAS, 1990) to determine significance of ewe breed and season effects on the categorical variables fertility, prolificacy, and lamb survival. For fertility, "0" and "1" denoted the status of "open" or "lambing", respectively. For prolificacy, "1", "2", and "3"

denoted litter sizes of singles, twins, and triplets, respectively. For survival, "0" signified "dead on or before 30 d of age" and "1" signified "alive at 31 d of age". Chi-square tests of significance of effects of ewe breed were calculated after controlling for effects of season, and vice versa, using the Cochran-Mantel-Haenszel statistics provided in SAS (1990). In addition, effects of ewe breed and season on survival were evaluated after controlling for litter size.

Analysis of variance was conducted, using the general linear models procedure of SAS, to evaluate the fixed effects ewe breed, season, and year, and their interactions, on lambing date, lamb birth weight, and lamb daily gain to 55 d and to weaning. The analysis was conducted with and without the effect of birth type in the model for these traits.

RESULTS AND DISCUSSION

Fertility

Ewe breed had no significant effect on fertility in either spring or fall lambing (Table 3.2.a,b). In spring, 94% of ¼-Finn ewes and 93% of Western ewes lambed. In fall lambing, ¼-Finns had a consistently higher percentage of ewes lambing (mean of $69 \pm 7\%$ for ¼-Finns vs. $59 \pm 5\%$ for Westerns over 3 yr). The non-significant breed effect on fertility agrees with previous studies (Fogarty et al., 1989; Notter and McClaugherty, 1991) but, when combined with differences in prolificacy, may contribute to a larger and significant effect on overall ewe productivity and profitability (Fahmy and Dufour, 1988). When the two seasons were combined, ¼-Finns had a slight, though nonsignificant, advantage over Westerns (82 vs. 77% lambing).

Season had a significant effect on fertility ($P < .001$). Overall fertility was 94% for spring-lambing and 64% for fall-lambing ewes. Barr et al. (1968) reported that compared to ewes bred in fall, ewes bred in spring had both a reduced occurrence of estrus and a reduced percentage of ewes lambing that had previously exhibited estrus. Thus the seasonal difference in fertility in the current study may have been caused by a combination of

factors, i.e., fewer ewes cycling and also reduced embryonic survival after fertilization.

Interestingly, over the 3 years of the study, fertility in the fall-lambing group declined by over 25 percentage units for both breed groups (although average litter size remained fairly constant; Table 3.2a,b), while the spring-lambing group showed no clear indication of declining fertility. This decline in fertility in spring of Yrs 2 and 3 may have been associated with the substantial weight loss of ewes grazing turnip during lactation in fall of Yrs 1 and 2 (see Chapter 6).

Prolificacy

Prolificacy, the number of lambs born per ewe lambing, was affected by both ewe breed and season ($P < .001$; Table 3.2a,b). When ewe breeds were combined, mean litter size was 2.06 in spring and 1.58 in fall. Western ewes averaged 1.84 and 1.40 lambs/ewe in spring and fall, respectively; $\frac{1}{4}$ -Finns averaged 2.25 and 1.71 lambs/ewe in spring and fall.

Mean litter size over three years (spring and fall lambings combined) was thus 2.03 for $\frac{1}{4}$ -Finns and 1.68 for Western ewes. One-quarter-Finn ewes gave birth in the spring to .59, .37, and .16 more lambs/ewe lambing in Yrs 1, 2, and 3, respectively, than Western ewes. In the fall, $\frac{1}{4}$ -Finn ewes produced .38, .17, and .38 more lambs/ewe than Westerns. Breed effects on prolificacy are similar to those reported by Oltenacu and Boylan (1981a), Fahmy and Dufour (1988), and Notter and McClaugherty (1991).

Examination of litter sizes showed that 53% of all $\frac{1}{4}$ -Finns and 56% of all Westerns produced twins. Over 3 yrs in the fall-lambing group, 60% of Western lambings produced singles and no Western ewes produced triplets, whereas 36% of the $\frac{1}{4}$ -Finn lambings produced singles and 7% produced triplets. In spring, 66% of the Westerns had twin litters and 9% had triplets, while 49% of $\frac{1}{4}$ -Finns had twins and 38% had triplets.

Lambing Date

Mean lambing dates were March 6 and September 13 for the spring- and fall-lambing groups, respectively (Table 3.1). Ewe breed had a significant effect on birth date. Over the 3 yrs, Western ewes lambed an

average of 5 ± 2 days later than $\frac{1}{4}$ -Finn ewes; the difference remained (4 ± 1 d) when birth date was adjusted for litter size. However, ewe breed effects were larger in fall (7 ± 2 d) than spring (2 ± 1 d; $P < .05$ for breed x season interaction). The significance of the ewe breed effect did not change when lambing date was adjusted for litter size.

Examination of mean lambing dates show that the average lambing date of spring-lambing Western ewes was 157, 157, and 156 d after first exposure to rams in Yrs 1, 2, and 3, respectively; $\frac{1}{4}$ -Finns' average lambing date was 156, 153, and 153 d after first exposure. The average lambing date for fall-lambing Western ewes was 168, 168, and 162 d after first ram exposure, while the average date for fall-lambing $\frac{1}{4}$ -Finn ewes was 166, 157, and 155 d after first exposure. Given a 150-d gestation, this would suggest that more $\frac{1}{4}$ -Finn ewes may have been already cycling when exposed to the ram, while Western ewes were induced to cycle by means of the "ram effect" (Nugent et al., 1988).

Birth Weight

Litter size affected birth weight ($P < .05$). Birth weights (BW) of single, twin, and triplet lambs of $\frac{1}{4}$ -Finn ewes were $10.8 \pm .3$, $8.8 \pm .2$, and $7.7 \pm .3$ lb, respectively. Weights for single, twin, and triplet lambs of Western ewes were $11.1 \pm .3$, $8.8 \pm .2$, $7.6 \pm .5$ lb, respectively. There was no significant litter size x season interaction.

Litter size x ewe breed effects on BW were consistent with those reported by Notter et al. (1991). Although not significant in this study, Western ewes produced slightly heavier singles, and only slightly lighter twins and triplets than $\frac{1}{4}$ -Finn ewes.

Ewe breed influenced lamb birth weight ($P < .01$). Lambs of Western ewes averaged $.6 \pm .2$ lb heavier at birth than lambs of $\frac{1}{4}$ -Finn ewes (Table 3.2a,b). This difference is slightly larger than that reported by Notter et al. (1991) for the same Western and $\frac{1}{4}$ -Finn crossbred types, but corresponds well with Maijala's (1984) estimate of a .27% decrease in BW with each 1% increase in proportion of Finnsheep genes.

There was virtually no difference in average birth weight of spring- and fall-born lambs of both breeds combined. When adjusted for birth type,

however, spring weights were significantly greater than those of fall ($.8 \pm .3$ lb). Similar trends were reported by Notter and Copenhaver (1980a), and also by Barr et al. (1968), who found significant seasonal effects without litter size adjustment.

There was, however, significant ewe breed x season interaction. The advantage of the Western ewe in lamb BW was $1.0 \pm .2$ lb in spring but only $.1 \pm .2$ lb in fall. When spring birth weights were adjusted for litter size, the breed difference was reduced but remained significant ($.5 \pm .3$ lb). When fall weights were adjusted for litter size, the breed difference was reversed, although not significant, with $\frac{1}{4}$ -Finns' lambs weighing $.4 \pm .4$ lb more than those of Westerns.

Small differences in birth weight were found between spring and fall lambs within ewe breeds ($P < .06$ for the $\frac{1}{4}$ -Finns' lambs, $P < .12$ for the Westerns' lambs, both favoring spring-born lambs). However, when BW was adjusted for litter size, birth weights of lambs from $\frac{1}{4}$ -Finn ewes did not differ between seasons ($9.2 \pm .2$ lb in spring, $9.0 \pm .2$ lb in fall), but lambs from Western ewes showed a seasonal effect on birth weight ($9.8 \pm .2$ lb in spring, $8.6 \pm .3$ lb in fall; $P < .001$).

Survival to 30 Days of Age

Survival to 30 d of age, a possible indicator of mothering ability or lamb vigor, was not significantly affected by ewe breed or season and averaged 87% (Table 3.2a,b).

There was no difference in survival between $\frac{1}{4}$ -Finn lambs born in fall and spring (87 ± 2 and $87 \pm 3\%$, respectively). However, there was a seasonal difference in survival of lambs from Western ewes that approached significance ($90 \pm 2\%$ survival in spring, $82 \pm 5\%$ survival in fall; $P < .09$) and may have been associated with reduced birth weight of fall-born lambs from Western ewes.

Survival to 30 d declined significantly with increasing litter size: singles, twins, and triplets had survival rates of 93.7, 88.0, and 81.4%, respectively. This pattern is similar to that noted by Oltenacu and Boylan in Minnesota (1981a), but differs from the report of a curvilinear relationship between perinatal survival and both birth type and birth weight reported by

Notter et al. (1991), where survival was maximal for twins and at a 9.68-lb birth weight.

Baby lamb survival, however, can be largely influenced by management style, which changed in this study from Yrs 1&2, when the Experiment Station was under interim management, to Yr3 when a full-time manager was employed. For example, average survival rates in spring increased from 89 and 85% in Yrs 1 and 2, respectively, to 92% in Yr3. This was in spite of lambing percentages of 2.05 and 1.96 lambs/ewe in Yrs 1 and 2, respectively, and 2.13 lambs/ewe lambing in Yr3.

Daily Gain, Birth to 55 Days of Age

Lambs were weighed at approximately 55 d of age (average of 59 d in spring and 56 d in fall) to determine ewe breed and season effects on early lamb growth.

Contrary to results summarized by Maijala (1984), this study found no negative relationship between Finn breeding in lambs and preweaning daily gain. Daily gain did not differ between ewe breed types and averaged .59 lb/d from birth to 55 d over the 3 yrs (Table 3.2a,b). The very slight and nonsignificant advantage in rate of gain in lambs from ¼-Finn vs. Western ewes ($.66 \pm .03$ vs. $.65 \pm .03$) was similar to that reported by Notter et al. (1991).

Birth type affected early lamb growth ($P < .001$). Over the 3 yrs, singles averaged $.82 \pm .02$ lb/d over the three years, twins averaged $.62 \pm .01$ lb/d, and triplets averaged $.57 \pm .04$ lb/d. There was no significant ewe breed x birth type interaction for daily gain to 55 d. However, when birth type was included in the model, the effect of Finn breeding on gain to 55 d became significant. At the same birth type, lambs from ¼-Finn ewes outgained lambs from Western ewes in spring ($.71 \pm .02$ vs. $.66 \pm .02$ lb/d) and fall ($.66 \pm .02$ vs. $.63 \pm .03$ lb/d).

A seasonal effect on early lamb gain was observed; gains in spring averaged $.64 \pm .01$ lb/d while gains in fall averaged $.67 \pm .01$ lb/d ($P < .05$). This effect is difficult to interpret in terms of the influence of environmental factors. Fall-born lambs in Yrs 1 and 2 did not have access to creep until mid-October, when they were approximately 30 d of age,

while fall-born lambs in Yr3 had continuous access to creep from birth. Spring-born lambs in Yrs 1 and 2 had access to creep only until approximately 45 d of age; spring-born lambs in Yr3 had no creep at all. Temperature would not have been extreme in either season during this period. With similar crossbred types given equal creep access in forage-based spring and fall systems, Notter et al. (1991) found no significant seasonal effect on lamb gain before 70 d. However, Notter and Copenhaver (1980b) reported that daily gain of lambs raised on expanded metal (and thus in a controlled environment except for seasonal temperature) was greater for April-born lambs than for September-born lambs. These results would suggest that pre-weaning gain is heavily influenced by environmental factors, such as temperature, forage, and creep. The higher rate of gain in fall, however, may also be due in part to a smaller number of lambs suckling/ewe. Single lambs tend to have more milk available to them and consequently have greater growth during lactation than twins (Barnicoat et al., 1956; Brown, 1964).

There were also some patterns in seasonal gain as affected by ewe breed. Lambs from ¼-Finn ewes consistently outgained lambs from Western ewes in spring ($.66 \pm .02$ vs. $.61 \pm .02$ lb/d), yet there was very little breed difference in fall ($.67 \pm .02$ for lambs of ¼-Finn ewes; $.68 \pm .02$ for lambs of Western ewes). There were no significant season x birth type interactions in the early lamb daily gains.

Lamb Daily Gain, Birth to Weaning

Lambs were weighed at weaning (approximately 90 d of age in spring and 70 d in fall) to determine the effect of breed type and season on overall lamb growth.

Ewe breed did not have a significant effect on lamb growth to weaning. Lambs born to ¼-Finn ewes gained $.63 \pm .01$ lb/d; lambs of Western ewes gained $.62 \pm .01$ lb/d (Table 3.2a,b). When birth type was included in the model, ewe breed effects became significant: lambs of ¼-Finn ewes gained $.04 \pm .02$ lb/d faster from birth to weaning than did lambs of Western ewes.

Birth type effects remained significant when daily gain was measured to weaning. Single, twin, and triplet lambs gained an average of $.73 \pm .01$, $.59 \pm .01$, and $.54 \pm .02$ lb/d, respectively. No significant breed x birth type or season x birth type interactions for daily gain to weaning were found.

Season also had an effect on lamb gain to weaning ($P < .001$). Lambs in spring gained $.57 \pm .01$ lb/d, while lambs in fall gained $.68 \pm .01$ lb/d. The difference in gain between spring and fall seasons increased from $.04 \pm .02$ lb/d at 55 d of age to $.11 \pm .01$ lb/d at weaning. This is likely due to differences in management and environment after 55 d. Fall lambs had continued access to creep feed; spring lambs did not. Also, spring lambs averaged 55 d of age in late April/early May when ambient air temperature and parasite exposure on pasture would have been increasing and thus compromising gains. Fall lambs averaged 55 d of age in late October/early November on turnip (an annual) and alfalfa (previously harvested as hay); cooler temperatures and reduced parasite exposure would have encouraged higher daily gains. There was no significant ewe breed x season interaction.

CONCLUSIONS

The addition of $\frac{1}{4}$ -Finn breeding to the crossbred ewe type increased reproductive efficiency, by consistently (although nonsignificantly) increasing fertility in the fall, and significantly increasing prolificacy in both spring and fall. The larger litter sizes and resultant lighter birth weights of lambs from $\frac{1}{4}$ -Finn ewes had no subsequent effect on lamb viability or growth, as there were no differences between breed groups in survival or rates of gain.

Fall lambing clearly reduced reproductive efficiency of both ewe breeds. However, $\frac{1}{4}$ -Finn ewes were more productive in the fall-lambing system than were Western ewes. More $\frac{1}{4}$ -Finn ewes appeared to be cycling at April breeding and had larger litter sizes at fall lambing. Fall-born lambs of Western ewes had reduced birth weights and survival. Lamb daily gain to weaning was greater in fall than in spring, possibly due to a

combination of factors, such as smaller litter sizes, cooler temperatures, and more access to creep.

The success of any production system is largely dependent on the quantity of marketable product produced within a given set of resources. Improving reproductive efficiency with more prolific breeds increases overall pounds of lamb weaned/ewe. The benefits of greater lamb numbers per ewe exposed must then be weighed against the demands of larger litter sizes on management and resources. Use of a prolific breed may, however, be essential for improved reproductive efficiency in an annual fall-lambing system.

Table 3.1 Dates of breeding, lambing, weighing, and weaning for spring- and fall-lambing systems, Yrs 1, 2, and 3

	<u>Yr1</u>	<u>Yr2</u>	<u>Yr3</u>
<u>Spring-lambing</u>			
Breeding dates	Oct 1 – Dec 30	Oct 1 – Nov 30	Oct 6 – Nov 24
No. ewes exposed	29 W, 35 $\frac{1}{4}$ -F	28 W, 30 $\frac{1}{4}$ -F	26 W, 25 $\frac{1}{4}$ -F
Lambing dates	Feb 22 – May 11	Feb 8 – Apr 9	Feb 24 – Apr 15
Mean lambing dt	March 6	March 5	March 9
"55-d" weigh dt		May 7	April 29
Ave. age (d)		65	52
Wean date	June 5	June 11	May 29
Ave. age (d)	92	98	81
<u>Fall-lambing</u>			
Breeding dates	Apr 4 – Jun 3	Apr 7 – Jun 6	Mar 31 – May 2
No. ewes exposed	27 W, 28 $\frac{1}{4}$ -F	26 W, 31 $\frac{1}{4}$ -F	26 W, 27 $\frac{1}{4}$ -F
Lambing dates	Aug 26 – Oct 26	Sept 1 – Oct 17	Aug 25 – Oct 14
Mean lambing dt	September 18	September 15	September 5
"55-d" weigh dt	November 8	November 12	October 27
Ave. age (d)	52	63	55
Wean date	Dec 2	Nov 21	Nov 16
Ave. age (d)	74	66	71

Table 3.2.a Least-squares means and standard errors for ewe reproductive performance, lamb birth weight and survival, and lamb daily gain to 55 d and to weaning: Spring-lambing system

	<u>Yr1</u>		<u>Yr2</u>		<u>Yr3</u>	
	Westerns <u>mean</u>	<u>s.e.</u>	Westerns <u>mean</u>	<u>s.e.</u>	Westerns <u>mean</u>	<u>s.e.</u>
	<u>W-Finns</u>		<u>W-Finns</u>		<u>W-Finns</u>	
	<u>mean</u>	<u>s.e.</u>	<u>mean</u>	<u>s.e.</u>	<u>mean</u>	<u>s.e.</u>
Fertility (%)	96.6	3.4	100.0		84.6	7.1
Prolificacy (lambs/ewe lambing)	1.75	.52	2.34	.59	2.05	.49
Mean lambing dt (Julian dt)	65	1	64	1	69	1
Birth wt (lb)	9.5	.3	8.1	.2	9.2	.5
30-d surv. (%)	87.8	6.1	89.0	5.3	93.3	4.9
Daily gain to 55 d (lb/d)						
to wean (lb/d)	.58	.02	.54	.01	.59	.02
					.54	.02
					.61	.02
					.56	.02

Table 3.2.b Least-squares means and standard errors for ewe reproductive performance, lamb birth weight and survival, and lamb daily gain to 55 d and to weaning: Fall-lambing system

	<u>Yr1</u>				<u>Yr2</u>				<u>Yr3</u>			
	<u>Westerns</u>		<u>%-Finns</u>		<u>Westerns</u>		<u>%-Finns</u>		<u>Westerns</u>		<u>%-Finns</u>	
	<u>mean</u>	<u>s.e.</u>	<u>mean</u>	<u>s.e.</u>	<u>mean</u>	<u>s.e.</u>	<u>mean</u>	<u>s.e.</u>	<u>mean</u>	<u>s.e.</u>	<u>mean</u>	<u>s.e.</u>
Fertility (%)	74.1	8.4	82.1	7.2	57.7	9.7	67.7	8.4	46.2	9.8	55.6	9.6
Prolificacy (lambs/ewe lambing)	1.40	.5	1.78	.6	1.40	.51	1.57	.51	1.42	.51	1.80	.68
Mean lambing dt (Julian dt)	263	2	260	2	265	2	254	2	252	2	244	2
Birth wt (lb)	8.5	.4	8.6	.13	9.5	.4	9.6	.3	9.2	.5	8.7	.4
30-d surv. (%)	82.1	7.4	82.9	7.1	76.2	8.4	93.9	4.3	88.2	6.3	85.2	6.8
Daily gain to 52 d (lb/d)	.66	.03	.64	.02	.68	.03	.65	.02	.69	.04	.71	.04
to wean (lb/d)	.6	.03	.63	.02	.67	.03	.66	.02	.74	.04	.76	.03

Table 3.3 Three-year marginal (least-squares) means and standard errors for ewe reproductive performance, lamb birth weight and survival, and lamb daily gain to 55 d and to weaning. Spring- and fall-lambing systems, and Western and λ -Finn ewes.

	Spring				Fall				Significance level	
	Westerns		λ -Finns		Westerns		λ -Finns		Breed effect	Season effect
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.		
Fertility (%)	92.8	2.8	94.4	2.4	59.5	5.5	68.6	5.0	NS	***
Prolificacy (lambs/ewe lambing)	1.84	.56	2.25	.67	1.4	.5	1.71	.59	***	***
Mean lambing dt (Julian dt)	66	1	64	1	260	1	253	1	***	
Birth wt (lb)	9.5	.2	8.5	.1	9.1	.2	9.0	.2	**	NS
30-d surv. (%)	90.1	2.4	86.9	2.4	81.8	4.7	87.1	3.3	NS	NS
Daily gain to 55 d (lb/d)	.61	.02	.66	.02	.68	.02	.67	.02	NS	*
to wean (lb/d)	.56	.01	.57	.01	.67	.02	.68	.01	NS	***

*** Significant ($P < .001$)

* Significant ($P < .05$)

** Significant ($P < .01$)

NS Nonsignificant

Chapter 4. Post-Weaning Lamb Gain and the Effect of Weaning on Summer Growth

INTRODUCTION

Management decisions concerning when or if lambs should be weaned are specific to each sheep operation and are influenced by time of lambing, forage and feed resources, and desired time of marketing.

Spring-born lambs are commonly weaned in early or mid-summer to allow lambs access to the best summer forage and to remove lambs from the ewes, the primary source of internal parasite infestation for lambs (Lewis et al., 1972). Whether weaned or unweaned, spring-born lambs can be marketed off pasture as finished lambs, or they can be moved to drylot to be finished and marketed in the fall months. Fall-born lambs tend to be weaned as fall pastures are depleted and fed in drylot to be marketed as prices rise in the spring months.

The weaning process can slow growth, even in lambs that are as much as 6 mo of age (Brown, 1964; Gibb et al., 1981; Lee et al., 1990). Whether or how quickly preweaning growth rates can be recovered depends on preweaning milk intake (Gibb et al., 1981), level of parasite population in ingested herbage (Lewis et al., 1972), and quality of lamb forage or feed after weaning (Gibb et al., 1981; Pope et al., 1984). Gibb et al. (1981) suggested that the negative effects of weaning on gain could be alleviated with improved postweaning feed quality.

This study tested the effect of weaning on the performance of spring-born lambs grazing through summer by imposing an additional treatment on the spring-lambing system. In early June, when lambs were approximately 90 d of age, ewes were randomly divided within breed group: half of the ewes and lambs were weaned, while half remained unweaned through the summer grazing period. Weights were recorded at intervals throughout the summer to determine periodic changes in lamb growth before fall marketing.

Postweaning gain of fall-born lambs was also determined. Lambs were weaned at approximately 70 d and put directly in drylot on high-concentrate diets, to be fed to market weight as rapidly as possible.

This chapter evaluates the growth performance of spring- and fall-born lambs after weaning or in late lactation (if unweaned), and the resultant age and weight of lambs when marketed.

MATERIALS AND METHODS

Mid-summer and drylot management of spring-born lambs differed fairly substantially over the course of the study. In Yr1 and Yr2, lambs were weighed periodically through the summer; lambs not marketed directly from pasture were moved to drylot by late September or early October. In Yr3, weaned lamb weights were not recorded after mid-July, and all non-weaned lambs were weaned by early August due to drought conditions. For this reason, Yr3 lamb performance after mid-July was not included in the analysis of lamb growth.

Management, spring-born lambs

Spring-lambing ewes and their lambs were divided into Weaned and Non-weaned groups in early June (Table 4.1). In Yrs 1&2, weaned lambs grazed improved bluegrass-clover pastures and non-weaned lambs grazed with their dams on grass-clover pastures, until they reached market weight or were moved to drylot on September 16 (Yr1) or October 6 (Yr2). In Yr3, unusually dry pasture conditions necessitated that suckling lambs be weaned on August 4; lambs in Yr3 were moved to drylot on September 4.

Non-weaned lambs and their dams were continuously stocked on perennial grass pastures in all 3 years. Weaned lambs were continuously stocked on improved bluegrass-white clover pastures (fertilized to encourage at least 25% white clover content) in Yrs 1&2, and were rotated through 1-ac paddocks of improved pasture in Yr3.

All lambs were dewormed with anthelmintic (injectable Ivermec) at 4-wk intervals throughout the trial. Lambs became heavily infested with internal parasites in mid-summer of Yr1 and Yr2; weaned lambs in Yr2 required an additional dose of anthelmintic in August.

To track summer weight gain after 90 d, lamb weights were recorded in mid-July of all three years, and then in early August and mid-September of Yr1 and Yr2 (Table 4.1). Lamb weights in Yr3 were recorded in mid-July and then from September through November.

Lambs were marketed off pasture as they reached a minimum live weight of 105 lb. Lambs not marketed by the end of the forage grazing period were moved to drylot. Drylot feed in Yrs 1&2 consisted of .5 lb grass-clover hay/hd/d plus *ad libitum* access to a ground corn-soybean mixture (13.5% CP). Drylot feed in Yr3 consisted of a 9:1 mixture of whole corn and pelleted protein supplement, fed *ad libitum*. Any lambs not weighing 105 lb by September 30 in Yrs 1&2, or by November 30 in Yr3, were marketed on that date as "lightweight" slaughter lambs (95 to 104 lb) or as "feeders" (less than 95 lb).

Management, fall-born lambs

Fall-born lambs were weaned directly to drylot when their dams finished grazing turnip (*Brassica rapa* L., Yrs 1&2) or alfalfa (Yr3, Table 4.1). Drylot rations were the same as described above for spring-born lambs in the respective years.

Fall-born lambs were also marketed as they reached a target liveweight of 105 lb. Lambs not weighing 105 lb by March 31 in all 3 years were marketed on that date as "lightweight" or "feeder" lambs.

Traits measured

Traits evaluated in this portion of the study were those that are indicative of lamb growth after weaning or during late lactation, and of lamb age and weight at marketing.

For spring-born lambs, daily gains in three periods were evaluated: from 90 d of age in early June to mid-July (Period A), from mid-July to early August (Period B), and from early August to mid-September (Period C, Table

4.1). Gain was also evaluated for the entire summer period, from 90 d to mid-September (Period ABC). Gain was determined by dividing weight change during that period by the number of days in the period.

Post-weaning daily gain of fall-born lambs was evaluated only at approximately 139 d ("Date A", Table 4.1). This date was selected as a point at which lambs in all 3 years were of similar age and at which few lambs had been marketed. Gain was determined by dividing weight change between weaning and Date A by the number of days in the period.

Lambs in all groups were evaluated for days to market (age from birth to market weight) and weight at marketing. Number of days in drylot (days between entering drylot and reaching final market weight) was analyzed for fall-born lambs.

STATISTICAL ANALYSIS

Performance of spring-born lambs

The summer grazing portion of the trial was arranged in a two-by-two factorial arrangement within each year. The effects of ewe breed (Western vs. $\frac{1}{4}$ -Finn) and weaning status (weaned at 90 d vs. non-weaned) on daily gain and age and weight at marketing were evaluated.

Analysis of variance was conducted using the General Linear Models procedure of SAS to evaluate the impact on gain in Periods A, B, and C of the fixed effects of weaning status, ewe breed, lamb sex, and year, the covariate 90-d weight, and weaning status x ewe breed and weaning status x year interactions. The effect of weaning status x 90-d-wt interaction on gain was considered in preliminary analyses but proved to be non-significant, and so was removed from the model. The effects of ewe breed, weaning status, sex, year, and their interactions on age and weight at marketing were also evaluated.

Because Period A differed only in grazing management of weaned lambs, and because preliminary analyses showed that patterns of growth were consistent with or without the inclusion of Yr3 data, Yr3 remained in the Period A analysis. Analysis for Periods B, C, and ABC was conducted

without Yr3 data. Therefore, in this chapter references to Period A include data of Yr3, while references to Periods B, C, and ABC include data of only Yrs 1 and 2. Market weights and ages for Yr3 were analyzed separately to derive figures for the final enterprise budgets.

Performance of fall-born lambs

The effect of ewe breed on post-weaning daily gain and age and weight at marketing was evaluated. As with spring lamb gain, analyses of variance were conducted using the General Linear Models procedure of SAS to evaluate fixed effects of ewe breed, sex, and year, and their interactions on gain to Date A.

Data for Yr3 was included in the analysis of fall lamb gain after weaning: although the drylot feed differed from that fed in the first 2 years, lambs were allowed ad libitum access in all 3 years, and management of drylot lambs did not change substantially. Analysis of market age and days in drylot, however, does not include Yr3. Lambs weaned from dams on alfalfa averaged 9.5 ± 2.4 lb heavier at weaning than those weaned from dams on turnip, giving Yr3 lambs a weight advantage. Thus market weights and dates for Yr3 were analyzed separately to derive figures for the final enterprise budgets.

RESULTS AND DISCUSSION

Summer daily gain of spring-born lambs

Weaning status had a significant effect on gains throughout the summer (Table 4.2); over the entire summer grazing season (Yrs 1&2 only), non-weaned lambs gained an average of $.42 \pm .01$ lb/d while weaned lambs gained $.24 \pm .01$ lb/d (Table 4.3). This $.18$ lb/d advantage of non-weaned lambs over weaned lambs is much larger than that reported by Lee et al. ($.03$ lb/d; 1990) and by Jordan and Marten ($.09$ lb/d; 1968). However, both of these studies implied very high forage quality, with a 50% legume content in the sward grazed by weaned lambs. The grass-clover

pasture in this current trial contained approximately 25% white clover; thus forage quality may have accentuated the difference in lamb gain.

Non-weaned lambs out-gained weaned lambs in all periods of all years, except Period B of Yr1, when non-weaned lambs grew $.04 \pm .04$ lb slower ($P < .06$, Table 4.2). In mid-July of Yr1 internal parasite infestation was pronounced and resulted in some lamb death; this is reflected in the poor gains of both groups in Period B. Non-weaned lambs appeared to recover more quickly, as Period C weights in Yr1 increased by $.45 \pm .04$ lb/d for non-weaned lambs, but only by $.11 \pm .03$ lb/d for weaned lambs. In Yr2 parasite infestation was again a severe problem, resulting in Period C weight loss in weaned lambs, while non-weaned lambs were able to maintain slow growth.

These observations on the impact of internal parasite challenge are supported by the research of Lewis et al. (1972) and Watson (1991). Lewis et al. (1972) noted that lambs drenched with anthelmintic, but grazed on pastures with high residual larval populations, grew no differently than lambs not drenched but grazed on pastures with low residual larval counts. In the current trial, lambs were on pastures grazed by sheep for many years; it may be assumed that larval populations on these pastures were substantial. Barger (1988) reported that Merino lambs first developed resistance to *Haemonchus contortus* (the most common intestinal parasite of sheep in Virginia) "as early as" 16 wk of age; the equivalent age would have occurred in early July in the current study. However, Watson (1991) found that at 12 wk of age, antibody responses of Merino lambs to *H. contortus* challenge were lower and slower to develop in weaned lambs, and suggested that at this age suckled lambs would be better able to withstand parasite infestation.

Year effects were also highly significant throughout the trial. However, weaning status x year interactions were pronounced in Periods A and B ($P < .001$). Non-weaned lambs in Period A grew faster than weaned lambs by $.22 \pm .03$, $.06 \pm .03$, and $.22 \pm .03$ lb/d in Yrs 1, 2, and 3, respectively (Table 4.2). Weaned and non-weaned lambs grew similarly poorly in Period B of Yr1, and both groups grew well in the same period of Yr2, with non-weaned lambs gaining $.15 \pm .05$ lb/d faster than weaned

lambs. The weaning status x year interaction disappeared in Period C and was not significant when gain over the entire summer (Period ABC) was evaluated. These results illustrate that although suckling lambs tend to have superior summer growth on pasture, management or environment can have substantial effects on the performance of weaned lambs on pasture, relative to unweaned lambs, at different ages or levels of parasite challenge.

Breed of the dam had no effect on gain during any period of the trial or on either weaning status group. This effect only approached significance ($P < .09$) in Period C when weaned lambs of $\frac{1}{4}$ -Finn dams lost weight while weaned lambs of Western dams were able to maintain slight weight gains ($-.03 \pm .03$ vs. $.05 \pm .03$ lb/d, respectively). The lack of breed effect is in concurrence with the results of Notter et al. (1991) and Fahmy (1989), who found no difference in post-weaning gain or slaughter age between spring-born lambs of $\frac{1}{4}$ -Finn ewes and their non-Finn counterparts.

There was also a weaning status x ewe breed effect in Period A ($P < .05$), as weaned lambs of Western dams gained $.19 \pm .03$ lb/d less than their non-weaned counterparts, while weaned lambs of $\frac{1}{4}$ -Finn dams gained only $.08 \pm .03$ lb/d less than their non-weaned counterparts. However, this interaction was non-significant in Periods B and C, and non-significant for gain over the entire summer.

Wether lambs grew faster than ewe lambs in Period A ($.04 \pm .02$, $P < .05$) but not in Periods B and C. Gain over the entire summer period was slightly affected by sex of the lambs ($P < .05$, Table 4.3).

Although 90-d wt varied by year at the start of the trial ($P < .001$; Table 4.2), it did not have a significant effect on gain at any point through the trial.

Marketing ages and weights, spring-born lambs

Both marketing weight and age were affected by weaning status ($P < .001$); weaned lambs were marketed at an average of 96.0 ± 1.1 lb at 201 ± 2 d of age, and non-weaned lambs were marketed at an average of 104.9 ± 1.1 lb at 186 ± 2 d of age. By September 30, 68% of all non-weaned lambs, but only 31% of weaned lambs, were marketed at greater than 104 lb (marketing distributions are listed in Table A.4).

Market age was also affected by year; lambs in Yr2 were marketed 17 ± 3 d earlier than lambs in Yr1 ($P < .001$). Of all Yr1 and Yr2 lambs, 2 and 34%, respectively, were marketed in July (Table A.4). The impact of parasite infestation appeared to peak in July of Yr1 and but not until August of Yr2. This emphasizes the importance of controlling parasite load in lambs grazing summer pastures. There were no ewe breed or interaction effects on market age or weight.

Very few lambs in Yr3 reached market weight before going to drylot on September 4 (Table A.4). Average market ages and weights in Yr3 were $108.8 \pm .7$ at 217 ± 3 d for non-weaned lambs, and $110.4 \pm .8$ lb at 240 ± 4 d for weaned lambs.

Post-weaning daily gain, fall-born lambs

Daily gain after weaning averaged .59 lb/d for fall-born lambs over 3 years, only .07 lb/d less than average preweaning daily gain. Ewe breed effects were significant ($P < .05$); lambs of Western and $\frac{1}{4}$ -Finn ewes gained $.61 \pm .02$ and $.57 \pm .01$ lb/d, respectively. Post-weaning daily gain was affected by year ($P < .01$); lambs in Yr2 grew $.08 \pm .03$ and $.07 \pm .03$ lb/d less than lambs in Yr1 and Yr3, respectively, suggesting strong management or environment effects on daily gain.

A ewe breed x year interaction was also evident ($P < .01$). Daily gains of lambs from $\frac{1}{4}$ -Finns did not vary significantly over the 3 years: $.57 \pm .22$, $.56 \pm .23$, and $.60 \pm .28$ lb/d for Yrs 1, 2, and 3, respectively. Lambs from Western ewes in Yr2 gained $.53 \pm .32$ lb/d, significantly less than lambs in Yrs 1 and 3 ($.69 \pm .26$ and $.63 \pm .35$ lb/d, respectively). Lambs from Western ewes in Yr2 did not differ in preweaning gain from those in Yrs 1 or 3. This postweaning difference in Yr2 appeared to be a function of age at weaning: because of later average birth dates, lambs from Western ewes averaged 60 d at weaning in Yr2, compared to 72 and 68 d in Yrs 1 and 3. Lambs from $\frac{1}{4}$ -Finn ewes averaged 76, 72, and 75 d of age at weaning in Yrs 1, 2, and 3, respectively.

Marketing ages and weights of fall-born lambs

For fall-born lambs, neither market age, market weight, nor number of days in drylot were affected by ewe breed. Lambs of ¼-Finn ewes were marketed at an average of 109.0 ± 1.1 lb liveweight at 164 ± 3 d of age, and after 92 ± 3 d in drylot. Lambs of Western ewes were marketed at an average of 110.9 ± 1.5 lb liveweight at 164 ± 3 d of age, and after 100 ± 4 d in drylot. Clearly the difference between postweaning daily gain and market age of spring- and fall-born lambs (194 vs. 164 d, respectively) is attributable to forage-based vs. concentrate-based diets. The difference in market age is not as pronounced as that reported by Notter et al. (1991), primarily because growth of spring lambs in that study was hampered by drought-limited forage, and lambs were consequently marketed later, at 234 d. This again emphasizes the influence of pasture management on a summer lamb grazing program.

Days spent in drylot was affected by year ($P < .05$). Lambs in Yr1 spent 16 ± 5 d less in drylot than lambs in Yr2. This can be explained in large part by their respective weaning dates, which was 11 d later for lambs in Yr1.

Ewe breed x year interactions were only significant for days in drylot ($P < .05$). This mirrors the interaction effect on daily gain after weaning, wherein daily gain of lambs of Western ewes in Yr2 was $.18 \pm .04$ lb/d less than in Yr1, and their time spent in drylot was consequently extended.

CONCLUSIONS

Spring-born lambs grew much faster after 90 d of age if they remained with their dams through the summer grazing period. Lambs weaned at 90 d to graze improved perennial pastures (primarily bluegrass, orchardgrass, and approximately 25% clover) were less able to withstand or recover from serious internal parasite challenge. At a set market date, weaning reduced the liveweight of lambs marketed. The effect of weaning was not altered by breed type.

Fall-born lambs grew faster after weaning than unweaned spring-born lambs. This was attributed to the high-concentrate drylot diet, cooler ambient temperatures, and reduced ingestion of internal parasites. Also, greater preweaning rates of gain and consequently heavier weaning weights of fall lambs resulted in substantially younger ages at marketing. Lambs from $\frac{1}{4}$ -Finn ewes grew slightly slower after weaning than lambs from Western ewes.

Lamb market ages and weights can, within reason, be controlled by management choices of feedstuffs. Fall-born lambs in this study could well have been fed on a higher-roughage diet to delay marketing; conversely, spring-born lambs could have been supplemented with grain in drylot to reach market weights earlier. Between-season comparisons are therefore limited to the nutritional conditions and management choices made for this study.

Table 4.1a Dates for weaning trial of spring-born lambs, Yrs 1, 2, 3

	<u>Yr1</u>	<u>Yr2</u>	<u>Yr3</u>
Start of trial	June 5	June 11	May 29
No. lambs at start	112	87	78
Mean age at start (d)	92 $\pm$ 1	98 $\pm$ 1	81 $\pm$ 1
End of Period A	July 17	July 8	July 13
End of Period B	August 7	August 5	
End of Period C	September 16	September 16	
Mean age at end of Period C (d)	194 $\pm$ 1	195 $\pm$ 1	

Table 4.1b Dates for post-weaning analysis of fall-born lambs, Yrs 1, 2

	<u>Yr1</u>	<u>Yr2</u>	<u>Yr3</u>
Weaning date	December 2	November 21	November
No. lambs at weaning	55	45	33
Mean age at weaning (d)	74 $\pm$ 10	68 $\pm$ 10	73 $\pm$ 9
Date A	February 4	February 3	January
Mean age at Date A (d)	138 $\pm$ 10	142 $\pm$ 10	136 $\pm$ 9

Table 4.2 Least-squares means and standard errors of daily gains of weaned (Wean) and non-weaned (NoWn) lambs during summer grazing on bluegrass-clover pastures

	Yr1		Yr2		Yr3	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
90-d gain, lb/d	.56	.01	.59	.01	.55	.01
90-d wt, lb	59.5	1.1	67.3	1.2	54.6	1.3
Period A, lb/d	Wean		Wean		Wean	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
	.40	.02	.59	.02	.26	.02
	NoWn		NoWn		NoWn	
Period B, lb/d	Mean		Mean		Mean	
	s.e.		s.e.		s.e.	
	.62		.64		.48	
	.02		.02		.02	
Period C, lb/d	Wean		Wean		Wean	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
	.07	.03	.42	.03	.26	.02
	.04		.57		.03	
Period ABC, lb/d	Mean		Mean		Mean	
	s.e.		s.e.		s.e.	
	.49		.11		.38	
	.02		.03		.02	

Table 4.3 Marginal (least squares) means and standard errors for lamb daily gains during summer grazing (lb/d)

	Mean	s.e.	Mean	s.e.	Mean	s.e.	Significance level
<u>Weaning status</u>	<u>Weaned</u>		<u>Non-weaned</u>				
Period A, Yr1, 2, 3	.41 .01		.58 .01				***
Period B, Yr1, 2	.24 .02		.30 .02				*
Period C, Yr1, 2	.01 .02		.30 .02				***
Period ABC, Yr1, 2	.24 .01		.42 .01				***
<u>Sex, Yr1, 2</u>	<u>Wethers</u>		<u>Ewe lambs</u>				
Period ABC	.34 .01		.31 .01				*
<u>Ewe breed, Yr1, 2</u>	<u>Westerns</u>		<u>W-Finn</u>				
Period ABC	.34 .01		.32 .01				NS
<u>Year</u>	<u>Yr1</u>		<u>Yr2</u>		<u>Yr3</u>		
Period A	.51 .01		.61 .02		.37 .02		***
Period ABC	.36 .01		.30 .01				***
*** Significant (P<.001)			* Significant (P<.05)				
** Significant (P<.01)			NS Nonsignificant				

Chapter 5. Annual Forages to Supplement Summer Grazing

INTRODUCTION

Perennial pastures in temperate regions, dominated by cool-season grasses, frequently undergo a period of summer dormancy. During this period pasture production may be insufficient to meet livestock needs. To counter this, stocking rates are generally lowered in the summer months to provide adequate forage for livestock.

Another means to offset summer declines in perennial pasture production is to use annual forages, planted to be available for mid-summer grazing. Warm-season (C_4) annual grasses such as pearl millet (*Pennisetum americanum* (L.) Leeke) yield a high quantity of forage and peak in production in June, July, and August (Rountree et al., 1974). At vegetative growth stages, C_4 grasses are similar in energy and slightly lower in protein levels than cool-season (C_3) grasses (Griffin et al., 1980; Vona et al., 1984), although the physical structure of C_4 grasses tends to reduce digestibility and limit forage intake (Griffin et al., 1980; Akin, 1989).

Brassicas such as turnip (*Brassica rapa* L.) or tyfon (*B. rapa* L. x *B. pekinensis* (Lour.) Rupr., a turnip x Chinese cabbage hybrid) have also been used to provide forage in mid-summer (Schwulst and Banbury, 1979; Jung et al.; Thomas et al., 1990), although it is not the optimal season for their usage. Brassicas yield a high quantity of forage, are highly digestible (Jung et al., 1983; Koch et al., 1987), and can be stocked at higher rates than cool-season grasses (Schwulst and Banbury, 1979; Guillard et al., 1988). Brassicas, however, appear to be initially unpalatable to sheep. Researchers have observed a 2-wk transition period when sheep were reluctant to graze brassicas for the first time and consequently lost weight (Schwulst and Banbury, 1979; Young et al., 1982; Thomas et al., 1990). Once accustomed to the brassicas, however, sheep consumed it readily and regained weight.

There is some risk associated with poor stand establishment of summer annuals. In previous studies, reported yields have varied widely between years for tyfon (Guillard et al., 1988) and millet (Schwulst and Robertson, 1980), as weather conditions were not conducive for germination, seedling survival, or stand development.

This portion of the study was designed to evaluate the mid-summer grazing potential of a warm-season annual grass (dwarf pearl millet) and a brassica (tyfon). During the month of July, dry ewes grazed tyfon or millet and weaned ewe lambs grazed millet. Grazing days, stocking rates, and daily gains of dry ewes and weaned lambs were calculated to assess the mid-summer carrying capacity and production level of each forage.

MATERIALS AND METHODS

Seedbed preparation

Seedbed preparation for no-till seeding of millet (Yrs 2 and 3) and tyfon (Yr2) began in mid-April with an application of Weedmaster (containing 2,4-D and dicamba in a 3:1 ratio) at 1.5 qt/ac to control perennial, broadleaf weeds, and a broadcast application of 60 lb N, 26 lb P, and 50 lb K/ac. Two d before seeding, Paraquat was applied at 1 qt/ac (plus surfactant) to kill existing sod.

In Yr2 a 5.8-ac field was divided into 6 paddocks; millet and tyfon were each seeded on May 15 into 3 alternating paddocks (Figure 5.1) at 25 and 5 lb seed/ac, respectively. In Yr3 the entire field was seeded with millet at 25 lb seed/ac on May 18.

Grazing management

In Yr 2 millet grazing began on July 18 with 44 dry ewes (averaging 189 lb) and 58 whitefaced, ¼-Finn ewe lambs (averaging 73 lb). Two groups of dry ewes (31 and 5 ewes, respectively) were later added to the original 44 ewes (Table 5.1). One ewe died after 7 d of grazing, of causes apparently unrelated to millet grazing. Ewes and lambs remained in their

same respective paddocks for the duration of the trial; weights were recorded at the start and completion of the trial period (Table 5.1).

Tyfon grazing in Yr2 began with 42 dry ewes (averaging 193 lb). One ewe died 3 d later, leaving 41 ewes for the remainder of the trial. As tyfon forage was depleted in each paddock, ewes were moved to successive paddocks (Table 5.1, Figure 5.1). Weights were recorded as ewes moved onto or off of each paddock.

The grazing trial ended in Yr2 when tyfon forage was depleted. However, the third millet paddock (E2) was still ungrazed at this point. All dry ewes were moved to graze this paddock; however, dates and ewe weights were not recorded and thus this paddock has not been included in the analysis.

Because tyfon production was clearly inferior to that of millet in Yr2 (Table 5.2), it was not planted in Yr3. Instead, the entire 5.8-ac field was seeded to millet, and again divided into the same 6 paddocks. Millet stand establishment was poor and variable over the field in Yr3; weed population was high. The decreased stand vigor was attributed to soil compaction from ewes and lambs grazing winter rye prior to no-till millet seeding, a condition that might have been alleviated with conventional tillage.

In Yr3, 75 dry ewes (averaging 175 lb) grazed paddocks A and C for 8 d, paddock D for 5 d, and paddock E, which contained very little millet, for only 3 d. Weights were recorded as ewes entered or moved from a paddock. Sixty-three whitefaced, $\frac{1}{4}$ -Finn ewe lambs (averaging 49 lb) also grazed millet in rotation. One lamb died after 18 d. Lambs strip-grazed paddock B for 26 d, then were moved to graze the regrowth of paddocks A and C for 9 d. Weights were recorded as lambs moved onto or off of a strip or paddock.

Analysis

To determine grazing days (GD) of a group (i.e., dry ewes or ewe lambs in Yr 2 or 3) on a forage type, the number of grazing animals was multiplied by the number of days those animals grazed a forage type (Table 5.2). In cases where stocking density varied due to death or additional ewes, individual grazing days were summed to determine total GD for that

group on that forage. Total GD was then divided by acres grazed by that group to determine GD/acre.

In Yr3 paddocks A and C (1.72 acres combined) were grazed by both dry ewes and ewe lambs for 8 and 9 d each, respectively. A percentage of the 1.72 ac was "charged" to each group by figuring Animal Unit Days (A.U.D.). That is, grazing days were adjusted for body weight on the basis of 1100 lb/A.U. (Forage and Grazing Terminology Committee, 1991):

$$75 \text{ ewe @ } 173 \text{ lb} = 12,975 \text{ lb} \div 1100 \text{ lb} = 11.8 \text{ AU} * 8 \text{ d} = 94.4 \text{ AUD}$$

$$62 \text{ lambs @ } 58 \text{ lb} = 3,596 \text{ lb} \div 1100 \text{ lb} = 3.3 \text{ AU} * 9 \text{ d} = 29.4 \text{ AUD.}$$

Thus a total of 123.8 AUD were grazed, and ewes and lambs were charged for 76% or 1.31 ac, and 24% or .41 ac, respectively, of the 1.72-ac field.

Daily gain was calculated by dividing mean weight change for a group by the total days grazing (Table 5.3). Ewes and lambs that died during the trial were not included in daily gain calculations, although they were included in determination of grazing days. Daily gains of dry ewes on millet in Yr2 were figured in 2 groups, as their weights and time spent grazing differed considerably. Daily gains of the 5 ewes added to millet grazing late in the trial (Yr2) were not calculated.

Stocking rate was figured on the basis of both Animal Units (A.U.)/ac and head/ac (Table 5.4). Animal Unit Days were determined as outlined above. Animal Units/ac was calculated:

$$\text{A.U.D.} \div \text{acres grazed} \div \text{days of grazing} = \text{A.U./ac.}$$

Stocking rate as head/ac was calculated by first determining head of ewes or lambs in that group per Animal Unit,

$$\text{Head/A.U.} = 1100 \text{ lb (A.U.)} \div \text{average weight of ewe or lamb,}$$

and then multiplying head/A.U. by A.U./ac.

RESULTS AND DISCUSSION

Tyfon

Tyfon, a turnip x Chinese cabbage hybrid, supported fewer ewes per acre than did millet over the same 29-d period in Yr2 (Table 5.4): 2.5 vs. 8.7 A.U./ac, respectively. Brassicas are primarily used to extend the fall grazing season, and are infrequently used as summer forage. However, early growing conditions in this trial should have benefited tyfon somewhat: tyfon has among the poorest level of germination of all brassica species (Wilson et al., 1992), particularly at temperatures above 30°C (86°F). Mid-May seeding should have provided more moderate temperatures than the mid-summer seeding common for fall brassica production.

The grazing period for tyfon extended from 54 d to 83 d after seeding. It is possible that insufficient time was allowed for forage growth before the onset of grazing. Had grazing been delayed somewhat, forage production may have been improved. Guillard and Allison (1984) and Koch et al. (1987) reported peak yields of fall-grown tyfon at 84 and 120 d after seeding, respectively. The 29-d grazing period was shorter than that reported by Koch et al. (1987), who grazed lambs on tyfon for 45- to 60-d periods, but was similar to the 30- to 36-d period of tyfon grazing by mature ewes in Connecticut (Guillard et al., 1988).

The stocking density and stocking rate in the current study, 424 GD/ac and 14.6 ewes/ac, respectively, are substantially less than that reported by Guillard et al. (1988), who had 1123 GD/ac and 32 mature ewes/ac on tyfon in an optimal year, and 695 GD/ac and 28 ewes/ac in a poor growing year.

Brassicas tend to be highly digestible and high in nutrients. Forage tests of whole tyfon plants (tops and roots) from this trial had 19.2% ADF, 21.7% CP, and 75% TDN, on a DM basis. Tyfon tops alone had only 14.8% ADF. By comparison, fresh, early vegetative bluegrass contains approximately 29% ADF, 17.4% CP, and 65% TDN (IFN 2-00-777; Jurgens, 1982). But tyfon samples were also low in DM; tops and whole plants yielded 13.5 and 10.5% DM, respectively. Vegetative bluegrass

averages 31% DM (Jurgens, 1982). Low DM content can limit ewes' ability to consume sufficient quantities of nutrients, and might have contributed to the weight loss observed in this trial (-.20 lb/d; Table 5.3).

Nonetheless, low dry matter content alone does not explain the weight loss of ewes grazing tyfon. Outhouse et al. (1980) averaged 44.5 mature ewes/ac and .18 lb/d gain on fall turnip, which also has high digestibility but low DM content. Mature ewes grazing tyfon and supplemented with .5 lb grass hay/d were able to gain .48 lb/d over a 34-d period (Guillard et al., 1988); these ewes were adjusted to tyfon forage for 7 d in drylot before being placed on tyfon pastures only. Numerous researchers have commented on initial reluctance of sheep to graze brassicas for the first time. This may have been a factor in the current study. Ewes' weight change was -1.06 lb/d during the first 8-d period of tyfon grazing, -.16 lb/d during the second 12-d period, and +.65 lb/d during the last 7-d period. It is possible that given a longer grazing period on tyfon, ewes could have continued to gain weight.

There appears to be little economic advantage to grazing ewes on tyfon. At a stocking rate of 14.6 ewes/ac for 29 d, and an establishment cost of \$104.54/ac (Table A.14.f), tyfon cost \$.247/ewe/d. The cost of open ewes stocked at 7 ewes/ac on summer perennial pastures was calculated to be \$.79/ewe for a 92-d period (Table A.14.c), or \$.008/ewe/d. The cost of perennial bluegrass-clover pasture in fall, at a slightly lower stocking rate than in summer, was \$.57/ewe for a 61-d period, or \$.009/ewe/d. Even if tyfon palatability and stand production factors could be overcome, such that stocking rate might be increased to 44 ewes/ac (Outhouse et al., 1980) and grazing period to 45 d (Koch et al., 1987), at \$104.45/ac tyfon costs would only decrease to \$.053/ewe/d. Therefore it does not appear that tyfon could be economically competitive with perennial grass-clover pastures in Virginia.

Millet

At an average stocking rate of 43.7 mature ewes/ac (Table 5.4), millet carried almost three times as many ewes/ac as tyfon, and six times as many ewes/ac as perennial pasture in mid-summer (Table A.14.c). Stocking

rates of ewe lambs (averaged at 51.2 lambs/ac) were also very high compared to those of weaned lambs continuously stocked (15 lambs/ac) in Yrs 1 and 2, and rotationally stocked (8 lambs/ac) in the very dry summer of Yr3.

Ewe grazing days/acre in Yr2 (1,591 GD/ac, Table 5.2) were similar to those reported by Schwulst and Robertson in Kansas (1,602 GD/ac; 1980), except that the millet was grazed for 80 d in Kansas (stocking rates or sward condition was not reported) and for only 29 d in this trial.

Poor stand establishment was evident in Yr3; grazing days/ac for mature ewes was 26% of the previous year. Had paddock E (2.0 ac grazed for only 3 d) been included in the analysis, this figure would have been even lower. These figures indicate that millet establishment and consequent production may be highly variable, and underscores what is perhaps the primary hazard of including annual forages in a production system. In systems designed to utilize annuals as part of the yearly forage program, a poor stand might have substantial economic and management impacts.

Grazing days/ac for lambs in Yr3 only dropped 16% below that of Yr2 (Table 5.2). This was because 62 lambs were able to remain on the most productive paddock (paddock B, 1.08 ac) for 26 d, before moving to graze regrowth on paddocks grazed 16 d earlier by ewes, thus extending the millet grazing an additional 9 d. This illustrates the increased production potential that is possible if millet is managed to take advantage of vegetative regrowth.

Daily "gain" in ewes on millet in Yr2 was very poor (Table 5.3). This may be due in part to high stocking rates, as weight was gained (.23 lb/d) in Yr3 when stocking rates were reduced from 55.9 to 32.5 ewes/ac. Somewhat like tyfon, daily gain on millet improved after the first days of exposure to the new forage. In Yr3, when periodic gains were recorded, ewes lost 2.40 lb/d in the first 2 d of grazing millet, but then gained .89 lb/d in the next 7-d period, and .53 lb/d in the following 3-d period. However, while grazing the weedy paddock E, ewes lost 1.11 lb/d; had this been included in daily gain calculations, overall weight change on millet would have been -.09 lb/d. The decrease from .89 to .53 lb/d gain may be a

reflection of increasing stand maturity, which rapidly lowers quality in warm-season grasses (Griffin et al., 1980; Vona et al., 1984).

Average weight gain in ewe lambs was less than the .45 and .60 lb/d gain recommended by the NRC (1985) for 77- and 55-lb lambs, respectively (Table 5.3). But gains on millet compared favorably to the gains of weaned, Suffolk-sired lambs continuously stocked on improved perennial pastures in Yrs 1 and 2, which averaged .24 lb/d during the mid-July to early-August period ("Period B", Table 4.4). Forage quality was tested in two millet samples taken from different millet paddocks on the first day of grazing in Yr2. The samples averaged 28.5% ADF, 11.9% digestible protein, and 64.5% TDN (DM basis). These nutrient levels are comparable to those of a bluegrass-white clover mix (25% clover), estimated by NRC (1985) and Jurgens (1982): 29% ADF, 14% digestible protein, and 65% TDN. As millet matures, however, lignification will cause digestibility and palatability to decline and can limit energy and protein availability to lambs (Vona et al., 1984; Hollingsworth et al., 1991). To maintain adequate forage intake, nutrition, and growth of lambs on millet, the sward must be managed to limit stand maturity and maximize leaf content.

Total gain per acre for ewe lambs in the millet trial was 567.9 and 457.7 lb in Yrs 2 and 3, respectively. Weaned lambs grazing improved grass-clover pastures in Yrs 1 and 2 averaged 5.01 lb gain/hd during Period B; thus at a stocking rate of 15 lambs/ac, perennial grass-clover pasture produced 75 lb gain/ac.

Cost of pearl millet establishment was calculated at \$120.54/ac (Table A.14.e); thus cost per lb of lamb gain was \$.21 and \$.26 for Yrs 2 and 3, respectively. Perennial grass-clover pasture costs were estimated to be \$1.85/ac per month of grazing, or \$.02/lb gain during Period B in Yrs 1 and 2. The grazing period for pearl millet has been at least 60 d in trials in Kansas (Schwulst and Robertson, 1980) and Missouri (Rountree, 1974). In the current study, if lamb gains on millet were maintained at approximately .32 lb/d, but the millet grazing season was extended to 60 d (thus doubling per-acre lamb gains), the cost of gain on millet would have been halved. Nevertheless, millet would probably only be economically competitive in a year such as Yr3, when stocking rates of lambs on perennial pastures were

greatly reduced and per-head costs of perennial pasture consequently increased. (Although in very dry summer conditions, palatability of millet may also become problematic, as alkaloid levels in millet increase with drought stress [Krejsa et al., 1987].)

At a stocking rate of 43.7 dry ewes/ac, the cost of millet was calculated at \$2.76/ewe/yr (Table A.14.e). Over the 29-d grazing period in Yr2, millet thus cost \$.10/ewe/d; in Yr3, because of the abbreviated grazing period, millet cost \$.21/ewe/d. If the grazing season were extended to 60 d, millet costs would be reduced to \$.046/ewe/d, and still would not likely be competitive with the \$.008/ewe/d cost for cool-season, grass-clover pastures in mid-summer, even under severely dry summer conditions.

One additional consideration in the use of summer forages such as millet is the highly efficient use of acreage, particularly in a farm situation where additional pasture acreage of appropriate quality in mid-summer is not readily available. Given stocking rates on perennial cool-season pastures of 7 dry ewes/ac and 15 weaned lambs/ac (Table A.14.c), a system that incorporated millet into summer grazing might require fewer acres mid-summer to support dry ewes and weaned lambs (Table 5.5). However, in a situation of limited acreage or inadequate summer forage, it may be as economical for a producer to feed purchased feedstuffs to dry ewes and weaned lambs. Given NRC (1985) recommendations of 1.5 lb TDN/154-lb dry ewe/d, a ewe's daily energy requirements could be met with 2 lb corn or 3 lb hay. At corn and hay costs of \$.055 and \$.037/lb, respectively (Table A.2), ewe maintenance costs on corn or hay are approximately \$.11/ewe/d, a per-ewe cost nearly equivalent to that of millet in Yr2 of this study.

CONCLUSIONS

Mid-summer carrying capacity of pearl millet was substantially greater than that of tyfon, and was apparently greater than the mid-summer carrying capacity of cool-season perennial pastures. Daily gain of dry ewes was poor in the first year of the trial but appeared to improve when stocking rates were reduced in the second year. Daily gain in lambs was adequate and comparable to historic gains of weaned lambs grazing bluegrass-clover pasture at the Experiment Station. Both millet and tyfon appeared to initially be unpalatable to grazing ewes, as ewes lost weight when first grazing the new forages, and then gained weight as the grazing season progressed.

The high establishment costs of tyfon and pearl millet resulted in lamb gain and ewe maintenance costs that were much higher than those of lambs and ewes on perennial pastures. Per-head costs for all annual and perennial forages are highly influenced by stocking rates. Economic comparisons of annual and perennial pastures are therefore somewhat specific and limited to the management of a particular production system.

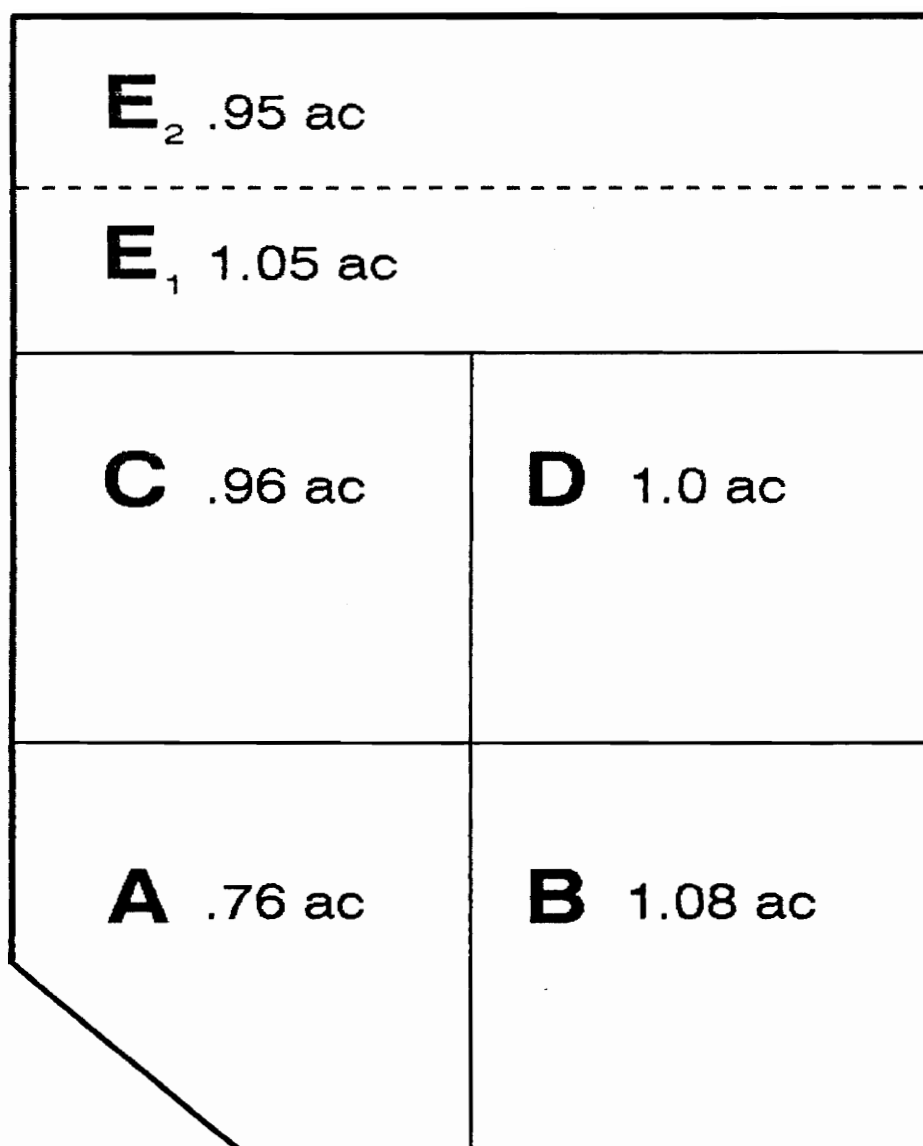


Figure 5.1 Paddocks for millet and tyfon, Yrs 2 and 3

Table 5.1 Grazing calendar for millet and tyfon, Yrs 2 and 3

Yr1	Date	Total hd grazing	Paddock	Acres
<u>Tyfon (dry ewes)</u>				
Start of grazing	July 8	41	A	0.76
	July 18		D	1.00
	July 30		E1	1.05
End of grazing	August 6			
<u>Millet (dry ewes)</u>				
Start of grazing	July 8	44	B	1.08
	July 24	75	B	
	July 28	80	B	
End of grazing	August 6			
<u>Millet (lambs)</u>				
Start of grazing	July 8	58	C	0.96
End of grazing	August 6			
Yr2	Date	Total hd grazing	Paddock	Acres
<u>Millet (dry ewes)</u>				
Start of grazing	June 30	75	A & C	1.31
	July 8		D	1.00
	July 13		E	2.00
End of grazing	July 16			
<u>Millet (lambs)</u>				
Start of grazing	June 29	63	B	1.08
	July 24		A & C	0.41
End of grazing	August 3			

Table 5.2 Grazing days (GD) of ewes and lambs on tyfon and millet

Group	Head	Days	GD	Total GD	Total acres	GD /acre
<u>Tyfon</u>						
Dry ewes	41	29	1189			
died early	1	3	3			
				1192	2.81	424
<u>Millet Yr2</u>						
Dry ewes	44	29	1276			
added ewes	30	13	390			
added ewes	5	9	45			
died early	1	7	7			
				1718	1.08	1591
Lambs	58	29	1682	1682	0.96	1752
<u>Millet Yr3</u>						
Dry ewes	75	13	975	975	2.31	422
Lambs	62	35	2170			
died early	1	18	18			
				2188	1.49	1468

Table 5.3 Weight change of ewes and lambs on tyfon and millet

Group	Starting wt (lb)	Ending wt (lb)	Ave. wt change (lb)	Days grazing	Daily gain (lb)	NRC sugg daily gain (lb)
Tyfon, ewes	193.0	187.1	-5.9	29	-0.20	0.02
Millet, ewes Yr2						
44 ewes	189.1	181.2	-7.9	29	-0.27	0.02
30 ewes	144.5	137.6	-6.9	13	-0.53	0.02
Millet, lambs Yr2	73.4	82.8	9.4	29	0.32	0.45
Millet, ewes Yr3	174.8	177.8	3.0	13	0.23	0.02
Millet, lambs Yr3	49.2	60.2	11.0	35	0.31	0.60

Table 5.4 Animal Unit Days (A.U.D.) and stocking rates of ewes and lambs on tyfon and millet

Group	Grazing days	Ave. wt. (lb)	A.U.D.	Acre	A.U.D. /acre	Days	A.U. /acre	Hd/A.U.	Head /acre
Tyfon ewes	1192	190.1	206	2.81	73	29	2.5	5.8	14.6
Millet									
Ewes Yr2	1718	174.1	272	1.08	252	29	8.7	6.3	54.9
Lambs Yr2	1682	78.1	119	0.96	124	29	4.3	14.1	60.4
Ewes Yr3	975	176.3	156	2.31	68	13	5.2	6.2	32.5
Lambs Yr3	2188	54.7	109	1.49	73	35	2.1	20.1	42.0

Table 5.5 Estimated acreage required for 100 ewes suckling 1.5 lambs/ewe (E + L), or 100 dry ewes (E) and 150 weaned lambs (L)

Season	Bluegrass-clover pasture No-wean		Bluegrass-clover pasture Wean		Millet Wean	
	Stocking rate	Acre	Stocking rate	Acre	Stocking rate	Acre
Spring	7E + 10L	14.3	7E + 10L	14.3	7E + 10L	14.3
Summer	4.5E + 7L	22.2	7E	14.3	44E	2.3
			15L	10.0	51L	3.0
Fall	6.5E	15.4	6.5E	15.4	6.5E	15.4

Chapter 6. Lactating and Dry Ewes Grazing Turnip in the Fall

INTRODUCTION

Brassicas are commonly used to extend the fall grazing season in Europe, Australia, and New Zealand. Usage in the U.S. has declined in the last few decades, but there has recently been some renewed interest in brassicas, as more productive and hardy cultivars have been developed (Guillard et al., 1988), as no-till cultivation has reduced establishment costs (Jung et al., 1983), and as sheep managers attempt to integrate annual and perennial forages into systems that limit the amount of grain fed to livestock.

Turnip (*Brassica rapa* L.) is a cold-tolerant species that with favorable conditions can be grazed into December (Outhouse et al., 1980; Jung et al., 1983), thereby providing forage after the decline of cool-season, perennial pastures. Turnips will increase their yield through the fall grazing season (Sheldrick and Lavender, 1981), and are highly digestible (Jung et al., 1984) and high in energy, although also low in dry matter (Guillard et al., 1988).

Ewe and lamb performance on turnip appears to vary greatly from year to year in any given location (Outhouse et al., 1980; Young et al., 1982), reflecting variations in the success of stand establishment. As with other annuals, weather conditions during germination and stand development can greatly affect the carrying capacity of turnip forage. Palatability of turnip can also be problematic, as sheep are reported to be reluctant to graze brassicas for the first time (Outhouse et al., 1980; Thomas et al., 1990).

This portion of the study was primarily designed to explore the use of turnip as a supply of high-quality forage for fall-lambing ewes through the fall grazing period. Two turnip cultivars were seeded in mid-summer in each of 2 years and were grazed by lactating ewes with their lambs, and by dry ewes for a short period of time, beginning in mid-October. Ewes grazed

both cultivars in alternate succession until forage was depleted. Ewe weights were recorded to determine the carrying capacity of the individual cultivars and to evaluate the effect of turnip grazing on lactating or dry ewes.

MATERIALS AND METHODS

Seedbed preparation

To prepare for no-till turnip seeding in Yr1, the existing grass sward was grazed down to 3 in. Paraquat was then applied at 1 qt/ac (plus surfactant) on July 31. At that point fertilizer was also applied at 60 lb N, 26 lb P, and 50 lb K/ac. On August 12, Paraquat was reapplied at 1 qt/ac to kill remaining sod cover. Paddocks were seeded with either Green Globe or Purple Top turnip cultivars (Table 6.1, Figure 6.1) on August 16 at 3 lb seed/ac. An insecticide (granular 15G Furadan, no longer approved in Virginia) was applied on August 16 at 7 lb/ac.

Seedbed preparation for turnip seeding in Yr2 began on August 20 with Paraquat application (1 qt/ac plus surfactant) and application of 60 lb N/ac. Granular 15G Furadan was applied on August 25 at 7 lb/ac and turnip was no-till seeded at 3 lb/ac. The two cultivars were seeded into the same plots as in Yr1.

Grazing

Turnip grazing commenced in Yr1 on October 24, when 43 lactating ewes and their 57 lambs were moved from alfalfa pastures onto a paddock containing the Purple Top cultivar. When all available forage (foliage and roots) had been consumed, ewes and lambs were moved to the next paddock (Table 6.1), and then to the third, until snow forced the end of turnip grazing on December 2. Ewes were weighed as they entered (or exited) each paddock.

Turnip grazing management was similar in Yr2, beginning on October 15, as 38 lactating ewes and their 50 lambs were moved from alfalfa pastures to a paddock containing the Green Globe cultivar. The sequence

of grazing cultivars was the reverse of Yr1 (Table 6.1). Ewes progressed through paddocks as the forage in each was depleted until November 21 when snows and heavy frost ended the turnip grazing. Ewe weights were taken when animals were moved onto or off of each paddock.

Dry ewes being bred for spring lambing also grazed turnips in Yr2, on paddocks separate from the ewes and lambs. Fifty-two ewes and 3 rams grazed a 2-ac paddock containing both Purple Top and Green Globe cultivars from October 15 to October 28, and were then moved to graze Purple Top until November 5, when all dry ewes were removed from turnip grazing. Ewe weights were recorded as animals moved onto or out of each paddock.

Statistical analysis

Analysis of variance was conducted on daily gain of lactating ewes, evaluating the fixed effects of turnip variety (Green Globe and Purple Top) and year (Yrs 1 and 2), with stage of lactation as a covariate. Daily gain was the average weight change of ewes for each period on a particular turnip cultivar divided by the number of days in that period. Data were included in the daily gain analysis only if the ewe completed the entire turnip grazing trial. One ewe in Yr1 and 3 ewes in Yr2 died during the trial of causes apparently unrelated to turnip grazing, and were therefore not included in the individual-animal analysis. Stage of lactation was the day of lactation of the ewe at the midpoint of each grazing period. Grazing days (GD) per acre were determined by multiplying the number of ewes (lactating or dry) by the number of days in the period, and then dividing by the acres grazed. Suckling lambs were not included in determination of grazing days (although at an average of 50 d of age, the lambs may have been consuming some forage). Rams and dry ewes were considered together for determination of GD, but rams were not included in calculations of dry ewe daily gains. Ewes that died during the trial were credited with the actual number of days spent on each paddock.

RESULTS AND DISCUSSION

Weight change of lactating ewes

Ewes were on turnip pasture in Yr1 from approximately d 35 to d 73 of lactation, suckling an average of 1.33 lambs/ewe. In Yr2 ewes grazed turnip from d 29 to d 66 of lactation, suckling an average of 1.32 lambs/ewe. Overall daily gain of lactating ewes grazing turnips was $-.37$ lb/d (Table 6.2.a). Averaged over both turnip varieties, ewes lost $-.40 \pm 0.07$ and $-.33 \pm 0.07$ lb/d in Yrs 1 and 2, respectively. The slightly reduced weight loss in Yr2 may be a reflection of correspondingly reduced stocking density in Yr2 (15.4 ewes/ac vs 12.7 ewes/ac). Weight gain of lambs and dry ewes on brassicas has been shown to be inversely related to stocking rate (Paterson et al., 1977; Outhouse, et al., 1980; Young et al., 1982).

Effects of turnip variety and year on daily gain were not significant, but effects of stage of lactation were highly significant ($P < .001$). Ewes lost $.01 \pm .002$ lb/d /less with each successive day of lactation. Extreme weight loss when ewes first entered turnip paddocks may be attributed in part to a reluctance to graze the novel forage (Schwulst and Banbury, 1979; Outhouse et al., 1980). Initial weight losses in lambs grazing brassicas, followed by weight gain when lambs adjust to the forage have been reported (Paterson et al., 1977; Young et al., 1982; Thomas et al., 1990).

Over the 2 years, lactating ewes averaged $-.42 \pm 0.07$ and $-.31 \pm 0.07$ lb/d on Green Globe and Purple Top cultivars, respectively. This weight loss was substantially greater than that recommended by the NRC for a 154-lb ewe in the first 6 to 8 wk of lactation ($-.06$ and $-.13$ lb/d for ewes suckling singles and twins, respectively; 1985). Whether this weight loss had any effect on the ewe's ability to produce milk is unclear. Preweaning weight gain of lambs averaged $.63 \pm .01$ in Yrs 1&2 combined, very similar to the preweaning gain of spring-born lambs (Chapter 3). Lambs in fall of Yr3 had preweaning gains of $.75 \pm .02$ lb/d, but had access to creep for a longer period of time than lambs in Yrs 1&2, and by the 70-d weaning age were probably consuming more nutritious forage (alfalfa) than were the lambs on turnip in Yrs 1 and 2.

There has been no published research on actual intake of turnip by mature ewes. Extrapolating from NRC (1985) estimates of nutrient composition of whole turnips containing 25% of total DM in the roots (Sheldrick and Lavender, 1981), turnip will contain approximately 12.75% DM, 18.85% CP, and 1.23 Mcal ME/lb DM (these estimates agree with those reported by Sheldrick and Lavender [1981] for whole turnips). Daily nutrient requirements of 154-lb ewes suckling an average of 1.5 lambs in the first 6 to 8 wk of lactation are 5.9 lb DM, 6.25 Mcal ME, and .83 lb CP per ewe (NRC, 1985). Given these requirements for energy and the low DM content of turnip, a ewe would need to consume 41 lb of fresh turnip daily to limit weight loss to approximately .06 to .13 lb/d. Thus it is possible that weight loss in these lactating ewes might have been due in part to an inability to consume adequate nutrients.

Turnips contain toxins such as nitrates and S-methyl cysteine sulphoxide (Smith and Greenhalgh, 1977; Guillard and Allison, 1989). Although these toxins may have subclinical effects on growth and milk production (Wright and Davison, 1964; Smith and Greenhalgh, 1977), these possible effects have not been confirmed or quantified. Obvious detrimental effects of toxins on milk production were not evident in this study, given the growth of suckling lambs.

Weight change of dry ewes

Overall daily gain for dry ewes in Yr2 was adequate, although ewes lost weight during the first 13 d on turnip (Table 6.2.b). This again was likely due to a slow period of adjustment to turnip. The initial weight loss was offset by substantial weight gains in the second period. Overall gain in dry ewes was .11 lb/d.

NRC (1985) advises a weight gain of .07 lb/d for non-lactating ewes in the first 15 wk of gestation. Thus turnip forage appears to have supplied adequate nutrition to dry ewes in this trial. The high rate of gain of dry ewes in the second period suggests that once the ewes had adjusted to turnip grazing, the overall stocking rate of 18.5 ewes/ac could have been increased. This is consistent with the stocking rate and gain for dry ewes grazing turnip reported by Outhouse et al. (1980).

Grazing period and grazing days

Turnip grazing began 69 d after seeding in Yr1, and lasted 39 d (Table 6.3). In Yr2 grazing began 51 d after seeding, and lasted 35 days, concluding after a heavy frost and snow killed or covered the remaining forage on November 21. Dry ewes had been removed from turnip 16 d earlier, and thus had only a 21-d grazing period. These grazing periods are comparable to those reported by Outhouse et al. (1980) and slightly shorter than those of Sheldrick and Lavender (1981), who reported that turnip grazing lasted at least 60 d.

Total GD/ac for lactating ewes in Yr1 and Yr2 were 614 and 469, respectively (Table 6.3.a). This difference of 145 GD/ac is equivalent to approximately 4 more days of grazing for lactating ewes on 2.8 ac of turnip in Yr1. Weather and other environmental conditions such as weed competition can affect the length of the grazing period. Turnips in Yr2 were planted 4 d later but were ready to graze 9 d earlier than turnips in Yr1. Yet poor weather in November of Yr2 forced an early end to turnip grazing; consequently total GD/ac were reduced. Stocking rate was also lower in Yr2. Thus optimum GD/ac is a balance of grazing period and stocking rate, as was also noted by Outhouse et al. (1980).

Averaged over 2 years of lactating ewes grazing turnip, there were a total of 562 GD/ac on Purple Top turnips, and 510 GD/ac on Green Globe turnips. Although this was a difference of 51 GD/ac, it only amounted to approximately 1.5 more days of grazing on the Purple Top than the Green Globe variety. Total GD/ac for dry ewes (in Yr2 only) was 390 GD/ac (Table 6.3.b).

Like the summer annuals discussed in Chapter 5, the establishment costs of turnip appear to make it a poor financial option. With an average of 37 d of grazing and with per-ewe costs of \$5.52 and 4.16 (Table A.14.g), turnip cost \$.149 and .112/ewe/d for lactating and dry ewes, respectively. If the grazing period were extended to 60 d, costs for fall grazing would still not be competitive with alfalfa (\$.076/lactating ewe/d for 80 d, Table A.14.a) or with perennial, cool-season grass pastures (\$.031/dry ewe/d for 60 d, Table A.14.c). However, if the supply of fall

grass-clover pastures was limited, particularly in a fall-lambing situation, annual forages might provide a more efficient use of acreage because of the greater stocking rates. It is also possible that weight loss in lactating (or dry) ewes could be reduced by supplementing hay, especially during the initial period of transition to turnip forage.

CONCLUSIONS

In terms of nutritional supply, fall-grazed turnips appear to be a viable alternative to perennial grass pastures for dry ewes being flushed and bred in the fall. Weight gains were adequate once the ewes had adjusted to the forage. At stocking rates of nearly 20 ewes/ac, turnips may allow efficient use of land. However, the cost of establishment and the risk associated with an abbreviated grazing period appear to make turnips economically infeasible. Turnips alone may not be an adequate feed for lactating ewes. The exact reason for this is unclear, and is perhaps a combination of low dry matter content and poor initial acceptance of ewes grazing turnip.

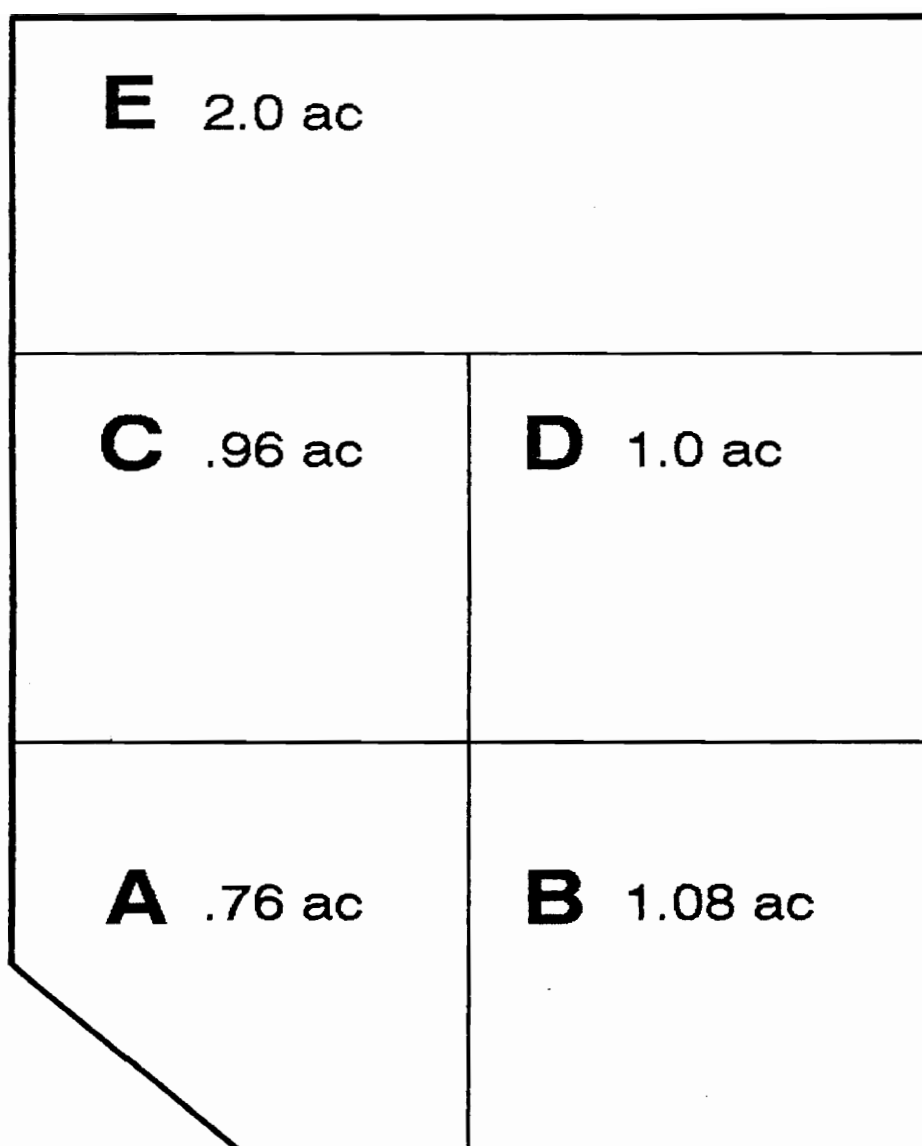


Figure 6.1 Paddock for turnip grazing, Yrs 1 and 2

Table 6.1 Calendar of turnip grazing by lactating and dry ewes

Lactating ewes, Yr1

Period	1	2	3
Grazing dates	10/24–11/8	11/8–11/19	11/19–12/2
Cultivar	Purple Top	Green Globe	Purple Top
Paddock	B	A	C
Ac/paddock	1.08	0.76	0.96
Ewes	43	43	43
Lambs	57	57	57

Lactating ewes, Yr2

Period	1	2	3
Grazing dates	10/15–10/27	10/27–11/12	11/12–11/21
Cultivar	Green Globe	Purple Top	Green Globe
Paddock	A	B	D
Ac/paddock	0.76	1.08	1.00
Ewes	38	35	35
Lambs	50	46	46

Dry ewes (and rams), Yr2 only

Period	1	2
Grazing dates	10/15–10/28	10/28–11/5
Cultivar	GrnGlb/PurpTop	Purple Top
Paddock	E	C
Ac/paddock	2.00	0.96
Ewes	52	52
Rams	3	3

Table 6.2.a Daily weight change (ADG, lb/d) of lactating ewes grazing turnip in Yrs 1 and 2

<u>Year</u>	<u>Turnip Variety</u>	<u>Period</u>	<u>Days</u>	<u>Ave Lact. Dt.*</u>	<u>Start wt. (lb)</u>	<u>End wt. (lb)</u>	<u>ADG</u>
1	Purple top	1	15	42	171.6	158.0	-0.91
1	Green globe	2	12	50	158.0	157.7	-0.03
1	Purple top	3	13	67	157.7	157.0	-0.05
2	Green globe	1	12	35	179.1	169.0	-0.84
2	Purple top	2	16	49	169.0	171.6	0.16
2	Green globe	3	9	62	171.6	166.8	-0.53

* Mean day of lactation at the midpoint of the grazing period

Table 6.2.b Daily weight change (ADG, lb/d) of dry ewes grazing turnip in Yr 2

<u>Year</u>	<u>Turnip Variety</u>	<u>Period</u>	<u>Days</u>	<u>No. Ewes</u>	<u>Start wt. (lb)</u>	<u>End wt. (lb)</u>	<u>ADG</u>
2	Both	1	13	52	173.2	171.2	-0.15
2	Purple top	2	8	52	171.2	175.3	0.51

Table 6.3.a Grazing days of lactating ewes grazing turnip, Yrs 1 and 2

<u>Year</u>	<u>Turnip Variety</u>	<u>Period dates</u>	<u>Days</u>	<u>No. ewes</u>	<u>GD</u>	<u>Acres</u>	<u>GD /ac</u>
1	Purple top	1	15	43	645	1.08	597
1	Green globe	2	12	43	516	0.76	679
1	Purple top	3	13	43	559	0.96	582
	Total acres					2.80	
2	Green globe	1	12	38	456	0.76	600
2	Purple top	2	16	35	560	1.08	519
2	Green globe	3	9	35	315	1.00	315
	Total acres					2.84	

Table 6.3.b Grazing days of dry ewes grazing turnip, Yr 2

<u>Year</u>	<u>Turnip Variety</u>	<u>Period dates</u>	<u>Days</u>	<u>No. Ewes</u>	<u>GD</u>	<u>Acres</u>	<u>GD /ac</u>
2	Both	1	13	55	715	2.00	358
2	Purple top	2	8	55	440	0.96	458
	Total acres					2.96	

Chapter 7. Economic Analyses of Sheep Production Systems

INTRODUCTION

The value of a change in animal performance, such as reproductive performance, growth, carcass characteristics, or wool production, should be assessed by its ultimate effect on the entire production system. Most biological or management changes have an accompanying cost, whether positive or negative. And few changes occur in isolation; most have an interactive effect on other production traits. Perceived advantages or disadvantages to management strategies such as choice of ewe breed, lambing season, weaning regimen, or forage use, may change when the options are integrated into a system and the consequence of each factor\choice is assigned an economic value. Thus the ultimate value of any change in performance should be assessed by its effect on the efficiency of a production system, that is, its effect on the relationship of production costs and receipts (Dickerson, 1970).

Integration of costs and receipts to derive an economic value for a system can be done in a variety of ways. Perhaps the best picture of any system will include enough variables to produce a "valid" or "real" conclusion, but will not include so many that the conclusion becomes overly specific and applicable only to limited numbers of very similar production systems (Hohenboken, 1986).

Most published economic analyses of sheep production systems include at least revenues from the sale of lambs and feed costs. A number of studies have reported that when comparing systems, variation in gross income has a greater effect on relative differences in net revenue than does variation in costs (Kilkenny and Read, 1974; Thonney et al., 1979; Saoud and Hohenboken, 1984). Feed costs have been reported to account for the largest percentage of variable costs in a system (Kilkenny and Read, 1974; Thonney et al., 1979). Although inclusion of other revenues and costs,

such as wool, labor, or replacement ewe costs, vary with the individual study/analysis, fixed costs such as insurance, taxes, or building or equipment maintenance tend not to be included, presumably because they are too site-specific and would limit the application of the results.

This final portion of the study was designed to integrate and assign values to the management options examined earlier: ewe crossbreed type, lambing season, weaning management, and forage use. This approach allows the interacting effects of management strategies to be weighted and assessed as part of a complete production system. Revenues and/or variable costs associated with each strategy were identified, and sorted into broad categories: lamb, wool, and cull animal revenues, and purchased feed, grazable forage, and non-feed costs. Revenues and costs for each spring- and fall-lambing system were then arranged in enterprise budget format, and gross margin (revenues less variable costs) was calculated for each system. Most sheep operations that breed in spring to lamb in fall employ a "clean-up" breeding in August for ewes that did not breed in spring. Ewes breeding in August would lamb in January and then be re-exposed soon after weaning in the following spring. An estimate of additional revenues and costs associated with a "clean-up" January lambing was therefore added to the annual fall-lambing systems to create budgets that would reflect a fall-plus-January lambing system.

MATERIALS AND METHODS

Budgets

Combinations of management options (ewe breed type, lambing season, weaning management, and forage use) were combined to create fourteen distinct annual production systems (Tables 7.1.a,b) and two production systems that combine fall and January lambing (Table 7.1.c). Results of Yrs 1 and 2 were analyzed together, except for the weaned groups which were considered separately because weaned ewes grazed permanent pasture in Yr1 but millet in Yr2. Yr3 production systems were

considered separately because of the substantial differences in management from Yrs 1 and 2. Over 25% of spring-born lambs in Yrs 1&2 were finished on summer pasture and another 22% finished in September (Table A.4) with a minimum of drylot feed (Chapter 4). In contrast, the spring-lambing system in Yr3 was one of deferred marketing, as only 6.5% of lambs were marketed from pasture and the remaining lambs were finished in drylot through the fall months.

Within each spring-lambing system, groups were distinguished by ewe breed and weaning treatment. Within each fall-lambing system, groups were distinguished by ewe breed. Variable revenues and expenses were quantified for each annual system, and are summarized in Tables 7.3 and 7.4 and detailed in the Appendices (see List of Tables, page vii). No fixed costs were included in any budgets. Variable costs and revenues associated exclusively with January lambing of $\frac{1}{4}$ -Finn ewes were estimated (Table A.13) and added to the existing fall-lambing budgets for $\frac{1}{4}$ -Finn ewes (Table 7.1.c). Because fall systems using Western ewes were economically uncompetitive with those using $\frac{1}{4}$ -Finn ewes (Table 7.1.b), a combined fall- and January-lambing budget was not calculated for Western ewes.

All revenues and variable costs were calculated on a per-ewe-exposed basis. Lamb costs were determined first on a per-lamb basis and then multiplied by the number of lambs per ewe in the appropriate group at the appropriate stage of production (Table A.1) to determine per-ewe-exposed costs. To avoid dealing with small fractions, revenues from lamb sales (Table A.3) and cull sales (Table A.7) were first calculated on the basis of 100 ewes exposed, and then converted (by dividing by 100) to a per-ewe-exposed figure.

January lambing

Additional revenues and variable costs associated with January lambing are detailed in Table A.13. Fertility for January lambing was

estimated at 80%; at that level, total fertility of fall (69%; Table 7.2) and January lambings equalled the 94% fertility of spring lambing.

$$69\% + (31\% * 80\% \text{ January fertility}) = 94\%$$

Prolificacy in January was estimated at 2.02 lambs/ewe lambing, .23 lambs less than the average spring lambing (Table 7.2). Notter and McClaugherty (1991) reported that litter size of ¼-Finn ewes of the same crossbred type was .23 lambs/litter less in January lambing than in March lambing. For the current study, average lamb birth weight in January was estimated at 9.5 lb, the average birth weight reported for spring-born lambs (Table 3.2).

The duration of a January "clean-up" lambing period must be relatively restricted to enable prompt rebreeding in early April. Ewes exposed to rams on August 1 for a 30-d breeding period would have an average lambing date of January 10. To allow a one-month interval between weaning and rebreeding, lambs would be weaned in the first week of March, at approximately 55 d of age.

The percentage of lambs marketed of those born in January was estimated at 83%, the average marketing percentage of lambs from ¼-Finn ewes lambing in spring (Table 7.2). Thus,

$$2.02 * 83\% = 1.68 \text{ lambs marketed/ewe lambing in January.}$$

Estimates of growth rates of January-born lambs from ¼-Finn ewes were derived from those reported by Notter et al. (1991). In that study, December-born lambs from the same ¼-Finn crossbred ewe type were creep fed until weaned at approximately 68 d of age, and then moved to drylot and given *ad libitum* access to a 13.5% CP ground corn-soybean-based mix. Daily gains of wethers and ewe lambs averaged .62 lb/d preweaning and .75 lb/d postweaning. These reported daily gains were used in the current study to estimate lamb age and weight at weaning, and the average number of days in drylot required for lambs to reach a 110-lb market weight (Table A.13.a).

Prices

Prices for revenue and expense items used in these budgets have been derived from a variety of sources, and represent 5-yr averages (1988 to 1992) of prices whenever possible. Yearly prices, 5-yr average prices, and price sources are listed in Table A.2 and further discussed below.

Revenues from spring- and fall-born market lambs

Marketing dates and weights

Lambs were considered to be salable as finished market lambs when they reached a minimum live weight of 105 lb. Lambs were "marketed" at biweekly intervals, based on actual recorded weights. For example, a lamb reaching at least 105 lb by September 15 was valued at September market lamb prices, as was a lamb that reached the 105-lb minimum by September 30. Lambs weighing only 95 to 104 lb by the last market date of a season (September 30, November 30, and March 31 for Spring Yrs 1&2, Spring Yr3, and Fall, respectively) were considered "lightweight" slaughter lambs; lambs weighing less than 95 lb by that date were considered feeder lambs (Tables A.3 and A.4).

Lamb market weights used to determine revenues from lamb sales (Table A.3) were the average weights of all lambs that reached market weight in a particular month in a given treatment group. Marketing distributions for each treatment group are summarized in Table A.4.

Market price

Prices for lambs weighing at least 105 lb are those received by the Eastern Lamb Producers' Cooperative, Inc. (ELPC) from 1988 to 1992. ELPC prices were averaged within each month of each year, and then averaged over the 5-yr period (Table A.2). Lambs weighing 95- to 104-lb were discounted \$2/cwt in ELPC sales of August to December, 1991; that discount was applied here to such lambs.

Feeder lamb prices are those posted weekly by the Virginia Agriculture Commodity Newsletter (VDACS) for 70- to 85-lb feeder lambs sold at Northern and Southwestern VA auctions, and the Monterey, VA Special Lamb Sales (Table A.5). These prices were also averaged within each month, and then again over the 1988 to 1992 period.

Number of lambs sold

For this analysis, the number of lambs considered sold per month is the fraction of lambs marketed from a treatment group in that month (Table A.4), multiplied by the total number of lambs marketed/ewe exposed in the treatment group (Table A.1). Lambs marketed/ewe was estimated for each treatment group by multiplying fertility, lambing percentage, and survival percentages to 30-d, 30 to 90 d (weaning), and 90 d to marketing. There were slightly more death losses from mid-summer parasite infestation among lambs of ¼-Finn ewes in Yr1 (Table 4.2). However, this pattern was not repeated in Yrs 2 and 3 and there was no significant ewe breed x weaning status interaction effect on either daily gain or final weight over the summer grazing period. Therefore no distinction in percentage survival from 90 d to marketing was made between ewe breed groups.

Unshorn wool incentive payments

Unshorn wool incentive payments are paid per hundredweight of live lamb sold. The payment of \$3.60/cwt (Table A.3) is the 5-yr average of annual unshorn wool incentives paid by the USDA Agricultural Stabilization and Conservation Service (ASCS, 1992; Table A.2). Total unshorn lamb payment in a treatment group is the product of the number of lambs sold in a month, the average lamb weight in that month, and the payment per hundredweight totaled over all months in that marketing period.

Lamb sales revenues and total revenue per ewe exposed

Revenue from lamb sales was figured on a monthly basis by multiplying the number of lambs sold by the average sale price for that month and the average weight of lambs sold in that treatment group in that month (Table A.3). Lamb revenue per ewe exposed was then calculated by

dividing the total revenue from lambs sold (lamb sales plus unshorn incentive payments) by the number of ewes exposed in the treatment group.

Revenues from January-born lambs

January-born lambs were estimated to be marketed at approximately 143.5 d of age (Table A.13.a). Given an average birth date of January 10, average marketing date would be June 2. Market price assigned to January lambs was \$.66/lb live weight, the average of ELPC prices for May and June (Table A.2).

Wool revenues from ewe flock

Values for shorn wool are average Virginia prices. Averages for 1988 to 1991 are as listed by the Virginia Agricultural Statistics Bulletin (1991); the 1992 price is as reported by the Virginia Cooperative Extension report on the State wool pool sales (Table A.2). Pounds of wool shorn/ewe (Table A.6) for the same $\frac{1}{4}$ -Finn and Western crossbred types were reported by Notter and McClaugherty (1991). The wool incentive payment used in this analysis is 121.4% of the value of the wool clip, again the average of wool incentive payments awarded by the ASCS for 1988 to 1992.

Revenues from cull breeding animals

A ewe flock culling rate of 15% per year is used by the Virginia Extension Service's Livestock Enterprise Budgets and was used in this study. Actual attrition rates for ewes in this trial were unclear, as natural attrition was confounded by dog attacks and inadvertant misbreedings. However, Ercanbrack and Knight (1989) found no difference in attrition rate or final age, after 7 yr of production, in $\frac{1}{4}$ -Finn and $\frac{1}{2}$ -Finn ewes and their purebred counterparts, despite significantly greater lifetime lamb production by the Finn-cross ewes.

Cull ewe weights (Table A.7) are those of mature $\frac{1}{4}$ -Finn and Western ewes reported by Notter and McClaugherty (1991). Prices for both

cull ewes and rams are derived from Virginia Cooperative Extension Livestock Budgets for sheep production (Table A.2).

Rams, purchased as yearlings, were considered culled after 4 years of age, giving a culling rate of 33% per year. The assumed ewe:ram ratio was 33:1, so annual cull ram value was divided by 33 ewes and then by 3 years to determine the per-ewe revenue. Ram weights are the average weights of yearling rams sold at the Shenandoah Valley Experiment Station performance tested ram sales in Steele's Tavern, VA (Table A.2).

Feed costs

Purchased feed costs were figured on a per-head basis (Tables A.8, A.9, A.10, A.11). Lamb feed costs/ewe exposed were determined by multiplying per-lamb costs by lambs/ewe exposed (at the appropriate stage of production) for each treatment group (Table A.1).

Estimates of daily per-head consumption of purchased feedstuffs, i.e., corn, hay, creep feed, and finishing rations, are presented in Table A.9. Prices for grass hay, corn, oats, soybean oil meal, salt-mineral mix, and lime are taken from Virginia Cooperative Extension Service's Livestock Enterprise Budgets for 1989, 1992 (for 1991 prices), and 1993 (for 1992 prices) and are detailed in Table A.2. Cost of "Tend-r-Lamb" protein supplement (distributed by Southern States Cooperative, Inc.) is an average of 1988 Experiment Station receipts and 1992 prices, as quoted by the Southern States store in Christiansburg, VA. Prices for molasses and salt (included in ground creep and finishing rations, Tables A.10 and A.11) were listed in Virginia Agricultural Statistics (1991).

Although hay may be produced on-site and considered a non-cash variable cost, in this analysis it has been valued at its opportunity cost and considered a cash variable cost.

Hay and corn consumption by ewes and rams

Daily hay consumption (Table A.9.a) estimates were derived from 1993 Extension Livestock Budgets for March-April and December-January lambing systems, respectively. Spring-lambing ewes were fed a grass-

clover hay from January, when fescue pastures were depleted, to mid-March, when rye pastures became ready for grazing. Ewes were fed corn during the last 6 wk of gestation and for approximately the first 10 d of lactation. Consumption of hay and corn during lactation was adjusted to reflect the 6% of ewes that did not conceive and thus were not lactating.

Fall-lambing ewes were flushed with .5 lb corn/d from March 10 to April 15. Ewes were maintained on grass-clover hay from early January until April 15, when permanent pastures became available.

Estimations of additional corn and hay consumed by January-lambing ewes in late gestation and early lactation were considered separately and are listed in Table A.13.a. January-lambing ewes were charged for 1.0 lb corn/hd/d for 6 wk in late gestation and 1.5 lb corn/hd/d for 60 d of lactation; these were the daily quantities charged to spring-lambing ewes (Table A.9). Lactating ewes would also require 3 lb hay/hd/d more than the 2 lb/d previously budgeted for fall-lambing (dry) ewes through winter.

Rams were maintained on grass-clover hay in late fall and winter (November 1 to April 15). Annual (individual) ram feed costs are apportioned over 33 ewes.

Creep feed

Spring-born lambs in Yr1&2 were given access to a corn-soybean-based ground creep mix (Table A.10) while their dams were grazing rye. Lambs were approximately 10 d old at the start of this period, and 45 d old when the rye grazing finished. However, as creep intake is nominal in the first 3 wk of life (SID, 1988), intake was estimated from 20 to 45 d of age. No creep was fed to spring-born lambs in Yr3.

Fall-born lambs in Yr1&2 were given access to the same creep mix while dams were grazing turnip. Lambs were approximately 30 d of age at the start, and 70 d of age at the end of turnip grazing. Fall-born lambs in Yr3 were given access to creep from September 11 to November 16 when lambs were weaned. Consumption was measured; lambs consumed 1000 lb of the ground creep mix and 125 lb of a 9:1 corn:Tend-r-Lamb mix. Assuming that very little creep was consumed in the first 20 d, and mean lambing date was September 5 (Table 3.1), 33 lambs (alive on September

25) consumed 1,125 lb creep feed over an average of 52 d. Average consumption was therefore .65 lb/lamb/d. This consumption figure was then used to estimate creep consumption in Yrs 1&2 (Table A.9) and for January-born lambs (Table A.13.a).

Drylot finishing ration

Drylot lambs in spring and fall of Yrs 1&2 were fed .5 lb grass-clover hay/hd/d and an *ad libitum* ground corn-soybean-based mix (described by Notter and McClaughterty, 1991). Using a 3.2 lb DM/d feed requirement for an 88-lb lamb (NRC, 1985), intake was estimated at approximately 3.10 and .50 lb of ground mix and hay/hd/d, respectively (Table A.9.b). Total consumption/hd for all drylot lambs (Table A.9) was figured by multiplying daily consumption by the least-squares mean for number of days in drylot for each treatment group.

Spring-born lambs in Yr3 were moved abruptly from pasture to drylot on September 4 and offered corn only; measured consumption was very low. On September 12, lambs were switched to a 9:1 corn:Tend-r-lamb ration; consumption from this point to September 22 was measured at 1.47 lb/hd/d. By September 22, lambs appeared to have adjusted to drylot feed, and consumption from this point until marketing averaged 3.57 lb feed/hd/d (Table A.9).

Fall-born lambs in Yr3 were fed the corn:Tend-r-Lamb mix with their creep feed for 1 wk prior to weaning and so were well-adapted to the drylot ration by weaning time. From weaning to marketing, drylot consumption averaged of 3.17 lb corn:Tend-r-Lamb mix/hd/d. This figure was also used to estimate drylot feed consumption by January-born lambs (Table A.13.a).

Salt and mineral

SID (1988) recommends that sheep receive .5 lb salt-trace mineral mix per 100 lb of complete feed. A mature ewe will consume 3 to 4 lb DM/d, equivalent to a hay-grain ration of 3.5 to 4.5 lb as-fed, depending on stage of production. Consequently recommended salt-mineral intake would be .021 lb per day, or 7.8 lb/hd/yr (Table A.8).

As outlined above, lambs in this study were estimated to consume 3.60 lb of feed per day in drylot, and thus would consume .019 lb salt-mineral mix per day. Per-lamb consumption was estimated by multiplying daily salt-mineral intake by average age at marketing for each treatment group.

Non-feed costs

Variable labor costs

The labor costs included in this analysis (Table A.12) are those affected by varying treatments or levels of production, i.e., lambing, worming, and feeding/monitoring lambs in drylot. Per-hour labor costs were derived from Virginia Agricultural Statistics (1991) and Extension Crop and Livestock Budgets (1991; 1993).

Although most would agree that lambing-time labor will increase with ewe reproductive efficiency, there are few documented figures in the literature that could be applied in a budget. Therefore, rather than inaccurately charging lambing labor costs to a treatment group, they have been left at zero for this analysis.

During this trial a "strategic" deworming program was followed, such that ewes and lambs were injected with anthelmintic (Ivermec) to coincide with periods of increased parasite challenge or decreased stock resistance. Spring-lambing ewes were dewormed before lambing, at first pasturing, twice in mid-summer, at the start of breeding, and in mid-autumn for a total of six treatments. Spring-born lambs were dewormed at first pasturing, and then at 4-wk intervals through mid-September, for a total of five treatments. Fall-lambing ewes were dewormed before lambing, in mid-autumn, at weaning, at the start of breeding, and twice during the summer, for a total of six treatments. Fall-born lambs were dewormed at 50 d, weaning, and in January, for a total of three treatments.

Labor requirements for deworming were estimated by the Experiment Station manager: 2 people required for 2 hours to deworm 100 ewes and their lambs. Thus 4 hours of labor were required to deworm approximately

200 head (100 ewes and 100 lambs) and per-dose labor was estimated at .02 hr/hd.

There is a cost associated with feeding and monitoring lambs over an extended drylot period. For this budget analysis feedlot labor was estimated as requiring .5 hr/d for 100 lambs on feed, thus .005 hr/lamb/d. Total labor/hd was figured by multiplying daily per-head labor by the least-squares means of days in drylot for each treatment group.

Health/medications

Prices of medications are the minimum found in screening numerous mail-order supply catalogs for each of the 5 yr (Table A.2). Ewes were annually vaccinated with a 2 cc clostridial/tetanus ("8-way") booster. Lambs were initially vaccinated with a 5 cc dose and then boosted with a 2 cc dose. Prices for 8-way vaccine are based on a 5 cc dose. Prices for dewormers have been scaled to a 100-lb dose, and then adjusted on the non-feed budget for a 150-lb ewe and a 75-lb lamb. Ewes were vaccinated annually against ovine vibriosis.

Marketing and shearing

Marketing fees of lambs and culls were assessed at \$2/hd; wool marketing fees at \$.025/lb wool sold (S. H. Umberger, personal communication). Shearing charges were derived from Virginia Cooperative Extension Livestock Budgets for sheep production.

Replacement ewe lambs and yearling rams

Replacement ewe lamb were valued at \$90/hd in 1989 (Virginia Extension Livestock Budgets), and \$76 and \$85 in 1991 and 1992, respectively (Virginia Commercial Ewe Sale, Dublin, VA). These values are approximately \$20/hd greater than the per-head values of 110-lb market lambs (\$.65, \$.50, and \$.59/lb, in 1989, 1991, and 1992, respectively). Following this pattern, annual replacement ewe lamb prices were based on a per-lb market price averaged across all months in a year:

$$\text{Ave. market price (\$/lb)} * 110 \text{ lb} + \$20.$$

The 15% cull rate was then used to determine a per-ewe-exposed charge for replacements.

Rams were valued at the average price paid for yearlings at the annual Shenandoah Valley Experiment Station ram test sales in Staunton, VA, and then divided by the number of ewes exposed in the system. Ewes were charged for the replacement of 1 ram/100 ewes/yr.

Interest on operating costs

Six and 3 months of interest were charged to ewes and lambs, respectively, for feed and non-feed expenses (Table A.12). The interest rate of 10.5% was the average of rates used in Virginia Extension Livestock Budgets (1989, 1991, 1993).

Additional non-feed costs of January-lambing

Ewes lambing in January incurred no further non-feed costs above the annual costs already budgeted for all ewes exposed in April (Table A.12). Non-feed costs of \$4.73/lamb for lambs born in January (Table A.13.a) were derived from the non-feed budget for ¼-Finn ewes in Fall Yrs 1&2. Lambs of that system averaged 92 d in drylot and thus had drylot labor costs similar to the 88.5 d in drylot estimated for January-born lambs. No deworming costs were charged to January-born lambs, as these lambs would be raised entirely in a drylot environment.

Forage crop costs

Only variable costs were considered in the forage crop expenses; fixed costs such as property taxes, rental opportunity costs, equipment depreciation, and insurance were not included. Equipment required for seed, fertilizer, or herbicide application were expensed on a rental basis. Seed costs were included for annual forages and alfalfa, but not for perennial bluegrass or fescue pastures.

All forage costs were first figured on a per-acre basis, then divided by the stocking rate of a given treatment group during a given calendar period,

to determine a per-head cost (Table A.14). Some actual stocking rates for perennial pastures were recorded in Yr3. Perennial pasture stocking rates for Yrs 1&2 are estimates based on Yr3 or on suggested animal unit days (A.U.D.) for various Virginia forages (Moore and White, 1980).

1991 and 1993 Extension Crop Budgets were used as the basis for the perennial forage costs, which are detailed in Table A.13.a-c. However, in Yr3 soil tests were taken on Experiment Station fields for each of the perennial crops; test results were used in this analysis to modify fertilizer application requirements for alfalfa and stockpiled fescue. Fertilizer application rates for the maintenance of permanent grass-clover pastures are those currently recommended by Extension forage agronomists (H. E. White, personal communication). Expenses for annual forages are the actual soil preparation and seeding costs for those crops. Prices for forage inputs were derived from Virginia Cooperative Extension Crop Budgets (1991, 1993; Table A.14), except for 10-10-10 and ammonium nitrate, which were priced in the Virginia Agricultural Statistics (1991; Table A.2).

Once costs had been established for individual forage crops, "forage use calendars" were constructed to sum the various forage costs for each treatment group on a per-ewe basis (Table A.15). In treatment groups that had weaned lambs grazing independently, cost/lamb was multiplied by lambs/ewe exposed in that system to arrive at a per-ewe cost for weaned lamb forage consumption. Forage costs for lactating ewes and open ewes were multiplied by percent of ewes bred and open, respectively, in that treatment group.

Forage crop costs were not altered for ewes lambing in January. Those ewes would graze stockpiled fescue with dry ewes that had lambed earlier in the fall, and would simply be supplemented with corn in late gestation (Table A.13.a). In April, weaned ewes would then graze and be bred along with the ewes that had lambed in the fall.

Alfalfa

Total annual pre-harvest costs for alfalfa grazed by lactating ewes in the fall were divided by 4 potential cuttings of hay (Table A.14.a). In Yrs 1&2 ewes grazed alfalfa from early September to late October and were

charged for the equivalent of one hay cutting. Ewes grazed alfalfa in Yr3 from late August to mid-November (weaning) and were charged for the equivalent of 2 cuttings.

The stocking rate of 7.7 lactating ewes/ac was estimated by assuming 2.25 ton silage/ac/cutting (50% moisture; Virginia Cooperative Extension Crop Budgets, 1993), which would yield 1.125 ton DM/ac/cutting, and 2,147.7 Mcal ME and 19.7% CP/ac on a DM basis (NRC, 1985). A ewe suckling 1.5 lambs in the first 6 to 8 wk of lactation requires 5.85 lb DM, 6.25 Mcal ME, and .825 lb CP/d. Given 45 grazing days/cutting, and assuming that pasture would be managed to the most limiting nutrient (in this case, energy), stocking rate was estimated at 7.7 ewes/ac.

Permanent (bluegrass-white clover) pasture

The per-acre cost of bluegrass-clover pasture maintenance (\$12.05/ac) was divided over 6.5 mo of grazing to estimate a per-acre-per-month grazing cost (Table A.14.c). The grazing season was then broken down by forage production period ("Calendar Period") and stage of production within a treatment group (for example, Yr1 Weaned ewes) for each of the spring- and fall-lambing ewe groups.

For each production group, the per-acre-per-month cost was divided by the stocking rate, and then multiplied by the number of months grazed during that period, to determine the cost/ewe during that production period.

Stocking rates on permanent grass-clover pastures varied by year and by management. June stocking rates in Yr3 were increased by rotational stocking of lactating ewes. After 90 d, all lactating ewes were continuously stocked in all 3 summers. Lambs in the non-weaned group were weaned a month earlier in Yr3 than in Yrs 1&2. Weaned spring lambs were continuously stocked in June through August of Yrs 1&2, but rotationally stocked in Yr3. Rotational stocking increased stocking rate for lambs in June of Yr3, but decreased the stocking rate during an unusually dry July and August of Yr3.

Fall-lambing ewes were bred on permanent grass-clover pasture. Stocking rates for Yrs 1&2 were estimated from Virginia Cooperative

Extension Service information (Moore and White, 1980). Ewes bred in the spring of Yr3 were rotated through 1-acre paddocks. Summer and autumn management and stocking rates on bluegrass-clover pastures for fall-lambing ewes were similar to those of open or weaned spring-lambing ewes.

Stockpiled fescue

Ewes grazed stockpiled fescue from the end of grazing of bluegrass-clover pastures (early November) or from the end of turnip or alfalfa grazing (late November), until the fescue was depleted in January, after which grass hay was fed. Ewes were charged August fertilizer applications for stockpiling (Table A.14.b). Stocking rates were estimated at 118 A.U.D./ac from November to mid-March (Moore and White, 1980), equaling 5.7 ewes/ac.

Winter rye

In Yr3 lactating ewes grazed 12 ac of broadcast-seeded winter rye from March 15 to April 20. This stocking rate of approximately 6 ewes with lambs/ac was also used for lactating ewes grazing rye in Yrs 1&2.

Turnip, millet, tyfon

Stocking rates for millet and brassica grazing were defined in Chapters 5 and 6. Turnip seedbeds were fertilized in Yr1 with 10-10-10 and in Yr2 with ammonium nitrate; the latter was less expensive on a per-pound basis and was used as the fertilizer expense for these budgets (Table A.14.e-g). A "grazing labor" charge was included to cover time spent setting up electric fencing for the annual forage paddocks.

Gross margins, breakeven points, and sensitivity analysis

Gross margin/ewe exposed in each system was calculated by subtracting the sum of all variable costs from the sum of all revenues (Table 7.1.a,b,c).

Breakeven points were determined for percent fertility in each system, and for prolificacy in the combined fall-January system. All accounts for revenues and expenses were linked through *Quattro Pro* (Borland, 1990)

spreadsheets. By raising or lowering the fertility or prolificacy in Table A.1, lambs per ewe exposed was altered, thus affecting per-ewe revenues and costs. Breakeven points were located by reducing or increasing fertility or prolificacy levels until gross margin reached zero.

Sensitivity analysis was also conducted on percent fertility and 30-d lamb survival. These traits were selected for examination because of the ranges exhibited during the 3-yr study, and because each represents a different route that may be taken to improve a production system. Potential changes in fertility would need to be achieved by altering the biology or the genetics of the ewe flock through hormonal manipulation or selection; changes in lamb survival would primarily be affected by management. Over the three years, fertility ranged from 84.6 to 100% in spring, and from 46.2 to 82.1% in fall. Lamb survival to 30 d ranged from 80.4 to 93.3% in spring, and from 76.2 to 93.9% in fall. Analysis was conducted on the most profitable system in each annual lambing season (Spring Yr1, non-weaned lambs, and Fall Yr3) and on ¼-Finn ewes in the combined Fall Yr3-plus-January lambing system, to determine the sensitivity of gross margin to increases in fertility from 60 to 100% and from 45 to 85% in the spring- and fall-lambing groups, respectively, and to increases in 30-d survival from 70 to 100%.

Breakeven lamb price was determined by multiplying total lamb sales (but not unshorn wool incentive; Table A.3) in a system by a percentage that would lower or raise the average price. For example, multiplying total sales of spring-born lambs by 76% would reduce the average market price from \$.53 to \$.40/lb. This in turn would reduce total revenues and gross margin/ewe exposed. Thus breakeven price was located by lowering lamb sales by increments until gross margin became negative.

Sensitivity of gross margin to changes in market lamb price was also determined for each of the most profitable systems in each season (Spring Yrs 1&2, non-weaned, and Fall Yr3) and for the combined fall-January-lambing system. From 1988 to 1992, ELPC prices for spring-born finished lambs, marketed between July and November, ranged from \$.42/lb liveweight to \$.65/lb (Table A.2). Prices for fall-born lambs marketed between December and April ranged from \$.48/lb to \$.82/lb. The

sensitivity analysis was designed to determine the effect of sequential price changes \$.05 and \$.10 below and above the 5-yr average prices used in the budgets. For spring-born lambs marketed in fall, prices analyzed were \$.43, .48, .53 (the 5-yr average price), .58, and .63/lb liveweight. For fall-born lambs marketed in late winter/early spring, prices analysed were \$.51, .56, .61 (the 5-yr average price), .66, and .71/lb liveweight. For the combined fall-January lambing system, prices used for January-born lambs were \$.56, \$.61, \$.66 (the 5-yr average of May and June prices), \$.71, and \$.76.

Furthermore, the differential between the lowest ELPC price in fall months and the highest price in spring months was \$.26, .23, .17, .13, and .20 in 1988, 1989, 1990, 1991, and 1992, respectively. Market prices were arranged in a five-by-five matrix, such that gross margins could be compared when price differentials were smaller (i.e., \$.63 and .51/lb for spring- and fall-born lambs, respectively) or larger (i.e., \$.43 and .71/lb for spring- and fall-born lambs, respectively).

RESULTS AND DISCUSSION

Revenues

Lamb revenues per ewe exposed

Spring lambing produced greater lamb revenues/ewe exposed than did annual fall lambing alone, regardless of ewe breed or weaning status (Table 7.1,a,b). This was largely a function of the number of lambs marketed/ewe exposed, especially since average price/lamb sold was, at a minimum, \$10/hd greater for fall than spring lambs (Table 7.3). Number of lambs marketed was primarily determined by lambs born/ewe exposed: Western and ¼-Finn ewes combined had an average of 1.94 lambs born/ewe exposed in spring, compared to 1.01 in fall. Lamb survival differed only slightly at 30 d, and not at all after 30 d. These observations are similar to those of Kilkenny and Read (1974) and Thonney et al. (1979), who found that net income increased with reproductive efficiency, in spite of accompanying increases in variable costs.

However, when revenues from fall- and January-lambings were combined, lamb sales/ $\frac{1}{4}$ -Finn ewe exposed (\$103.34; Table 7.1.c) were similar to the \$105.77/ewe in sales for $\frac{1}{4}$ -Finns in Spring Yrs 1&2, non-weaned. Although average market price for fall and January lambs combined was only slightly higher than that of fall lambs alone (Table 7.3), the total number of lambs marketed increased from .69 to 1.37/ewe originally exposed in April.

One-quarter-Finn ewes consistently had greater lamb revenues/ewe exposed than Western ewes. This again was a function of number of lambs marketed: over the course of the study, $\frac{1}{4}$ -Finn ewes marketed an average of 21 and 52% more lambs than Westerns in the spring and fall, respectively (Table 7.2). There was no breed difference in market weight or marketing distribution (Table A.4), and consequently no substantial ewe breed difference in price/lamb sold (Table 7.3). Revenues from the unshorn wool incentive accentuated the effects of differing numbers of lambs sold (Table A.3). For instance, unshorn incentive from non-weaned lambs of $\frac{1}{4}$ -Finns in Yrs 1&2 contributed an extra \$1.09/ewe exposed over that of lambs of Westerns. Because unshorn incentive is based on hundredweight of lamb sold, its effects were even greater in fall-born lambs, who had heavier market weights than spring-born lambs: $\frac{1}{4}$ -Finns' lambs in Yr3 contributed an extra \$1.42/ewe exposed in wool incentive over that of Westerns' lambs.

The effects of weaning on lamb revenue varied with management. In Yrs 1&2, when many lambs were marketed directly from pasture, and the remainder were sold at the end of September regardless of weight, weaning clearly had a detrimental effect on lamb revenues. Only 11% of weaned lambs were marketed in July and August, before prices reached seasonal lows, while 43% of the non-weaned lambs were marketed in July and August (Table A.4). In Yr3, when lambs were required to grow to finished weight through November in drylot, the effect of weaning on lamb revenues was reversed. Of the non-weaned lambs, 75% were marketed in October, when price was lowest; 34% of the weaned lambs were marketed in November, when the price had risen by \$3/cwt (Table A.2). Furthermore, the extended period in drylot removed weight differences associated with

weaning status, and at marketing weaned lambs weighed only 1 lb less than those who had not been weaned.

Wool sales and cull revenues

Wool income/ewe exposed differed by nearly \$2 in favor of Western ewes. This is due to the reduced wool production in $\frac{1}{4}$ -Rambouillet breeding ($\frac{1}{4}$ -Finn ewes) compared to $\frac{1}{2}$ -Rambouillet breeding (Western ewes). The \$.94 difference in wool clip value is increased by the wool incentive payments, which are paid as a percentage of the total value of the wool clip.

Revenues from cull animals did not differ by ewe breed, as neither attrition nor body weight (Notter and McClaugherty, 1991) differed between Westerns and $\frac{1}{4}$ -Finns.

Variable costs

Purchased feed costs

Feed costs are those of purchased feedstuffs, as listed on Table A.8, and do not include forage costs. Table A.9 details consumption of the various feed types for each treatment group.

Feed costs were greatest in those management systems that involved feeding lambs for an extended time in drylot. For instance, feed costs of Spring Yrs 1&2 ranged from \$18.83 to \$24.34/ewe exposed (Table 7.1.a); lambs averaged 2.3 to 12.4 days in drylot (Table 7.4). By comparison, feed costs in Spring Yr3 ranged from \$25.88 to \$33.72/ewe exposed; lambs in Yr3 spent between 40 and 67 d in drylot.

Ewe feed regimens were the same for all ewes within a season, and differed little between seasons (\$14.73 and \$11.10 for ewe feed/ewe exposed in annual spring- and fall-lambing systems, respectively; Table 7.4). Thus the large variations in feed costs are due almost entirely to the cost of lamb feed. As an example, in Yr3 non-weaned spring-born lambs of Western ewes consumed \$11.15 in feed/ewe exposed vs. \$20.99 in feed for weaned lambs. Weaned lambs were in drylot for an average of 66 d, 26 d longer than non-weaned lambs, and consumed nearly 100 lb more feed

than the non-weaned lambs. Consequently, although the weaned lambs had a lamb sales revenue advantage of \$6.81 because of remaining in feedlot until market lamb prices were higher, this was quickly lost in feedlot consumption.

These results differ from those of Thonney et al. (1979), whose simulation study indicated that the profitability of differing lambing seasons was more influenced by feed and overhead costs than by return factors. In the current study, total variable costs did not differ greatly between spring- and fall- lambing seasons; the large seasonal differences in gross margin were primarily attributable to differences in reproductive efficiency. Thonney's conclusions may hold true, however, in comparisons of ¼-Finn ewes in spring (Yrs 1&2, non-weaned) and fall-plus-January systems. Revenues in that case were similar (\$117.69 vs \$115.27/ewe exposed, respectively; Tables 7.1.a,c), and the \$24.59 difference in gross margin was largely due to feed costs of drylot lambs.

Non-feed costs

Spring lambing systems incurred slightly more non-feed costs than did annual fall lambing systems (Table 7.1.a,b), with costs ranging from \$34.70 to \$39.08/ewe exposed in spring-lambing ewes, but only between \$30.86 and \$33.70/ewe exposed in fall-lambing ewes. Because non-feed costs for ewes were fairly constant, the differences in non-feed costs are again due to lamb costs, which were at least \$3/ewe less for fall-born lambs than for spring-born lambs (Table 7.4). Much of this is explained by the greater number of lambs/ewe exposed in the spring. However, most of the difference is found in the two extra anthelmintic treatments required by spring-born lambs. Use of Ivermec in this study was very costly. Estimations of the cost of drenching with Tramisol, at \$.20/dose, as a substitute for Ivermec at \$.43/dose, indicate that Tramisol would have been less expensive by \$1.81 and \$2.16/ewe exposed for spring-lambing Western and ¼-Finn ewes, respectively. The reduction in cost would have been somewhat less in the fall systems, which required fewer anthelmintic treatments.

Perhaps the most management-dependent non-feed cost is the labor cost of maintaining drylot lambs. Drylot labor was estimated at .055 hr/lamb/d; at \$5.12/hr, each 2-wk period lambs spent in drylot cost an additional \$.55 and \$.66 in labor per spring-lambing Western and ¼-Finn ewe, respectively, and an additional \$.24 and \$.37 per fall-lambing Western and ¼-Finn ewe, respectively.

Forage crop costs

Forage costs were generally greater in the spring-lambing systems than in the fall-lambing systems (Table 7.1.a,b,c). However, the differences between seasons are minimal if the two most economical forage systems in each season, Spring Yr3 non-weaned and Fall Yr3, are compared. In the September to November period, while spring-lambing ewes were being bred on grass-clover pasture, fall-lambing ewes incurred \$3/ewe more in forage costs, as over half the ewes were lactating on alfalfa (Table A.15.a,c). Winter forage costs (on fescue) were the same for both systems. From March through September, spring-lambing ewes were lactating and had costs of \$4.43/ewe; during this same period, fall-lambing forage costs were only \$1.15/ewe.

Use of annual forages increased costs in both seasons. Forage costs of ewes grazing turnip after alfalfa were greater by approximately \$1.50/ewe exposed than for ewes that grazed alfalfa only (Yr3). Weaned ewes grazing millet in July (Yrs 2 and 3) cost \$2.50/ewe more during the three summer months (Table A.15.b) than did weaned ewes that remained on bluegrass-white clover pasture through the summer (Yr1). However, if fixed costs, particularly land ownership costs, were considered in the budgets, or if acreage was a limiting determinant of the livestock operation size, annual forages with greater carrying capacity might have improved value. As an example, a 100-ewe, fall-lambing, system utilizing only bluegrass-clover pastures would require 12.5 ac (8 ewes/ac) in spring and 14.3 ac (7 ewes/ac) in summer, but 33.3 ac (approximately 3 lactating ewes with lambs/ac) in fall. By comparison, lactating ewes grazing turnip would require only 6.9 ac in fall (14.5 lactating ewes/ac). Thus, the farm that grazed lactating ewes on perennial pasture would require at least 33.3

ac to support 100 ewes year-round, whereas a farm utilizing turnip might only require 14.3 ac to support 100 ewes.

Weaning did not necessarily increase forage expenses in the spring-lambing systems. For example, non-weaned Western ewes and lambs in Yrs 1&2 had forage costs of approximately \$1.15/ewe for the months of June, July, and August, while weaned Western ewes and lambs in Yr1 (ewes grazing perennial pastures) had costs of \$.97/ewe. The effect of weaning on forage costs may depend on stocking rates, particularly for lambs. Per-lamb forage costs were doubled in mid-summer of Yr3 (Table A.14.c), as stocking rates were nearly halved from 15.0 lambs/acre in Yrs 1&2 to 8.4 lambs/acre in the dry summer of Yr3.

Gross margin

Among the spring-lambing systems, gross margin was greatest for non-weaned, $\frac{1}{4}$ -Finn ewes in Yrs 1&2 (Table 7.1.a); among the annual (one lambing per year) fall systems, $\frac{1}{4}$ -Finn ewes in Yr3 had the greatest gross margin (Table 7.1.b). Number of lambs marketed per ewe exposed had a large influence on the profitability of a system. In Spring Yrs 1&2, for instance, lambs of Western ewes had slightly higher average price and revenue/lamb sold (Table 7.3), yet $\frac{1}{4}$ -Finn ewes had .30 more lambs marketed/ewe exposed and consequently had lamb revenues 19% above those of Western ewes. And because at least 70% of all feed and non-feed expenses (Table 7.4) and nearly 100% of forage expenses were constant ewe costs, as the number of lambs marketed/ewe increased, costs did not rise proportionally with revenues. Therefore, with higher lamb revenues/ewe but not proportionally higher variable costs/ewe, the increased market lamb production of $\frac{1}{4}$ -Finn ewes had a substantial positive effect on gross margin.

This pattern was similar in the annual fall-lambing systems (Table 7.1.b). In Yr3, for example, $\frac{1}{4}$ -Finn ewes produced .33 more market lambs/ewe exposed than Western ewes and consequently \$25.58 more in lamb revenues/ewe exposed. However, because of lengthened time of drylot feeding, lamb feed costs were 62 and 70% of total feed costs for Western and $\frac{1}{4}$ -Finn ewe groups, respectively. As the number of

lambs/ewe exposed increased, costs rose more proportionally with revenues. Consequently, with a greater number of lambs marketed/ewe exposed, the ¼-Finn ewe had a \$23.47 advantage in total revenues but only a \$14.85 advantage in gross margin.

The addition of January lambing to the annual fall-lambing system increased gross margin by over \$17 per ¼-Finn ewe exposed (Table 7.1.c). The cost of ewe maintenance had been previously charged to the annual fall-lambing budgets (Tables A.8 and A.12). Therefore, rebreeding open ewes to lamb in January only increased ewe costs by \$14.05/ewe (Table A.13.a), the cost of additional hay and grain in late gestation and lactation. Net revenue per January-born lamb marketed was estimated at \$51.00/lamb, and at 1.34 market lambs/ewe lambing, net revenues were estimated at \$71.30/ewe lambing in January (Table A.13.d). With higher average lamb prices to balance reduced numbers of market lambs (Table 7.3), fall-plus-January lambing produced per-ewe revenues similar to that of non-weaned, ¼-Finn ewes in Spring Yrs 1&2. Gross margins were lower in fall-plus-January systems, however, because of the greater cost of growing lambs in drylot, compared to the cost of growing lambs on pasture.

Breakeven analysis

Breakeven fertility for spring-lambing ewes was approximately half the average fertility level achieved in this study (Table 7.5). Likewise, breakeven market lamb price was generally 50 to 70% of the 5-yr average price received by ELPC market lambs in late-summer and fall months. This would suggest that spring-lambing sheep operations facing economic difficulties in Virginia may be limited in production and economics by poor prolificacy and/or survival rates. Breakeven points for fertility and market lamb price in annual fall-lambing systems tended to be near or above the average fertility levels (59 to 69% for Western and ¼-Finn ewes, respectively) and prices (\$.61/lb lamb) reported for this study. Based on these breakeven points, a positive gross margin would be difficult to achieve with fall lambing alone without the incorporation of a more prolific breed such as the Finnsheep into the crossbred ewe flock.

Breakeven market lamb prices for fall-plus-January systems were 75% below 5-yr average ELPC prices: \$.49/lb liveweight for lambs (from ¼-Finn ewes) born in fall and marketed December through February, and \$.46/lb for lambs born in January and marketed in May/June. Breakeven fertility in fall could not be determined for combined fall-plus-January lambing. Because an estimated 80% of ewes open in August would be rebred to lamb at a profit in January, reducing fall fertility to 0% still produced a positive gross margin (approximately \$23.50/ewe exposed).

Changing prolificacy in fall-plus-January lambing systems

The effect of changing prolificacy on the gross margin of fall-plus-January systems was estimated (Tables 7.6.a,b). Improving prolificacy to 1.91 lambs/ewe lambing in fall increased gross margin by only \$5/ewe exposed in April. Increasing prolificacy by .25 lambs/ewe lambing in both fall and January (to 1.96 lambs/ewe in fall and 2.27 lambs/ewe in January) increased gross margins by \$8/ewe exposed in Yrs 1&2 and by \$9/ewe exposed in Yr3. This relatively small response in gross margin to increases in lamb numbers may be attributed to the ratio of lamb feed costs to total lamb revenues. Per-lamb feed costs in the fall-plus-January system are estimated to be nearly 36% of total revenues/lamb sold (Tables 7.3 and 7.4). By comparison, feed costs/lamb in spring Yrs 1&2 (¼-Finn ewe, non-weaned) were only 14% of total revenues/lamb sold.

Sensitivity analyses

Gross margins of spring-lambing systems and those utilizing ¼-Finn ewes were more sensitive to changes in fertility and lamb survival than annual fall-lambing systems and those utilizing Western ewes (Tables 7.7.a,b). For example, at 90% lamb survival, increasing spring-lambing fertility by 10 percentage units increased gross margins by \$7.85 and \$9.57 per Western and ¼-Finn ewe exposed, respectively. At 90% fertility, increasing lamb survival by 10 percentage units increased gross margins by \$8.54 and \$10.33 per Western and ¼-Finn ewe exposed, respectively. Similarly, as fertility increased 10 units while survival remained at 90%, gross margins of ¼-Finn ewes increased by \$9.57 in spring lambing but

only by \$6.25 in annual fall lambing. These results suggest that a more reproductively efficient system, i.e., a system marketing more lambs per ewe maintained, will be more responsive to improvements in biology or management.

As discussed earlier, changes in fall fertility appear to have only a slight effect on the gross margin of the fall-plus-January lambing system (Table 7.7.c). At poor survival rates of fall- and January-born lambs (70% survival, thus fewer lambs marketed/ewe), gross margins declined slightly as fall fertility increased. This suggests that at low numbers of lambs marketed per fall-lambing ewe, profitability of the system may be improved when more ewes lamb in January than in fall. When survival rates were higher, resulting in more lambs marketed/ewe, improving fall fertility had a positive (though very slight) effect on the system's gross margin.

As with fertility and lamb survival, systems with greater reproductive efficiency were more responsive to changes in market lamb prices, simply because of the greater number of market lambs/ewe exposed that would receive a higher (or lower) price. For instance, as lamb price increased by \$.05/lb, gross margins/¼-Finn ewe exposed increased by \$9.47, \$5.42, and \$7.82 in spring (Yrs 1&2), annual fall (Yr3), and fall-plus-January systems, respectively (Tables 7.8.b,c). These systems marketed 1.75, .96, and 1.37 lambs/ewe exposed, respectively (Table 7.3). The greater economic sensitivity of the reproductively-efficient systems can be seen in Figure 7.1. In that diagram, the system with the largest response to improved market prices utilized spring-lambing, ¼-Finn ewes(Yrs 1&2).

In market conditions that would favor fall lambing relative to spring lambing (high prices for fall-born lambs and low prices for spring-born lambs; Table 7.8.b), gross margin of ¼-Finn ewes in the Yr3 annual fall-lambing system was only 59% of that of non-weaned ¼-Finn ewes in Yrs 1&2 spring-lambing system (Table 7.8.b). When the fall lambing system included January lambing (Table 7.8.c), gross margin of fall lambing only equalled that of spring lambing when spring lamb prices were \$.10 below the 5-yr average and fall (and January) lamb prices were \$.10 above the 5-yr average.

CONCLUSIONS

The most economically efficient sheep production systems in this experiment were those with the greatest reproductive efficiency (and thus greater revenues/ewe exposed). Lamb feed costs had substantial impact on gross margins, particularly in those systems with extended feeding of lambs in drylot. The integration of annual forages into a system had only a slight, though negative, economic effect. That effect may have been more positive, however, if considerations of land ownership costs or limited land resources had been included in the economic assessment of systems. In spite of higher market lamb prices, fall-lambing systems were not economically competitive with spring-lambing systems. Improvements in prolificacy of fall-lambing ewes may serve to narrow the economic difference between the two seasons. Factors not considered in this study, such as increasing difficulties in the control of summer parasite challenge and predation, may weigh against spring lambs pastured through summer and increase the value of fall-lambing systems. The economics of fall-lambing systems might also be improved by delaying weaning and grazing ewes with their lambs on stockpiled fescue, thereby reducing feedlot time of fall-born lambs.

Table 7.1.a Final budgets: Spring-lambing systems

	SPRING, Yr1/2			
	Western no wean	½-Finn no wean	Western wean (no millet, Yr1)	½-Finn wean (millet, Yr2)
<u>Revenues, per ewe exposed</u>				
Lamb revenues	\$88.65	\$105.77	\$81.25	\$97.08
Wool sales	9.45	7.36	9.45	7.36
Cull revenues	4.59	4.56	4.59	4.56
Total Revenues	\$102.69	\$117.69	\$95.29	\$109.00
<u>Variable Costs, per ewe exposed</u>				
Feed costs	\$18.83	\$20.49	\$22.43	\$24.34
Non-feed costs	34.87	36.57	35.34	37.07
Forage crop costs	11.02	11.05	11.14	13.78
Total Variable Costs	\$64.71	\$68.11	\$68.91	\$75.19
Gross Margin per Ewe Exposed	\$37.98	\$49.58	\$26.37	\$33.82

Table 7.1.a (cont.) Final budgets: Spring-lambing systems

	SPRING, Yr-3			Western wean	½-Finn wean	½-Finn wean (millet)
	Western no wean	½-Finn no wean				
<u>Revenues, per ewe exposed</u>						
Lamb revenues	\$88.17	\$108.84	\$94.98	\$108.36		
Wool sales	9.45	7.36	9.45	7.36		
Cull revenues	4.59	4.56	4.59	4.56		
Total Revenues	\$102.21	\$120.77	\$109.02	\$120.28		
<u>Variable Costs, per ewe exposed</u>						
Feed costs	\$25.88	\$29.48	\$35.72	\$33.67		
Non-feed costs	36.58	38.69	37.91	39.26		
Forage crop costs	11.43	11.60	13.76	13.95		
Total Variable Costs	\$73.89	\$79.77	\$87.39	\$86.88		
Gross Margin per Ewe Exposed	\$28.32	\$41.00	\$21.62	\$33.40		

Table 7.1.b Final budgets: Annual Fall-lambing systems
(does not include additional revenues and costs of January lambing)

	FALL, Yr1/2		FALL, Yr3	
	<u>Western</u>	<u>W-Finn</u>	<u>Western</u>	<u>W-Finn</u>
<u>Revenues, per ewe exposed</u>				
Lamb revenues	\$48.19	\$71.87	\$46.14	\$71.72
Wool sales	9.45	7.36	9.45	7.36
Cull revenues	4.59	4.56	4.59	4.56
Total Revenues	\$62.23	\$83.80	\$60.18	\$83.65
<u>Variable Costs, per ewe exposed</u>				
Feed costs	\$29.54	\$37.10	\$25.69	\$31.62
Non-feed costs	31.62	33.87	31.03	33.17
Forage crop costs	12.48	13.28	11.01	11.56
Total Variable Costs	\$73.63	\$84.25	\$67.73	\$76.35
Gross Margin per Ewe Exposed	(\$11.40)	(\$0.45)	(\$7.55)	\$7.30

Table 7.1.c Final budgets: ½-Finn ewes in fall-lambing systems with "clean-up" January lambing

	<u>Yr1/2</u>	<u>Yr3</u>
<u>Revenues, per ewe exposed</u>		
Lamb revenues, Fall	\$71.87	\$71.72
Lamb revenues, January	31.62	31.62
Wool sales	7.36	7.36
Cull revenues	4.56	4.56
Total Revenues per ewe exposed	\$115.42	\$115.27
<u>Variable Costs, per ewe exposed</u>		
Feed costs	\$37.10	\$31.62
Non-feed costs	33.87	33.17
Additional January feed and non-feed costs	13.94	13.94
Forage crop costs	13.28	11.56
Total Variable Costs per ewe exposed	\$98.19	\$90.28
Gross Margin per ½-Finn Ewe Exposed for Fall and January lambings combined	\$17.23	\$24.99

Table 7.2 Average production levels and average number of lambs marketed per ewe exposed for each treatment group

	<u>SPRING</u>		<u>FALL</u>		<u>JANUARY (est.)</u>
	<u>Western</u>	<u>W-Finn</u>	<u>Western</u>	<u>W-Finn</u>	<u>W-Finn</u>
Fertility	93%	94%	59%	69%	80%
Lamb drop	184%	225%	140%	171%	202%
30-d survival	90%	87%	82%	87%	87%
Survival					
30 d to wean	94%	95%	93%	94%	95%
Wean to market	100%	100%	100%	100%	100%
Lambs marketed per ewe exposed	1.45	1.75	0.63	0.96	1.34

Table 7.3 Revenues and average price of lambs sold in each treatment group

	Lamb revenues /ewe exp.	Lambs marketed /ewe exp.	Average price /lamb sold	Total revenues /lamb sold (c)
<u>Spring Yr1/2</u>				
West. no-wean	\$88.65	1.45	\$57.44	\$61.24
¼-Finn no-wean	105.77	1.75	56.73	60.51
West. wean	81.25	1.45	52.63	56.13
¼-Finn wean	97.08	1.75	52.13	55.54
<u>Spring Yr3</u>				
West. no-wean	\$88.17	1.45	\$57.05	\$60.91
¼-Finn no-wean	108.84	1.75	58.32	62.27
West. wean	94.98	1.45	61.55	65.61
¼-Finn wean	108.36	1.75	58.06	61.99
<u>Fall Yr1/2</u>				
West.	\$48.19	0.63	\$72.52	\$76.51
¼-Finn	71.87	0.96	70.56	74.49
<u>Fall Yr3</u>				
West.	\$46.14	0.63	\$69.19	\$73.25
¼-Finn	71.72	0.96	70.20	74.33
<u>January (est.)</u>				
¼-Finn	\$31.62 (a)	1.34 (b)	\$72.09	\$76.05
<u>Fall Yr3 & January, combined</u>				
¼-Finn	\$103.34	1.37 (d)	\$70.77 (d)	\$74.85 (d)

(a) January lamb revenues per ewe originally exposed in April

(b) Lambs marketed per ewe exposed in August to lamb in January

(c) Sum of market revenue and unshorn wool incentive, per lamb sold

(d) Weighted average: 69.8% of market lambs born in fall, 30.2% of market lambs born in Janu

Table 7.4 Feed and non-feed costs per ewe exposed for ewes and lambs of each treatment group, and least-squares means for days in drylot. Operating interest not included in feed and non-feed costs listed below.

	Ewe feed	Ewe non-feed	Lamb feed	Lamb non-feed	Drylot Days
<u>Spring Yrs1/2</u>					
West. no-wean	\$14.73	\$24.59	\$4.09	\$7.73	2
½-Finn no-wean	14.73	24.55	5.76	9.39	4
West. wean	14.73	24.59	7.70	8.10	11
½-Finn wean	14.73	24.55	9.61	9.78	12
<u>Spring Yr3</u>					
West. no-wean	\$14.73	\$24.59	\$11.15	\$9.22	40
½-Finn no-wean	14.73	24.55	14.75	11.23	43
West. wean	14.73	24.59	20.99	10.26	66
½-Finn wean	14.73	24.55	18.94	11.67	53
<u>Fall Yrs1/2</u>					
Western	\$11.10	\$24.59	\$18.44	\$4.38	100
½-Finn	11.10	24.55	26.00	6.43	92
<u>Fall Yr3</u>					
Western	\$11.10	\$24.59	\$14.59	\$3.91	72
½-Finn	11.10	24.55	20.52	5.88	71
<u>Fall Yr3 & January, combined</u>					
½-Finn	\$14.61	\$24.55	\$29.08	\$7.86	

Note: Full descriptions of feed and non-feed costs, including operating interest, are listed in Tables A.8 and A.12. January lambing costs are listed in Table A.13.

Table 7.5 Break-even points for fertility and market lamb price for all treatment groups in spring- and annual fall-lambing systems. All other production parameters were held constant.

	Fertility <u>/ewe exp.</u>	Market lamb <u>price</u>	Breakeven price as % of <u>ave. price</u>
<u>Spring, Western ewes</u>			
No wean, Yr1&2	0.45	\$0.29	55%
No wean, Yr3	0.52	0.35	66%
Wean, Yr1	0.53	0.35	66%
Wean, Yr2	0.57	0.37	69%
Wean, Yr3	0.59	0.40	76%
<u>Spring, ½-Finn ewes</u>			
No wean, Yr1&2	0.41	\$0.27	50%
No wean, Yr3	0.45	0.32	60%
Wean, Yr1	0.48	0.32	60%
Wean, Yr2	0.51	0.33	63%
Wean, Yr3	0.51	0.36	67%
<u>Fall, Western ewes</u>			
Yr1&2	0.92	\$0.76	125%
Yr3	0.78	0.71	117%
<u>Fall, ½-Finn ewes</u>			
Yr1&2	0.70	\$0.62	101%
Yr3	0.57	0.54	89%

Table 7.6.a Change in gross margin of combined fall and January
($\frac{1}{2}$ -Finn) lambings as levels of fall prolificacy change

Lambing % <u>/ewe lambing</u>	Gross margin Fall Yrs 1&2 <u>& January</u>	Gross margin Fall Yr3 <u>& January</u>
1.51	\$12.72	\$19.77
1.61	14.98	22.38
1.71	17.23	24.99
1.81	19.49	27.60
1.91	21.75	30.21

Table 7.6.b Change in gross margin of combined fall and January
($\frac{1}{2}$ -Finn) lambings as levels of fall and January prolificacy change
(fall lambing percentage capped at 1.96 lambs/ewe lambing)

Lambing % per <u>in fall</u>	ewe lambing <u>in Jan.</u>	Gross margin Fall Yrs 1&2 <u>& January</u>	Gross margin Fall Yr3 <u>& January</u>
1.46	1.77	\$8.97	\$15.84
1.71	2.02	17.23	24.99
1.96	2.27	25.50	34.13
1.96	2.52	28.12	36.75
1.96	3.02	33.36	41.99

Table 7.7.a Sensitivity analyses: sensitivity of Spring-lambing gross margins to changes in fertility and 30-d survival, holding all other production parameters constant. Based on budgets for No-wean, Western and ½-Finn (½ ewes, Spring Yrs 1&2.

		Gross margin per ewe exposed, \$			
		Survival			
		70%	80%	90%	100%
Fertility 60%	W	\$0.85	\$6.54	\$12.23	\$17.93
	½F	\$6.69	\$13.57	\$20.46	\$27.34
70%	W	\$6.80	\$13.45	\$20.09	\$26.73
	½F	\$13.96	\$21.99	\$30.02	\$38.06
80%	W	\$12.76	\$20.35	\$27.94	\$35.53
	½F	\$21.24	\$30.42	\$39.59	\$48.77
90%	W	\$18.71	\$27.25	\$35.79	\$44.33
	½F	\$28.51	\$38.84	\$49.16	\$59.49
100%	W	\$24.67	\$34.16	\$43.65	\$53.14
	½F	\$35.79	\$47.26	\$58.73	\$70.20

Table 7.7.b Sensitivity analyses: sensitivity of Fall-lambing gross margins to changes in fertility and 30-d survival, holding all other production parameters constant. Based on budgets for Western (W) and ½-Finn (½F) ewes, Fall Yr3.

		Gross margin per ewe exposed, \$			
		Survival			
		70%	80%	90%	100%
Fertility					
45%	W	(\$17.78)	(\$13.83)	(\$9.88)	(\$5.93)
	½F	(\$15.15)	(\$10.19)	(\$5.23)	(\$0.27)
55%	W	(\$14.78)	(\$9.96)	\$5.13	(\$0.31)
	½F	(\$11.11)	(\$5.05)	\$1.02	\$7.08
65%	W	(\$11.79)	(\$6.08)	(\$0.38)	\$5.32
	½F	(\$7.06)	\$0.10	\$7.26	\$14.42
75%	W	(\$8.79)	(\$2.21)	\$4.37	\$10.95
	½F	(\$3.02)	\$5.24	\$13.50	\$21.77
85%	W	(\$5.79)	\$1.66	\$9.12	\$16.58
	½F	(\$1.02)	\$10.38	\$19.75	\$29.11

Table 7.7.c Sensitivity analysis: sensitivity of gross margin of fall- and January-lambings (combined) to changes fertility in fall and 30-d survival in both fall and January, holding all other production parameters constant. Based on budgets for ¼-Finn ewes in Fall Yr3 and estimated January lambings.

Gross margin per ¼-Finn ewe exposed, \$				
Fertility	Survival			
	70%	80%	90%	100%
45%	\$8.35	\$17.84	\$27.33	\$36.82
55%	\$8.09	\$17.86	\$27.62	\$37.39
65%	\$7.82	\$17.87	\$27.92	\$37.96
75%	\$7.56	\$17.89	\$28.21	\$38.53
85%	\$7.30	\$17.90	\$28.50	\$39.10

Table 7.8.a Sensitivity analysis: sensitivity of gross margins for Western ewes to changes in market lamb prices. Price changes are relative to 5-yr average price for lambs in each season: \$.53 and .61/lb for spring- and fall-born lambs, respectively. All other production parameters are unchanged. Based on budgets of Spring, non-weaned Yrs 1&2 and Fall Yr3.

		Western ewes Gross margins, \$/ewe exposed				
		Fall-born lambs, \$/lb				
Spring-born lambs, \$/lb		0.51	0.56	0.61	0.66	0.71
0.63	Fall	(14.35)	(10.86)	(7.37)	(3.89)	(0.40)
	Spring	53.95	53.95	53.95	53.95	53.95
0.58	Fall	(14.35)	(10.86)	(7.37)	(3.89)	(0.40)
	Spring	45.63	45.63	45.63	45.63	45.63
0.53	Fall	(14.35)	(10.86)	(7.37)	(3.89)	(0.40)
	Spring	38.15	38.15	38.15	38.15	38.15
0.48	Fall	(14.35)	(10.86)	(7.37)	(3.89)	(0.40)
	Spring	30.67	30.67	30.67	30.67	30.67
0.43	Fall	(14.35)	(10.86)	(7.37)	(3.89)	(0.40)
	Spring	22.35	22.35	22.35	22.35	22.35

Table 7.8.b Sensitivity analysis: sensitivity of gross margins for ¼-Finn ewes to changes in market lamb prices. Price changes are relative to 5-yr average price for lambs in each season: \$.53 and .61/lb for spring- and fall-born lambs, respectively. All other production parameters are unchanged. Based on budgets of Spring, non-weaned Yrs 1&2 and Fall Yr3.

		¼-Finn ewes Gross margins, \$/ewe exposed				
		Fall-born lambs, \$/lb				
Spring-born lambs, \$/lb		0.51	0.56	0.61	0.66	0.71
0.63	Fall	(3.36)	2.06	7.48	12.90	18.32
	Spring	68.80	68.80	68.80	68.80	68.80
0.58	Fall	(3.36)	2.06	7.48	12.90	18.32
	Spring	58.68	58.68	58.68	58.68	58.68
0.53	Fall	(3.36)	2.06	7.48	12.90	18.32
	Spring	49.75	49.75	49.75	49.75	49.75
0.48	Fall	(3.36)	2.06	7.48	12.90	18.32
	Spring	40.83	40.83	40.83	40.83	40.83
0.43	Fall	(3.36)	2.06	7.48	12.90	18.32
	Spring	30.91	30.91	30.91	30.91	30.91

Table 7.8.c Sensitivity analysis: sensitivity of gross margins to changes in market lamb prices. Ewes are $\frac{1}{2}$ -Finn lambs in combined fall and spring lambings. Price changes are relative to the 5-yr average price for lambs in each season: \$.53, \$.61, and \$.66 for spring-, fall-, and January-born lambs, respectively. All other production parameters are unchanged. Based on budgets of Spring, non-weaned Yrs 1&2 and Fall Yr3.

		$\frac{1}{2}$ -Finn ewes Gross margins, \$/ewe exposed				
		Fall-born lambs, \$/lb				
		0.51	0.56	0.61	0.66	0.71
		January-born lambs, \$/lb				
Spring-born lambs, \$/lb		0.56	0.61	0.66	0.71	0.76
0.63	Fall+Jan	9.35	17.17	25.16	32.80	40.62
	Spring	68.80	68.80	68.80	68.80	68.80
0.58	Fall+Jan	9.35	17.17	25.16	32.80	40.62
	Spring	58.68	58.68	58.68	58.68	58.68
0.53	Fall+Jan	9.35	17.17	25.16	32.80	40.62
	Spring	49.75	49.75	49.75	49.75	49.75
0.48	Fall+Jan	9.35	17.17	25.16	32.80	40.62
	Spring	40.83	40.83	40.83	40.83	40.83
0.43	Fall+Jan	9.35	17.17	25.16	32.80	40.62
	Spring	30.91	30.91	30.91	30.91	30.91

Gross margin sensitivity to changes in market lamb prices

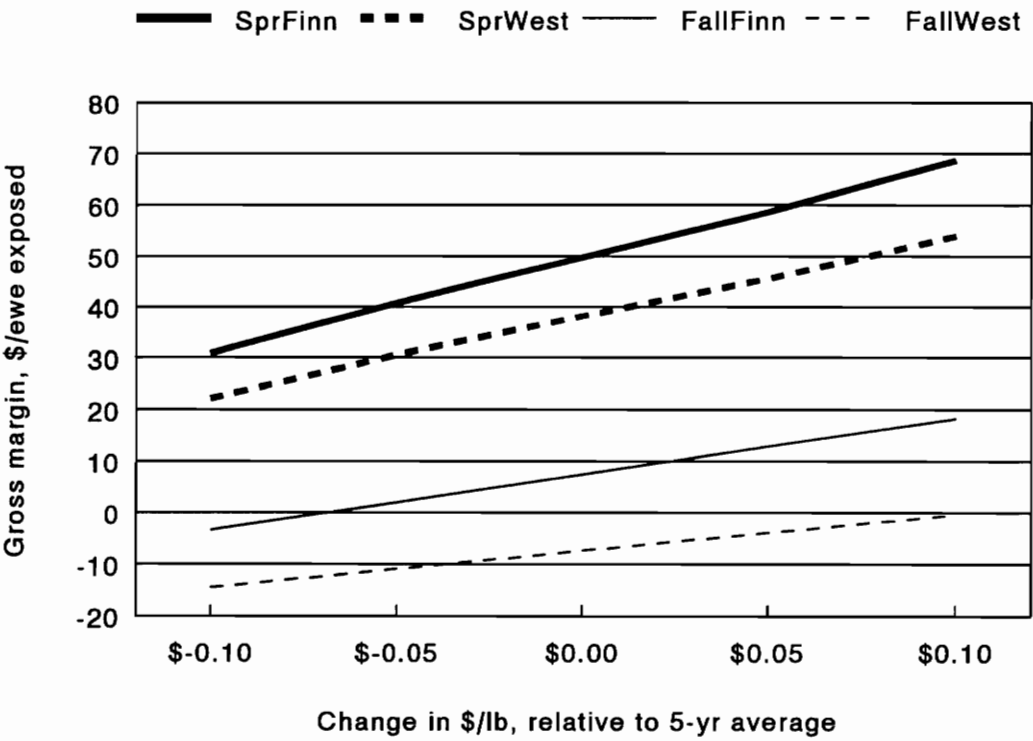


Fig. 7.1 Sensitivity of gross margin to changes in market lamb prices. Based on Spring Yr1&2 and Fall Yr3 budgets.

Chapter 8. Summary

In spring and fall lambing seasons, $\frac{1}{4}$ -Finn genetics in the crossbred ewe improved reproductive efficiency without adversely affecting lamb viability or preweaning growth rates. The value of this improvement was evident in the budgets: systems with the greatest reproductive efficiency (number of lambs born/ewe exposed) had the highest revenues/ewe exposed, regardless of the per-head price of market lambs. Fall-lambing decreased fertility and prolificacy to such an extent that total revenues/ewe exposed in annual fall systems never exceeded those of spring lambing, even though total revenues/lamb sold (market lamb sales plus unshorn wool incentive) in the fall-lambing system with the greatest gross margin was nearly \$15/lamb more than that of the most profitable spring-lambing system. The inclusion January lambing in fall systems improved gross revenues, but the high cost of feeding lambs in drylot reduced fall gross margins to nearly half that of the best spring-lambing system.

Fall-born lambs grew faster after weaning than did spring-born lambs, probably due to improved environmental and management factors, such as cooler temperatures, less exposure to internal parasites, and greater access to creep feed. On high-concentrate rations, fall-born lambs from Western ewes had faster postweaning growth rates than those from $\frac{1}{4}$ -Finn ewes; there were no differences between breed types, however, among spring-born lambs grazing pasture through summer. Early-summer weaning reduced daily gains and increased age at market weight of spring-born lambs grazing summer pastures. Analysis of periodic growth rates indicated that weaned lambs were less able to withstand or recover from internal parasite challenge. The primary economic effect of summer weaning was to increase the time and therefore the feed required to finish lambs to market weight in drylot. In systems that marketed lambs in later fall months, the greater drylot feed costs were not offset by higher market lamb prices.

All annual forages in this experiment were grazed at stocking rates higher than those traditionally employed on perennial, cool-season grass pastures during similar grazing periods. Ewes grazing tyfon, millet, and

turnip had periods of both weight loss and weight gain. These observations suggested that optimal weight maintenance of ewes grazing annual forages may be influenced by transition to the new forage, stocking rate, and stand quality. Daily gains of weaned lambs grazing millet were comparable to historical summer gains of lambs grazing bluegrass-clover pastures at the Experiment Station. In forage-based production systems, an advantage to annual forages, stocked at rates higher than perennial pastures, is the potential reduction of the acreage required to maintain stock during the mid-summer or late-fall periods of pasture dormancy. However, high establishment costs, variable stand production, and variable length of grazing period appear to increase the risk and diminish the advantages of annual forage production and utilization.

The most profitable production systems were those that had the greatest reproductive efficiency, minimized feedlot costs, and maximized use of perennial pastures. Because of the substantially greater number of lambs marketed per ewe exposed, spring-lambing systems had larger gross margins than fall-lambing systems. Among spring systems the most profitable were those that did not wean lambs from their dams over the course of summer grazing. Sensitivity analysis on market price indicated that at production levels demonstrated in this experiment, fall-plus-January lambing systems utilizing $\frac{1}{4}$ -Finn ewes would not be economically competitive with spring-lambing systems except in favorable market conditions of high prices in spring months concurrent with low prices in fall months.

Sensitivity analyses on ewe fertility, 30-d lamb survival, and market lamb price indicated that gross margins of systems with greater reproductive efficiency (i.e., spring-lambing and $\frac{1}{4}$ -Finn ewes) would be the most responsive to changes in those variables. Thus the operator with the potential for higher reproductive efficiency in his or her ewe flock would be in a better position to capitalize on improvements in reproduction, management, or market lamb price.

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Appendices

Table A.1 Average production levels and average number of lambs per ewe exposed, for each treatment group

	<u>SPRING</u>		<u>FALL</u>	
	<u>Western</u>	<u>W-Finn</u>	<u>Western</u>	<u>W-Finn</u>
Fertility	93%	94%	59%	69%
Lamb drop	184%	225%	140%	171%
30-d survival	90%	87%	82%	87%
Survival				
30 d to wean	94%	95%	93%	94%
Wean to market	100%	100%	100%	100%
Lambs marketed per ewe exposed	1.45	1.75	0.63	0.96

Lambs per ewe exposed, used to derive lamb costs per ewe exposed for marketing, and feed, non-feed, and forage costs:

For lambing labor, spring creep, 8-way:

Fert % * Lambdrop %	1.71	2.12	0.83	1.18
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For fall creep, worming, op.cost, finish feed, salt/min:

Fert % * Lambdrop % * Survival %	1.54	1.84	0.68	1.03
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For mkting cost and no. lambs sold:

Marketing %	1.45	1.75	0.63	0.96
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Table A.2 Yearly prices for revenue and expense items, 1988 - 1992, and the 5-yr average price

Item	1988	1989	1990	1991	1992	Ave.	Source**
Feedstuffs							
Corn, \$/bu	3.25		3.00		3.10	\$3.12	1
Oats, \$/bu					3.00	\$3.00	1
Soybean oil meal, \$/ton	290.00		256.00		268.00	\$271.33	1
Tend-r-Lamb, \$/cwt	14.76				17.50	\$16.13	2
Molasses, /cwt	9.83	10.20	10.43	10.70		\$10.29	3
Mineral mix, \$/cwt	9.95		13.60			\$11.78	1
Grass hay, \$/ton	60.00		80.00		80.00	\$73.33	1
Salt, \$/cwt	8.05	8.25	8.40	8.60		\$8.33	3
Salt & Min, \$/cwt	18.00		22.00		21.90	\$20.63	1
Lime, \$/ton			66.00		75.00	\$70.50	1
Vet/Med, \$/dose							
Ivermectin, 1 ml dose	0.54	0.58	0.58		0.60	\$0.57	4
Tramisol inj, 2ml dose	0.28	0.24	0.26		0.27	\$0.26	4
Ovine vibrio, 5 ml dose	0.36	0.38		0.59	0.43	\$0.44	4
Covexin 8-way, 5 ml dose	0.22	0.22		0.36	0.28	\$0.27	4
Other							
Ram, \$/hd	336	340	288	309	271	\$308.80	5
Ram weight, lb	278	270	253	244		261	5
Cull ewes, \$/lb	0.2		0.10		0.25	\$0.18	1
Cull rams, \$/lb	0.15		0.13		0.30	\$0.19	1
Repl. ewe price, \$/hd	95.73	92.30	80.75	76.63	87.41	\$86.57	
Labor, \$/hr			5.00	5.04	5.31	\$5.12	1
Interest charge, %/yr	11.00%		12.00%		8.50%	10.50%	1
Wool							
Shorn, \$/lb	0.91	0.81	0.40	0.25	0.44	\$0.56	6
Wool Incentive, %	29.0%	42.7%	127.5%	241.8%	166.2%	\$1.21	7
Unshorn Incentive							7
\$/cwt lamb	1.60	2.12	4.08	5.32	4.90	\$3.60	
Shearing, \$/hd	1.50		2.00		2.00	\$1.83	1

Table A.2, cont. Yearly prices, 5-yr averages, and price sources

Market lambs, \$/lb							
January	0.821	0.664	0.557	0.486	0.536	\$0.613	8
February	0.815	0.690	0.590	0.480	0.588	\$0.633	8
March	0.814	0.752	0.640	0.543	0.695	\$0.689	8
April	0.807	0.801	0.613	0.585	0.680	\$0.697	8
May	0.725	0.751	0.637	0.615	0.755	\$0.697	8
June	0.580	0.663	0.581	0.569	0.678	\$0.614	8
July	0.562	0.648	0.543	0.520	0.560	\$0.567	8
August	0.574	0.613	0.520	0.514	0.505	\$0.545	8
September	0.594	0.579	0.490	0.452	0.555	\$0.534	8
October	0.614	0.571	0.505	0.452	0.490	\$0.526	8
November	0.648	0.572	0.468	0.475	0.624	\$0.557	8
December	0.708	0.583	0.484	0.488	0.688	\$0.590	8
Ave. all prices	0.688	0.657	0.552	0.515	0.613	\$0.605	
Feeder Lamb Prices, \$/lb							
Feb	0.877	0.677	0.567	0.528	0.659	\$0.662	9
March	0.853	0.700	0.631	0.553	0.710	\$0.689	9
Sept	0.675	0.662	0.488	0.455	0.567	\$0.569	9
Oct	0.678	0.645	0.478	0.460	0.626	\$0.578	9
Nov	0.693	0.590	0.479	0.448	0.637	\$0.569	9
Field costs							
10-10-10, \$/ton	156.00	165.00	162.00	166.00		\$162.25	3
Ammon nitr, \$/ton	184.0	197.0	192.0	193.0		\$191.50	3

** Price sources:

- Virginia Cooperative Extension Service, Crop and Livestock Enterprise Budgets for 1989, 1991, 1993
- Southern States Cooperative, Inc., Christiansburg, VA Service
- Virginia Agricultural Statistics Service, 1992 Bulletin no. 63
- Numerous veterinary supply mail-order catalogs
- Shenandoah Valley Agricultural Experiment Station yearling ram test sale, Steele's Tavern, VA
- 1988-1991 prices: Virginia Agricultural Statistics Bulletin no. 63; 1992 prices: 1992 State wool pool sales, reported by Coop.Ext. Livestock Update May 1993
- ASCS Commodity Fact Sheet, Summary of 1992 Wool Support Program
- Eastern Lamb Producers' Cooperative, Inc., weekly prices listed by VDACS Market News
- Virginia Agricultural Commodity Newsletter, listings of weekly feeder lamb prices for Northern and Southwestern VA auctions, and Monterey VA Special Lamb Sales

Table A.3 Lamb and unshorn wool revenues, per 100 ewes and per ewe exposed

SPRING YR1&2		WESTERN EWES, SPRING LAMBING NOT WEANED			½-FINN EWES, SPRING LAMBING NOT WEANED		
Month	Price	No.	Ave wt.	Total	No.	Ave wt.	Total
Sold	(\$/lb)	Lambs	(lb/hd)	Revenue	Lambs	(lb/hd)	Revenue
July	\$0.57	26	110	\$1,617.36	46	109	\$2,840.99
Aug	\$0.55	41	110	\$2,444.86	25	112	\$1,498.19
Sept	\$0.53	41	109	\$2,372.64	40	107	\$2,281.18
SeptLight	\$0.51	19	100	\$950.14	49	100	\$2,528.33
SeptFeedr	\$0.57	19	88	\$929.99	15	88	\$768.34
Total Sales		145		\$8,314.98	175		\$9,917.03
Unshorn wool incentive per Cwt lamb:	\$3.60			\$550.10			\$659.62
Total Revenue from Lambs				\$8,865.09			\$10,576.65
Ewes exposed				100			100
Total Revenue per Ewe Exposed				\$88.65			\$105.77

		WESTERN EWES, SPRING LAMBING WEANED			½-FINN EWES, SPRING LAMBING WEANED		
Month	Price	No.	Ave wt.	Total	No.	Ave wt.	Total
Sold	(\$/lb)	Lambs	(lb/hd)	Revenue	Lambs	(lb/hd)	Revenue
July	\$0.57	13	108	\$820.25	18	110	\$1,111.72
Aug	\$0.55	3	110	\$201.92	0	0	\$0.00
Sept	\$0.53	27	109	\$1,571.25	36	111	\$2,106.89
SeptLight	\$0.51	47	100	\$2,426.07	29	101	\$1,485.23
SeptFeedr	\$0.57	54	85	\$2,599.45	93	83	\$4,407.95
Total Sales		145		\$7,618.93	175		\$9,111.79
Unshorn wool incentive per Cwt lamb:	\$3.60			\$506.21			\$596.05
Total Revenue from Lambs				\$8,125.14			\$9,707.84
Ewes exposed				100			100
Total Revenue per Ewe Exposed				\$81.25			\$97.08

Table A.3, con't. Lamb and unshorn wool revenues, per 100 ewes and per ewe exposed

<u>SPRING YR3</u>		WESTERN EWES, SPRING LAMBING NOT WEANED			½-FINN EWES, SPRING LAMBING NOT WEANED		
Month	Price	No.	Ave wt.	Total	No.	Ave wt.	Total
Sold	(\$/lb)	Lambs	(lb/hd)	Revenue	Lambs	(lb/hd)	Revenue
July	\$0.57	0	0	\$0.00	8	107	\$481.71
Aug	\$0.55	16	108	\$947.18	16	108	\$935.76
Sept	\$0.53	0	0	\$0.00	0	0	\$0.00
Oct	\$0.53	105	108	\$5,943.33	135	110	\$7,820.53
Nov	\$0.56	8	112	\$502.08	16	108	\$956.62
NovLight	\$0.54	8	104	\$449.49	0	0	\$0.00
NovFeedr	\$0.57	8	91	\$416.73	0	0	\$0.00
Total Sales		145		\$8,258.80	175		\$10,194.62
Unshorn wool incentive per Cwt lamb:	\$3.60			\$558.55			\$689.85
Total Revenue from Lambs				\$8,817.36			\$10,884.46
Ewes exposed				100			100
Total Revenue per Ewe Exposed				\$88.17			\$108.84

Table A.3, con't. Lamb and unshorn wool revenues, per 100 ewes and per ewe exposed

<u>SPRING YR3, con't.</u>		WESTERN EWES, SPRING LAMBING WEANED			W-FINN EWES, SPRING LAMBING WEANED		
Month	Price	No.	Ave wt.	Total	No.	Ave wt.	Total
Sold	(\$/lb)	Lambs	(lb/hd)	Revenue	Lambs	(lb/hd)	Revenue
July	\$0.57	0	0	\$0.00	0	0	\$0.00
Aug	\$0.55	0	0	\$0.00	0	0	\$0.00
Sept	\$0.53	0	0	\$0.00	17	108	\$960.10
Oct	\$0.53	51	110	\$2, 958.22	125	110	\$7, 229.06
Nov	\$0.56	94	114	\$5, 952.15	17	114	\$1, 057.85
NovLight	\$0.54	0	0	\$0.00	8	102	\$456.27
NovFeedr	\$0.57	0	0	\$0.00	8	94	\$445.53
Total Sales		145		\$8, 910.36	175		\$10, 148.81
Unshorn wool Incentive per Cwt lamb:	\$3.60			\$587.42			\$687.00
Total Revenue from Lambs				\$9, 497.78			\$10, 835.80
Ewes exposed				100			100
Total Revenue per Ewe Exposed				\$94.98			\$108.36

Table A.3, con't. Lamb and unshorn wool revenues, per 100 ewes and per ewe exposed

<u>FALL YR1&2</u>		WESTERN EWES, FALL LAMBING			%—FINN EWES, FALL LAMBING		
Month	Price	No.	Ave wt.	Total	No.	Ave wt.	Total
<u>Sold</u>	<u>(\$/lb)</u>	<u>Lambs</u>	<u>(lb/hd)</u>	<u>Revenue</u>	<u>Lambs</u>	<u>(lb/hd)</u>	<u>Revenue</u>
Dec	\$0.59	3	107	\$215.04	3	105	\$189.85
Jan	\$0.61	5	114	\$356.77	20	111	\$1,358.97
Feb	\$0.63	24	112	\$1,680.97	37	111	\$2,582.81
Mar	\$0.69	24	114	\$1,872.78	29	112	\$2,237.69
MarLight	\$0.67	5	102	\$348.42	2	102	\$104.49
MarFeedr	\$0.69	2	80	\$93.86	6	79	\$334.61
Total Sales		63		\$4,567.85	96		\$6,808.41
Unshorn wool incentive per Cwt lamb:	\$3.60			\$251.56			\$378.89
Total Revenue from Lambs				\$4,819.41			\$7,187.30
Ewes exposed				100			100
Total Revenue per Ewe Exposed				\$48.19			\$71.87

<u>FALL YR3</u>		WESTERN EWES, FALL LAMBING			%—FINN EWES, FALL LAMBING		
Month	Price	No.	Ave wt.	Total	No.	Ave wt.	Total
<u>Sold</u>	<u>(\$/lb)</u>	<u>Lambs</u>	<u>(lb/hd)</u>	<u>Revenue</u>	<u>Lambs</u>	<u>(lb/hd)</u>	<u>Revenue</u>
Dec	\$0.59	10	109	\$623.49	14	109	\$931.21
Jan	\$0.61	39	114	\$2,698.90	63	117	\$4,478.83
Feb	\$0.63	15	113	\$1,035.93	19	112	\$1,364.11
Mar	\$0.69	0	0	\$0.00	0	0	\$0.00
MarLight	\$0.67	0	0	\$0.00	0	0	\$0.00
MarFeedr	\$0.69	0	0	\$0.00	0	0	\$0.00
Total Sales		63		\$4,358.32	96		\$6,774.16
Unshorn wool incentive per Cwt lamb:	\$3.60			\$255.83			\$398.01
Total Revenue from Lambs				\$4,614.15			\$7,172.16
Ewes exposed				100			100
Total Revenue per Ewe Exposed				\$46.14			\$71.72

Table A.4 Actual marketing dates and weights: Summary spring-born lambs Yr1 & Yr2

Year	Yr1	Yr2	Yr1	Yr2	Yr1	Yr2	Yr1	Yr2
Group	Fnn-No	Fnn-No	Fnn-Wn	Fnn-Wn	Wst-No	Wst-No	Wst-Wn	Wst-Wn
Actual no.								
lambs marketed	30	27	33	16	20	19	19	24
<u>Percent of lambs marketed</u>								
July: >104 lb	3%	52%	0%	31%	5%	32%	0%	17%
Aug: >104 lb	20%	7%	0%	0%	45%	11%	5%	0%
Sept: >104 lb	40%	4%	21%	19%	30%	26%	21%	17%
Sept: 95-104 lb	23%	33%	21%	6%	15%	11%	37%	29%
Sept: <95 lb	13%	4%	58%	44%	5%	21%	37%	38%

Combined lamb numbers, Spring Yr1 & Yr2

Group	Fnn-No	Fnn-Wn	Wst-No	Wst-Wn
Total no.	57	49	39	43
Ave. no./yr	29	25	20	22

Percent marketed and average marketing weight

July: >104	26%	10%	18%	9%
ave wt	109	110	110	108
Aug: >104	14%	0%	28%	2%
ave wt	112		110	110
Sept: >104	23%	20%	28%	19%
ave wt	107	111	109	109
Sept: 95-104	28%	16%	13%	33%
ave wt	100	101	100	100
Sept: <95	9%	53%	13%	37%
ave wt	88	83	88	85

OVERALL SUMMARY for Spring Yr1 & Yr2

	%-Finn	Western	No-wean	Wean	Yr1	Yr2
<u>% marketed</u>						
July: >104	19%	13%	23%	10%	2%	34%
Aug: >104	8%	15%	20%	1%	16%	5%
Sept: >104	22%	23%	25%	20%	28%	15%
Sept: 95-104	23%	23%	22%	24%	24%	22%
Sept: <95	29%	26%	10%	46%	30%	24%
Ave mkt wt (lb)	99	101	105	96	100	100

Table A.4 Actual marketing dates and weights: Summary spring-born lambs Yr3

Year Group	Yr3 Fnn-No	Yr3 Fnn-Wn	Yr3 Wst-No	Yr3 Wst-Wn
Actual no. lambs marketed	22	21	18	17
<u>Percent marketed and average marketing weight</u>				
July: >104 lb	5%	0%	0%	0%
ave wt	107	0	0	0
Aug: >104 lb	9%	0%	11%	0%
ave wt	108	0	108	0
Sept: >104 lb	0%	10%	0%	0%
ave wt	0	108	0	0
Oct: >104 lb	77%	71%	72%	35%
ave wt	110	110	108	110
Nov: >104 lb	9%	10%	6%	65%
ave wt	108	114	112	114
Nov: 95-104 lb	0%	5%	6%	0%
ave wt	0	102	104	0
Nov: <95 lb	0%	5%	6%	0%
ave wt	0	94	91	0

OVERALL SUMMARY for Spring Yr3

	%-Finn	Western	No-wean	Wean	Total Yr3
<u>% marketed</u>					
July: >104 lb	2%	0%	3%	0%	1%
Aug: >104 lb	5%	6%	10%	0%	5%
Sept: >104 lb	5%	0%	0%	5%	3%
Oct: >104 lb	74%	54%	75%	55%	65%
Nov: >104 lb	9%	34%	8%	34%	21%
Nov: 95-104 lb	2%	3%	3%	3%	3%
Nov: <95 lb	2%	3%	3%	3%	3%
Ave mkt wt (lb)	109	110	109	110	110

Table A.4 Actual marketing dates and weights: Summary fall-born lambs Yr1, Yr2, Yr3

Year Group	Yr1 %Finn	Yr2 %Finn	Yr3 %Finn	Yr1 Western	Yr2 Western	Yr3 Western
Actual no. lambs marketed	33	30	20	22	15	13
<u>Percent of lambs marketed</u>						
Dec: >104 lb	6%	0%	15%	9%	0%	15%
Jan: >104 lb	12%	30%	65%	14%	0%	62%
Feb: >104 lb	39%	37%	20%	41%	33%	23%
Mar: >104 lb	30%	30%	0%	23%	60%	0%
Mar: 95-104 lb	3%	0%	0%	9%	7%	0%
Mar: <95 lb	9%	3%	0%	5%	0%	0%

Year Group	Yr1&2 %Finn	Yr3 %Finn	Yr1&2 Western	Yr3 Western
Total no.	63	20	37	13
Ave. no./yr	32	20	19	13

Percent marketed and average marketing weight

Dec: >104	3%	15%	5%	15%
ave wt	105	109	107	109
Jan: >104	21%	65%	8%	62%
ave wt	111	117	114	114
Feb: >104	38%	20%	38%	23%
ave wt	111	112	112	113
Mar: >104	30%	0%	38%	0%
ave wt	112		114	
Mar: 95-104	2%	0%	8%	0%
ave wt	102		102	
Mar: <95	6%		3%	
ave wt	79		80	

Table A.4 (cont.) Overall Summary for Yr1&2, and Yr3

	Yr1&2 %—Finn	Yr1&2 Western	Yr3 %—Finn	Yr3 Western	Total Yr1&2	Total Yr3
<u>% marketed</u>						
Dec: >104	3%	5%	15%	15%	4%	15%
Jan: >104	21%	8%	65%	62%	16%	64%
Feb: >104	38%	38%	20%	23%	38%	21%
Mar: >104	30%	38%	0	0	33%	0
Mar: 95–104	2%	8%	0	0	4%	0
Mar: <95	6%	3%	0	0	5%	0
Ave mkt wt (lb)	109	111	113	111	110	112

Table A.5 Feeder lamb prices. Prices for 70- to 85-lb lambs in September, October, November, February, and March, sold in Northern and Southwestern VA auctions and the Monterey VA Special Lamb Sale, as listed by the Virginia Agriculture Commodity Newsletter

<u>1988</u>	<u>S.W.</u>	<u>North.</u>	<u>Mont.</u>	<u>Ave.</u>
Feb	\$0.82	\$0.93		\$0.88
Mar	0.84	0.86		0.85
Sept	0.59	0.68	0.75	0.67
Oct	0.60	0.68	0.76	0.68
Nov	0.62	0.69	0.77	0.69

<u>1989</u>	<u>S.W.</u>	<u>North.</u>	<u>Mont.</u>	<u>Ave.</u>
Feb	\$0.62	\$0.74		\$0.68
Mar	0.65	0.75		0.70
Sept	0.59	0.70	0.70	0.66
Oct	0.55	0.69	0.69	0.64
Nov	0.56	0.58	0.64	0.59

1988-1992

<u>5-year averages</u>	
Feb	\$0.66
Mar	0.69
Sept	0.57
Oct	0.58
Nov	0.57

<u>1990</u>	<u>S.W.</u>	<u>North.</u>	<u>Mont.</u>	<u>Ave.</u>
Feb	\$0.56	\$0.58		\$0.57
Mar	0.58	0.68		0.63
Sept	0.42	0.49	0.56	0.49
Oct	0.43	0.49	0.52	0.48
Nov	0.39	0.52	0.53	0.48

<u>1991</u>	<u>S.W.</u>	<u>North.</u>	<u>Mont.</u>	<u>Ave.</u>
Feb	\$0.50	\$0.55		\$0.53
Mar	0.55	0.55		0.55
Sept	0.43	0.46	0.48	0.46
Oct	0.47	0.45	0.46	0.46
Nov	0.42	0.47	0.46	0.45

<u>1992</u>	<u>S.W.</u>	<u>North.</u>	<u>Mont.</u>	<u>Ave.</u>
Feb	\$0.61	\$0.71		\$0.66
Mar	0.70	0.72		0.71
Sept	0.52	0.57	0.62	0.57
Oct	0.58	0.65	0.66	0.63
Nov	0.55	0.70	0.66	0.64

Table A.6 Wool revenues from ewe flock, per ewe exposed

Spring- and Fall-lambing ewes			
Item	Value	Unit	Western ewes
			Lbs. \$\$/Hd
Wool clip	\$0.56	Lb	7.59 \$4.27
Wool incentive	121.4%	of clip	5.92 \$3.33
			\$4.04
Wool income per Ewe Exposed			\$9.45
			\$7.36

Table A.7 Revenues from cull animals, per ewe exposed

	<u>Western ewes</u>		<u>½-Finn ewes</u>	
No. ewes in system	100		100	
Ewe salvage @ cull rate of	15%		15%	
Cull value & wt \$0.18 /lb	149	\$4.10	148	\$4.07
No. rams in system	3		3	
Ram salvage @ cull rate	33%		33%	
Cull value & wt \$0.19 /lb	261	<u>\$0.50</u>	261	<u>\$0.50</u>
Cull Income per Ewe Exposed		\$4.59		\$4.56

Table A.8 Purchased feed costs, per ewe exposed

WESTERN EWES, SPRING-LAMBING SYSTEM, Yr1 & Yr2, NON-WEANE

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	16.3	\$1.28	1.71	\$2.19
Finish ration							
Ground mix	\$0.07	Lb	\$0.07	7.0	\$0.51	1.54	\$0.78
Hay	\$73.33	Ton	\$0.04	1.1	\$0.04	1.54	\$0.06
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	3.3	\$0.69	1.54	\$1.06
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$18.83

%-FINN EWES, SPRING-LAMBING SYSTEM, Yr1 & Yr2, NON-WEANED

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	16.3	\$1.28	2.12	\$2.71
Finish ration							
Ground mix	\$0.07	Lb	\$0.07	12.5	\$0.91	1.84	\$1.67
Hay	\$73.33	Ton	\$0.04	2.0	\$0.07	1.84	\$0.14
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	3.3	\$0.68	1.84	\$1.25
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$20.49

WESTERN EWES, SPRING-LAMBING SYSTEM, Yr1 & Yr2, WEANED

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	16.3	\$1.28	1.71	\$2.19
Finish ration							
Ground mix	\$0.07	Lb	\$0.07	35.8	\$2.60	1.54	\$4.00
Hay	\$73.33	Ton	\$0.04	5.8	\$0.21	1.54	\$0.33
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	3.7	\$0.77	1.54	\$1.19
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$22.43

¼-FINN EWES, SPRING-LAMBING SYSTEM, Yr1 & Yr2, WEANED

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	16.3	\$1.28	2.12	\$2.71
Finish ration							
Ground mix	\$0.07	Lb	\$0.07	38.6	\$2.80	1.84	\$5.16
Hay	\$73.33	Ton	\$0.04	6.2	\$0.23	1.84	\$0.42
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	3.5	\$0.72	1.84	\$1.32
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$24.34

WESTERN EWES, SPRING-LAMBING SYSTEM, Yr3, NON-WEANED

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	0.0	\$0.00	1.71	\$0.00
Finish ration							
Corn	\$3.12	Bu	\$0.06	4.2	\$0.24	1.54	\$0.36
Corn+TrL	\$0.07	Lb	\$0.07	93.2	\$6.17	1.54	\$9.51
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	4.0	\$0.83	1.54	\$1.28
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		<u>\$0.83</u>
Total Purchased Feed Costs							\$25.88

W-FINN EWES, SPRING-LAMBING SYSTEM, Yr3, NON-WEANED

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	0.0	\$0.00	2.12	\$0.00
Finish ration							
Corn	\$3.12	Bu	\$0.06	4.2	\$0.24	1.84	\$0.43
Corn+TrL	\$0.07	Lb	\$0.07	104.6	\$6.93	1.84	\$12.75
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	4.1	\$0.85	1.84	\$1.57
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		<u>\$0.83</u>
Total Purchased Feed Costs							\$29.48

WESTERN EWES, SPRING-LAMBING SYSTEM, Yr3, WEANED

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	0.0	\$0.00	1.71	\$0.00
Finish ration							
Corn	\$3.12	Bu	\$0.06	4.2	\$0.24	1.54	\$0.36
Corn+TrL	\$0.07	Lb	\$0.07	187.8	\$12.44	1.54	\$19.15
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	4.6	\$0.96	1.54	\$1.47
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$35.72

½-FINN EWES, SPRING-LAMBING SYSTEM, Yr3, WEANED

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	266.4	\$9.77		\$9.77
Corn, ewe	\$3.12	Bu	\$0.06	45.6	\$2.54		\$2.54
Creep feed	\$0.08	Lb	\$0.08	0.0	\$0.00	2.12	\$0.00
Finish ration							
Corn	\$3.12	Bu	\$0.06	4.2	\$0.24	1.84	\$0.43
Corn+TrL	\$0.07	Lb	\$0.07	138.2	\$9.15	1.84	\$16.84
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	4.4	\$0.91	1.84	\$1.67
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$33.67

WESTERN EWES, FALL-LAMBING SYSTEM, Yr1 & Yr2

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	210.0	\$7.70		\$7.70
Corn, ewe	\$3.12	Bu	\$0.06	17.5	\$0.97		\$0.97
Creep feed	\$0.08	Lb	\$0.08	29.3	\$2.30	0.68	\$1.56
Finish ration							
Ground mix	\$0.07	Lb	\$0.07	309.5	\$22.46	0.68	\$15.21
Hay	\$73.33	Ton	\$0.04	49.9	\$1.83	0.68	\$1.24
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	3.1	\$0.63	0.68	\$0.43
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		<u>\$0.83</u>
Total Purchased Feed Costs							\$29.54

½-FINN EWES, FALL-LAMBING SYSTEM, Yr1 & Yr2

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	210.0	\$7.70		\$7.70
Corn, ewe	\$3.12	Bu	\$0.06	17.5	\$0.97		\$0.97
Creep feed	\$0.08	Lb	\$0.08	29.3	\$2.30	1.03	\$2.36
Finish ration							
Ground mix	\$0.07	Lb	\$0.07	285.2	\$20.70	1.03	\$21.25
Hay	\$73.33	Ton	\$0.04	46.0	\$1.68	1.03	\$1.73
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	3.1	\$0.64	1.03	\$0.66
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		<u>\$0.83</u>
Total Purchased Feed Costs							\$37.10

WESTERN EWES, FALL-LAMBING SYSTEM, Yr3

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	210.0	\$7.70		\$7.70
Corn, ewe	\$3.12	Bu	\$0.06	17.5	\$0.97		\$0.97
Creep, ground	\$3.12	Bu	\$0.06	30.2	\$1.68	0.83	\$1.39
Corn+TrL	\$0.07	Lb	\$0.07	3.6	\$0.24	0.83	\$0.20
Finish ration							
Corn+T-r-L	\$0.07	Lb	\$0.07	229.5	\$15.20	0.83	\$12.55
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	2.6	\$0.54	0.83	\$0.45
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$25.69

½-FINN EWES, FALL-LAMBING SYSTEM, Yr3

Item	Cost	Unit	\$/Lb	Lb/Hd	\$/Hd	Lambs /Ewe Exp.	Total Cost/Ewe Exposed
Hay, ewe	\$73.33	Ton	\$0.04	210.0	\$7.70		\$7.70
Corn, ewe	\$3.12	Bu	\$0.06	17.5	\$0.97		\$0.97
Creep, corn	\$3.12	Bu	\$0.06	30.2	\$1.68	1.18	\$1.98
Corn+TrL	\$0.07	Lb	\$0.07	3.6	\$0.24	1.18	\$0.28
Finish ration							
Corn+T-r-L	\$0.07	Lb	\$0.07	225.1	\$14.90	1.18	\$17.59
Salt/min, ewe	\$20.63	Cwt	\$0.21	7.8	\$1.60		\$1.60
Salt/min, lamb	\$20.63	Cwt	\$0.21	2.7	\$0.56	1.18	\$0.67
Hay, ram	\$73.33	Ton	\$0.04	742.5	\$27.23		\$0.83
Total Purchased Feed Costs							\$31.62

Table A.9 Consumption of purchased feeds: Corn, hay, creep

Table A.9.a Corn and hay

Corn, ewe

Period	SPRING			FALL		
	Days	Lb/day	Total Lbs	Days	Lb/day	Total Lbs
Flushing	0	0.00	0.0	35	0.50	17.5
Late gest.	42	0.75	31.5	0	0.00	0.0
Lactation	10	1.41	14.1	0	0.00	0.0
Total corn consumed, per ewe			45.6			17.5

Hay, ewe

Period	SPRING			FALL		
	Days	Lb/day	Total Lbs	Days	Lb/day	Total Lbs
Dry (maint.)	0	0.00	0.0	105	2.00	210.0
Mid gest.	30	2.50	75.0	0	0.00	0.0
Late gest.	42	3.50	147.0	0	0.00	0.0
Lactation	10	4.44	44.4	0	0.00	0.0
Total hay consumed, per ewe			266.4			210.0

Hay, ram

Period	Days	Lb/day	Total Lbs
Winter maint.	165	4.50	742.5

Table A.9.b Creep feed

Item	SPRING, YR1&2			FALL, Yr1&2		
	Days	Lb/day	Total Lbs	Days	Lb/day	Total Lbs
Ground creep	25	0.65	16.3	45	0.65	29.3

Item	SPRING, Yr3			FALL, Yr3		
	Days	Lb/day	Total Lbs	Days	Lb/day	Total Lbs
Ground creep	0	0.00	0.0	52	0.58	30.2
Corr:Tendr-Lamb	0	0.00	0.0	52	0.07	3.6

Table A.9.c Consumption of drylot feed rations, Yrs1&2

Item	SPRING, Yr1&2 (Not-weaned, Western dams)			SPRING, Yr1&2 (Not-weaned, ¼-Finn dams)		
	Days	Lb/day	Lbs	Days	Lb/day	Lbs
Ground mix	2.3	3.10	7.0	4.0	3.10	12.5
Mixed hay	2.3	0.50	1.1	4.0	0.50	2.0
			8.1			14.5

Item	SPRING, Yr1&2 (Weaned, Western dams)			SPRING, Yr1&2 (Weaned, ¼-Finn dams)		
	Days	Lb/day	Lbs	Days	Lb/day	Lbs
Ground mix	11.5	3.10	35.8	12.4	3.10	38.6
Mixed hay	11.5	0.50	5.8	12.4	0.50	6.2
			41.6			44.8

Item	FALL, Yr1&2 (of Western dams)			FALL, Yr1&2 (of ¼-Finn dams)		
	Days	Lb/day	Lbs	Days	Lb/day	Lbs
Ground mix	99.7	3.10	309.5	91.9	3.10	285.2
Mixed hay	99.7	0.50	49.9	91.9	0.50	46.0
			359.3			331.2

Table A.9.c (con't.) Consumption of drylot feed rations, Yr3.
 Spring Yr3: lambs fed corn only for first 8 days in drylot.

Item	SPRING, Yr3 (Not-weaned, Western dams)			SPRING, Yr3 (Not-weaned, ¼-Finn dams)		
	Days	Lb/day	Lbs	Days	Lb/day	Lbs
Corn	8.0	0.53	4.2	8.0	0.53	4.2
Corn/Tend-r-Lamb	10.0	1.47	14.7	10.0	1.47	14.7
Corn/Tend-r-Lamb	<u>22.0</u>	<u>3.57</u>	<u>78.5</u>	<u>25.2</u>	<u>3.57</u>	<u>90.0</u>
	40.0		97.4	43.2		108.9

Item	SPRING, Yr3 (Weaned, Western dams)			SPRING, Yr3 (Weaned, ¼-Finn dams)		
	Days	Lb/day	Lbs	Days	Lb/day	Lbs
Corn	8.0	0.53	4.2	8.0	0.53	4.2
Corn/Tend-r-Lamb	10.0	1.47	14.7	10.0	1.47	14.7
Corn/Tend-r-Lamb	<u>48.5</u>	<u>3.57</u>	<u>173.1</u>	<u>34.6</u>	<u>3.57</u>	<u>123.5</u>
	66.5		192.0	52.6		142.4

Item	FALL, Yr3 (of Western dams)			FALL, Yr3 (of ¼-Finn dams)		
	Days	Lb/day	Lbs	Days	Lb/day	Lbs
Corn/Tend-r-Lamb	72.4	3.17	229.5	71.0	3.17	225.1

Table A.10 Creep feed mix, ground on-site

<u>Ingredients</u>	<u>Actual</u> <u>Lbs</u>	<u>% of</u> <u>Ration</u>	<u>\$ per</u> <u>Unit</u>	<u>Unit</u>	<u>\$ per lb</u> <u>Ingred</u>	<u>\$ per</u> <u>Ingred.</u>	<u>Ingred.</u> <u>As fed CP</u>	<u>Creep</u> <u>CP%</u>
Corn	650	62.8%	\$3.12	Bu	\$0.06	\$0.035	8.9	5.6
SBOM 48%	215	20.8%	\$271.33	Ton	\$0.14	\$0.028	44.8	9.3
Oats	80	7.7%	\$3.00	Bu	\$0.09	\$0.007	12.6	1.0
Molasses	50	4.8%	\$10.29	Cwt	\$0.10	\$0.005	4.4	0.2
Lime	15	1.4%	\$70.50	Ton	\$0.04	\$0.001		0.0
Mineral Mix	25	2.4%	\$11.78	Cwt	\$0.12	\$0.003		0.0
	1035							
Total, 1 lb.		100.0%			\$/lb	\$0.079		16.1

Ingredient prices listed in Table A.2

Table A.11.a Drylot ground feed, used Yrs1&2

<u>Ingredients</u>	<u>Actual Lbs</u>	<u>% of Ration</u>	<u>\$ per Unit</u>	<u>Unit</u>	<u>\$ per lb Ingrd.</u>	<u>\$ per Ingrd.</u>	<u>Ingrd. As fed CP</u>	<u>Ration CP%</u>
Corn	72	72.0%	\$3.12	Bu	\$0.06	\$0.040	8.9	6.4
SBOM 48%	12.5	12.5%	\$271.33	Ton	\$0.14	\$0.017	44.8	5.6
Oats	10	10.0%	\$3.00	Bu	\$0.09	\$0.009	12.6	1.3
Molasses	5	5.0%	\$10.29	Cwt	\$0.10	\$0.005	4.4	0.2
Salt/min. mix	0.5	0.5%	\$20.63	Cwt	\$0.21	\$0.001		0.0
	100							
Total, 1 lb.		100.0%			\$/lb	\$0.073		13.5

Dry matter content of drylot mix/hay ration

Drylot mix 88.6%

Grass/clov hay 90.0% (Fescue 92%, clover 88%, orchardgrass 90%)

Requirements of a drylot lamb

3.2 lb/day DM intake

ave. 66 – 88 lb finishing lamb, 4–7 mo old

DM supplied by feed mix/hay ration

0.50 lb hay/d 90.0% DM 0.5 lb DM/d

3.10 lb mix/d 88.6% DM 2.8 lb DM/d

Table A.11.b Drylot feed mix of corn and Tend-r-Lamb, used Yr3

<u>Ingredients</u>	<u>Actual Lbs</u>	<u>% of Ration</u>	<u>\$ per Unit</u>	<u>Unit</u>	<u>\$ per lb Ingrd.</u>	<u>\$ per Ingrd.</u>
Corn	90	90.0%	\$3.12	Bu	\$0.06	\$0.050
Tend-r-Lamb	10	10.0%	\$16.13	Cwt	\$0.16	\$0.016
	100				\$/lb	\$0.066

Table A.12 Non-feed costs, per ewe exposed
Western, Spring-lambing ewes, Yrs1&2

Item	Units	Units /Hd.	Cost /Unit	Cost /Hd.	Lambs /Ewe Exp.	Total Cost /Ewe exp.
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	1.71	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.10	\$5.12	\$0.51	1.54	\$0.79
Drylot feed, no wean	Hrs	0.01	\$5.12	\$0.06	1.54	\$0.09
Drylot feed, wean	Hrs	0.06	\$5.12	\$0.29	1.54	\$0.45
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	1.71	\$0.46
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	1.71	\$0.18
Ivermec inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec inj, lamb	.75 ml dos	5	\$0.43	\$2.15	1.54	\$3.32
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	1.45	\$2.90
Wool	Lb	7.59	\$0.03	\$0.19		\$0.19
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs, no wean						\$32.49
Non-feed costs, wean						\$32.85
Operating interest						
10.5% Interest						
Ewe feed, 6 mo	Hd	0.5	\$14.73	\$0.77		\$0.77
non-feed, 6 mo	Hd	0.5	\$24.75	\$1.30		\$1.30
Lamb feed, 3 mo, no wean	Hd	0.25	\$4.09	\$0.11		\$0.11
Lamb feed, 3 mo, wean	Hd	0.25	\$7.70	\$0.20		\$0.20
non-feed, 3 mo, no wean	Hd	0.25	\$7.73	\$0.20		\$0.20
non-feed, 3 mo, wean	Hd	0.25	\$8.10	\$0.21		\$0.21
Total Non-Feed Costs, non-weaned group						\$34.87
Total Non-Feed Costs, weaned group						\$35.34

Table A.12, con't. Non-feed costs, per ewe exposed
 ¼-Finn, Spring-lambing ewes, Yrs1&2

<u>Item</u>	<u>Units</u>	<u>Units</u> <u>/Hd.</u>	<u>Cost</u> <u>/Unit</u>	<u>Cost</u> <u>/Hd.</u>	<u>Lambs</u> <u>/Ewe</u> <u>Exp.</u>	<u>Total</u> <u>Cost</u> <u>/Ewe exp.</u>
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	2.12	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.10	\$5.12	\$0.51	1.84	\$0.94
Drylot feed, no wean	Hrs	0.02	\$5.12	\$0.10	1.84	\$0.19
Drylot feed, wean	Hrs	0.06	\$5.12	\$0.32	1.84	\$0.58
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	2.12	\$0.57
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	2.12	\$0.23
Ivermec inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec inj, lamb	.75 ml dos	5	\$0.43	\$2.15	1.84	\$3.96
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	1.75	\$3.50
Wool	Lb	5.92	\$0.03	\$0.15		\$0.15
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs, no wean						\$34.10
Non-feed costs, wean						\$34.49
Operating Interest						
		10.5% Interest				
Ewe feed, 6 mo	Hd	0.5	\$14.73	\$0.77		\$0.77
non-feed, 6 mo	Hd	0.5	\$24.71	\$1.30		\$1.30
Lamb feed, 3 mo, no wean	Hd	0.25	\$5.76	\$0.15		\$0.15
Lamb feed, 3 mo, wean	Hd	0.25	\$9.61	\$0.25		\$0.25
non-feed, 3 mo, no wea	Hd	0.25	\$9.39	\$0.25		\$0.25
non-feed, 3 mo, wean	Hd	0.25	\$9.78	\$0.26		\$0.26
Total Non-Feed Costs, non-weaned group						\$36.57
Total Non-Feed Costs, weaned group						\$37.07

Table A.12, cont. Non-feed costs per ewe exposed
Western, Spring-lambing ewes, Yr3

<u>Item</u>	<u>Units</u>	<u>Units</u> <u>/Hd.</u>	<u>Cost</u> <u>/Unit</u>	<u>Cost</u> <u>/Hd.</u>	<u>Lambs</u> <u>/Ewe</u> <u>Exp.</u>	<u>Total</u> <u>Cost</u> <u>/Ewe exp.</u>
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	1.71	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.10	\$5.12	\$0.51	1.54	\$0.79
Drylot feed, no wean	Hrs	0.20	\$5.12	\$1.02	1.54	\$1.58
Drylot feed, wean	Hrs	0.33	\$5.12	\$1.70	1.54	\$2.62
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	1.71	\$0.46
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	1.71	\$0.18
Ivermec Inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec Inj, lamb	.75 ml dos	5	\$0.43	\$2.15	1.54	\$3.32
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	1.45	\$2.90
Wool	Lb	7.59	\$0.03	\$0.19		\$0.19
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs, no wean						\$33.97
Non-feed costs, wean						\$35.02
Operating Interest						
10.5% Interest						
Ewe feed, 6 mo	Hd	0.5	\$14.73	\$0.77		\$0.77
non-feed, 6 mo	Hd	0.5	\$24.75	\$1.30		\$1.30
Lamb feed, 3 mo, no wean	Hd	0.25	\$11.15	\$0.29		\$0.29
Lamb feed, 3 mo, wean	Hd	0.25	\$20.99	\$0.55		\$0.55
non-feed, 3 mo, no wean	Hd	0.25	\$9.22	\$0.24		\$0.24
non-feed, 3 mo, wean	Hd	0.25	\$10.26	\$0.27		\$0.27
Total Non-Feed Costs, non-weaned group						\$36.58
Total Non-Feed Costs, weaned group						\$37.91

Table A.12, cont'. Non-feed costs per ewe exposed
 ¼-Finn, Spring-lambing ewes, Yr3

<u>Item</u>	<u>Units</u>	<u>Units</u> <u>/Hd.</u>	<u>Cost</u> <u>/Unit</u>	<u>Cost</u> <u>/Hd.</u>	<u>Lambs</u> <u>/Ewe</u> <u>Exp.</u>	<u>Total</u> <u>Cost</u> <u>/Ewe exp.</u>
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	2.12	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.10	\$5.12	\$0.51	1.84	\$0.94
Drylot feed, no wean	Hrs	0.22	\$5.12	\$1.10	1.84	\$2.03
Drylot feed, wean	Hrs	0.26	\$5.12	\$1.34	1.84	\$2.47
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	2.12	\$0.57
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	2.12	\$0.23
Ivermec inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec inj, lamb	.75 ml dos	5	\$0.43	\$2.15	1.84	\$3.96
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	1.75	\$3.50
Wool	Lb	5.92	\$0.03	\$0.15		\$0.15
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs, no wean						\$35.94
Non-feed costs, wean						\$36.38
Operating interest						
		10.5%	Interest			
Ewe feed, 6 mo	Hd	0.5	\$14.73	\$0.77		\$0.77
non-feed, 6 mo	Hd	0.5	\$24.71	\$1.30		\$1.30
Lamb feed, 3 mo, no wean	Hd	0.25	\$14.75	\$0.39		\$0.39
Lamb feed, 3 mo, wean	Hd	0.25	\$18.94	\$0.50		\$0.50
non-feed, 3 mo, no wean	Hd	0.25	\$11.23	\$0.29		\$0.29
non-feed, 3 mo, wean	Hd	0.25	\$11.67	\$0.31		\$0.31
Total Non-Feed Costs, non-weaned group						\$38.69
Total Non-Feed Costs, weaned group						\$39.26

Table A.12, con't. Non-feed costs, per ewe exposed
Western, Fall-lambing ewes, Yrs1&2

<u>Item</u>	<u>Units</u>	<u>Units</u> <u>/Hd.</u>	<u>Cost</u> <u>/Unit</u>	<u>Cost</u> <u>/Hd.</u>	<u>Lambs</u> <u>/Ewe</u> <u>Exp.</u>	<u>Total</u> <u>Cost</u> <u>/Ewe exp.</u>
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	0.83	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.06	\$5.12	\$0.31	0.68	\$0.21
Drylot feed	Hrs	0.50	\$5.12	\$2.55	0.68	\$1.73
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	0.83	\$0.22
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	0.83	\$0.09
Ivermec inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec inj, lamb	.75 ml dos	3	\$0.43	\$1.29	0.68	\$0.87
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	0.63	\$1.26
Wool	Lb	7.59	\$0.03	\$0.19		\$0.19
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs						\$29.14
Operating Interest						
Ewe feed, 6 mo	Hd	0.5	\$11.10	\$0.58		\$0.58
non-feed, 6 mo	Hd	0.5	\$24.75	\$1.30		\$1.30
Lamb feed, 3 mo	Hd	0.25	\$18.44	\$0.48		\$0.48
non-feed, 3 mo	Hd	0.25	\$4.38	\$0.12		\$0.12
Total Non-Feed Costs						\$31.62

Table A.12, con't. Non-feed costs, per ewe exposed
¼-Finn, Fall-lambing ewes, Yrs1&2

<u>Item</u>	<u>Units</u>	<u>Units</u> <u>/Hd.</u>	<u>Cost</u> <u>/Unit</u>	<u>Cost</u> <u>/Hd.</u>	<u>Lambs</u> <u>/Ewe</u> <u>Exp.</u>	<u>Total</u> <u>Cost</u> <u>/Ewe exp.</u>
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	1.18	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.06	\$5.12	\$0.31	1.03	\$0.32
Drylot feed	Hrs	0.46	\$5.12	\$2.35	1.03	\$2.41
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	1.18	\$0.32
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	1.18	\$0.13
Ivermec inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec inj, lamb	.75 ml dos	3	\$0.43	\$1.29	1.03	\$1.33
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	0.96	\$1.93
Wool	Lb	5.92	\$0.03	\$0.15		\$0.15
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs						\$31.14
Operating interest						
Ewe feed, 6 mo	Hd	0.5	\$11.10	\$0.58		\$0.58
non-feed, 6 mo	Hd	0.5	\$24.71	\$1.30		\$1.30
Lamb feed, 3 mo, no wean	Hd	0.25	\$26.00	\$0.68		\$0.68
non-feed, 3 mo	Hd	0.25	\$6.43	\$0.17		\$0.17
Total Non-Feed Costs						\$33.87

Table A.12, con't. Non-feed costs per ewe exposed
Western, Fall-lambing ewes, Yr3

<u>Item</u>	<u>Units</u>	<u>Units</u> <u>/Hd.</u>	<u>Cost</u> <u>/Unit</u>	<u>Cost</u> <u>/Hd.</u>	<u>Lambs</u> <u>/Ewe</u> <u>Exp.</u>	<u>Total</u> <u>Cost</u> <u>/Ewe exp.</u>
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	0.83	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.06	\$5.12	\$0.31	0.68	\$0.21
Drylot feed	Hrs	0.36	\$5.12	\$1.85	0.68	\$1.25
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	0.83	\$0.22
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	0.83	\$0.09
Ivermec inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec inj, lamb	.75 ml dos	3	\$0.43	\$1.29	0.68	\$0.87
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	0.63	\$1.26
Wool	Lb	7.59	\$0.03	\$0.19		\$0.19
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs						\$28.66
Operating interest						
Ewe feed, 6 mo	Hd	0.5	\$11.10	\$0.58		\$0.58
non-feed, 6 mo	Hd	0.5	\$24.75	\$1.30		\$1.30
Lamb feed, 3 mo	Hd	0.25	\$14.59	\$0.38		\$0.38
non-feed, 3 mo	Hd	0.25	\$3.91	\$0.10		\$0.10
Total Non-Feed Costs						\$31.03

Table A.12, cont'. Non-feed costs per ewe exposed
 ½-Finn, Fall-lambing ewes, Yr3

<u>Item</u>	<u>Units</u>	<u>Units</u> <u>/Hd.</u>	<u>Cost</u> <u>/Unit</u>	<u>Cost</u> <u>/Hd.</u>	<u>Lambs</u> <u>/Ewe</u> <u>Exp.</u>	<u>Total</u> <u>Cost</u> <u>/Ewe exp.</u>
Labor						
Lambing	Hrs	0	\$5.12	\$0.00	1.18	\$0.00
Worming, ewes	Hrs	0.12	\$5.12	\$0.61		\$0.61
Worming, lambs	Hrs	0.06	\$5.12	\$0.31	1.03	\$0.32
Drylot feed	Hrs	0.36	\$5.12	\$1.82	1.03	\$1.86
Health/Vet						
8-way, ewe, 2cc	2 cc dose	1	\$0.11	\$0.11		\$0.11
8-way, lamb, 5cc	5 cc dose	1	\$0.27	\$0.27	1.18	\$0.32
8-way, lamb boost	2 cc dose	1	\$0.11	\$0.11	1.18	\$0.13
Ivermec Inj, ewe	1.5 ml dos	6	\$0.86	\$5.17		\$5.17
Ivermec Inj, lamb	.75 ml dos	3	\$0.43	\$1.29	1.03	\$1.33
Ovine vibrio	5 ml dose	1	\$0.44	\$0.44		\$0.44
Marketing costs						
Mkt. lambs	Hd	1	\$2.00	\$2.00	0.96	\$1.93
Wool	Lb	5.92	\$0.03	\$0.15		\$0.15
Culls, 15% cull	Hd	0.15	\$2.00	\$0.30		\$0.30
Shearing	Hd	1	\$1.83	\$1.83		\$1.83
Repl. ewes, 15%/yr	Hd	0.15	\$86.57	\$12.98		\$12.98
Ram, 1 per 33 ewes	Hd	0.01	\$308.80	\$3.12		\$3.12
Non-feed costs						\$30.59
Operating interest						
Ewe feed, 6 mo	Hd	0.5	\$11.10	\$0.58		\$0.58
non-feed, 6 mo	Hd	0.5	\$24.71	\$1.30		\$1.30
Lamb feed, 3 mo	Hd	0.25	\$20.52	\$0.54		\$0.54
non-feed, 3 mo	Hd	0.25	\$5.88	\$0.15		\$0.15
Total Non-Feed Costs						\$33.17

Table A.13.a Estimates of revenues and additional costs of ¼-Finn ewes lambing in January (ewes that failed to lamb in fall).

Average weight at weaning

Wean age (d)	ADG lb/d	Prewritean gain (lb)	Birth wt (lb)	Wt at wean (lb)
55	0.62	34.1	9.5	43.6

Average days to slaughter weight

Wean wt (lb)	Finish wt (lb)	Postwean ADG (lb/d)	Days postwean	Age at slaughter (d)
43.6	110	0.75	88.5	143.5

Feed costs, January-born lambs

	Days	Consumption		Feed cost (per lb)	Feed cost (per lamb)
		lb/d	lb/lamb		
Creep	35.0	0.65	22.8	\$0.079	\$1.80
Feedlot	88.5	3.17	280.7	\$0.066	\$18.52

Additional ewe feed costs, ewes lambing in January

	Days	Consumption		Feed cost (per lb)	Feed cost (per ewe)
		lb/d	lb/ewe		
Hay, lact.	60	3.0	180.0	\$0.037	\$6.66
Corn, gest.	42	1.0	42.0	\$0.056	\$2.35
Corn, lact.	60	1.5	90.0	\$0.056	\$5.04

Additional non-feed costs, January lambing

Ewes: no additional costs

Lambs: use non-feed costs per lamb determined for lambs
of ¼-Finn ewes, Fall Yrs1/2 (92 d in drylot):

\$4.73

Table A.13.b

Revenues per lamb marketed (January lambing)

Finished wt (lb)	Mkt price (per lb)	Per-lamb price	Unshorn incent. (per cwt)	Unshorn incent. (per lamb)	Total revenue per lamb
110	\$0.66	\$72.09	\$3.60	\$3.96	\$76.05

Table A.13.c

Total additional revenues and costs per ewe lambing in January

(assuming 2.02 lambs born/ewe lambing; 87% lamb survival to weaning;
and 83% lamb survival to market)

<u>Revenues</u>	Revenue /lamb \$76.05	Lambs per ewe lambing 1.68	Total revenues per ewe lambing \$127.50
<u>Costs</u>	Cost /lamb	Lambs per ewe lambing	Costs per ewe lambing
Lamb costs			
Creep	\$1.80	1.76	\$3.16
Drylot	\$18.52	1.68	31.06
Non-feed	\$4.73	1.68	7.93
Ewe feed			<u>14.05</u>
Total additional cost per ewe lambing			\$56.20

Table A.13.d

January revenues and expenses added to Fall ¼-Finn budgets

Percent lambing in fall:	69%	
Percent open in August:	31%	
Given 80% fertility in August breeding,		
Percent of ewes lambing in January:	25%	
Total revenues/ewe lambing in January	\$127.50	
Additional revenues/ewe exposed in April		\$31.62
Total additional costs/ewe lambing in January	\$56.20	
Additional costs/ewe exposed in April		\$13.94

Table A.14.a Forage crop costs: Alfalfa

*Soll test recom: 0-60-75, 2x/ac/yr = 30 lb P, 124 lb K /ac/yr

*4 cuttings/yr; seed pro-rated over 5 yr

Item	Units	1990 \$/Unit	1992 \$/Unit	Ave. \$/Unit	Units /acre	Total \$/acre
Seed	Acre	\$46.68	\$43.38	\$45.03	1	\$45.03
Phosphate	Lb	\$0.25	\$0.22	\$0.24	30	\$7.05
Potash	Lb	\$0.16	\$0.14	\$0.15	124	\$18.60
Boron	Lb	\$2.45	\$2.84	\$2.65	3	\$7.94
Lime	Ton	\$20.00	\$21.05	\$20.53	0.5	\$10.26
Fert. appl.	Acre	\$5.50	\$5.04	\$5.27	1	\$5.27
Total Cost per Acre						\$94.15
Cost per cutting (4 cuttings/yr)						\$23.54
Cost per ewe				Stock rate		
Fall Yr1/2, lactating ewes, 1 cutting				7.7		\$3.06
Fall Yr3, lactating ewes, 2 cuttings				7.7		\$6.11

Table A.14.b Forage crop costs: Stockpiled fescue

*Soil test recomb: 40-35-80, applied in August for stockpiling

* => 40 lb N, 15 lb P, 66.5 lb K /ac/yr

Item	Units	1990 \$/Unit	1992 \$/Unit	Ave. \$/Unit	Units /acre	Total \$/acre
Seed	Acre	\$14.30	\$13.73	\$14.02	0	\$0.00
Nitrogen	Lb	\$0.27	\$0.25	\$0.26	40	\$10.40
Phosphate	Lb	\$0.25	\$0.22	\$0.24	15	\$3.53
Potash	Lb	\$0.16	\$0.14	\$0.15	66.5	\$9.98
Lime	Ton	\$20.00	\$21.05	\$20.53	0.25	\$5.13
Fert. appl.	Acre	\$5.50	\$5.04	\$5.27	1	\$5.27
Total Cost per Acre						\$34.30
Stocking rate, ewes/ac				5.7		
Cost per ewe						\$6.02

Table A.14.c Forage crop costs: Perennial grass-legume pastures

Maintenance of bluegrass-orchardgrass-white clover-fescue sward

*Sward <25% clover; fertilize with 0-80-40 lb/ac every 3 yrs

* => 0 lb N, 11.47 lb P, 11.07 lb K /ac/yr

* Lime: 2 tons/acre, every 6-8 yrs

Item	Units	1990 \$/Unit	1992 \$/Unit	Ave. \$/Unit	Units /acre	Total \$/acre
Seed	Lb	\$2.93	\$3.52	\$3.23	0	\$0.00
Nitrogen	Lb	\$0.27	\$0.25	\$0.26	0	\$0.00
Phosphate	Lb	\$0.25	\$0.22	\$0.24	11.5	\$2.70
Potash	Lb	\$0.16	\$0.14	\$0.15	11.1	\$1.66
Lime	Ton	\$20.00	\$21.05	\$20.53	0.3	\$5.95
Fert. appl.	Acre	\$5.50	\$5.04	\$5.27	0.3	\$1.74
Total Cost per Acre						\$12.05
Cost per acre per month (6.5 month period: Apr15-Nov1)						\$1.85

Table A.14.c (cont.) Per-head costs for grass-clover pasture

Cost per head for spring-lambing ewes (& lambs)

Group	Stocking rate	Calendar Period	No.months used	Cost /head
Spr Yr1/2, lact. ewes	7.0	Apr15-Jun1	1.5	\$0.40
Spr Yr3, lact. ewes	9.9	Apr15-Jun1	1.5	\$0.28
Spr Yr1/2/3, open ewes	18.0	Apr15-Jun1	1.5	\$0.15
Summer Yr1/2, lact. ewes	4.5	Jun, Jul, Aug	3.0	\$1.24
Summer Yr3, lact. ewes	4.5	Jun, Jul	2.0	\$0.82
Summer, Yr1/2/3, open ewes	7.0	Jun, Jul, Aug	3.0	\$0.79
Summer, Yr1, weaned ewes	7.0	Jun, Jul, Aug	3.0	\$0.79
Summer, Yr2/3, weaned ewes	7.0	June & Aug	2.0	\$0.53
Spr Yr1/2, weaned lambs	15.0	June	1.0	\$0.12
Spr Yr3, weaned lambs	20.3	June	1.0	\$0.09
Summer Yr1/2, weaned lambs	15.0	July, Aug	2.0	\$0.25
Summer Yr3, weaned lambs	8.4	July, Aug	2.0	\$0.44
Fall, Yr1/2/3, breeding ewes	6.5	Sept1-Nov1	2.0	\$0.57
Fall, Yr3, dry ewes	6.5	Aug	1.0	\$0.29

Cost per head for fall-lambing ewes (gestating)

Group	Stocking rate	Calendar Period	No.months used	Cost /head
Spr Yr1/2	7.4	Apr15-Jun15	2.0	\$0.50
Spr Yr3	8.3	Apr15-May1	1.0	\$0.22
Summer Yr1/2	7.0	Jun15-Sept1	2.5	\$0.66
Summer Yr3	7.0	May15-Sept1	3.5	\$0.93
Fall Yr1/2/3 (open ewes)	6.5	Sept1-Nov1	2.0	\$0.57

Table A.14.d Forage crop costs: Winter rye

Item	Units	1990 \$/Unit	1992 \$/Unit	Ave. \$/Unit	Units /acre	Total \$/acre
Seed	Bu	\$8.75	\$8.72	\$8.74	1.5	\$13.10
Seeder rent	Ac	\$4.94	\$4.94	\$4.94	1	<u>\$4.94</u>
Total Cost per Acre						\$18.04
Stocking rate, lact. ewes/ac				5.9		
Cost per lactating ewe						\$3.06

Table A.14.e Forage crop costs: Pearl millet

*Fert appl: 10-10-10 @ 600 lb/ac; 2 applications herbicide

Item	Units	1990 \$/Unit	1992 \$/Unit	Ave. \$/Unit	Units /acre	Total \$/acre
Seed	Lb	\$0.70	\$0.64	\$0.67	25	\$16.75
10-10-10	Lb			\$0.08	600	\$48.68
Lime	Ton	\$20.00	\$21.05	\$20.53	0.25	\$5.13
Fert. appl.	Acre	\$5.50	\$5.04	\$5.27	1	\$5.27
Paraquat	Qt	\$8.38	\$8.31	\$8.34	2	\$16.69
Herb. appl.	Acre	\$5.50	\$5.29	\$5.40	2	\$10.79
Grazing lbr.	Hr	\$5.00	\$5.31	\$5.16	1	\$5.16
Seeder rent	Acre	\$12.08	\$12.08	\$12.08	1	\$12.08
Total Cost per Acre						\$120.54
Stocking rate, dry ewes/ac				44		
Stocking rate, lambs/ac				51		
Cost per dry ewe						\$2.76
Cost per lamb						\$2.35

Table A.14.f Forage crop costs: Tyfon

*Fert appl: 10-10-10 @ 600 lb/ac; 2 applications herbicide

Item	Units	1990 \$/Unit	1992 \$/Unit	Ave. \$/Unit	Units /acre	Total \$/acre
Seed	Lb			\$1.78	3	\$5.34
10-10-10	Lb			\$0.08	600	\$48.68
Lime	Ton	\$20.00	\$21.05	\$20.53	0.25	\$5.13
Fert. appl.	Acre	\$5.50	\$5.04	\$5.27	1	\$5.27
Paraquat	Qt	\$8.38	\$8.31	\$8.34	2	\$16.69
Herb. appl.	Acre	\$5.50	\$5.29	\$5.40	2	\$10.79
Grazing lbr.	Hr	\$0.55	\$0.61	\$0.58	1	\$0.58
Seeder rent	Acre	\$12.08	\$12.08	\$12.08	1	\$12.08
Total Cost per Acre						\$104.56
Stocking rate, dry ewes/ac				15		
Cost per dry ewe						\$7.16

Table A.14.g Forage crop costs: Turnip

*Year1 fert: 10-10-10 @ 600 lb/ac; Year2: 34-0-0 @ 176 lb/ac

*(Fertilize to apply 60 lb N/ac/yr)

Item	Units	1990 \$/Unit	1992 \$/Unit	Ave. \$/Unit	Units /acre	Total \$/acre
Seed	Lb			\$1.78	3	\$5.34
10-10-10 fert	Lb			\$0.08	0	\$0.00
Ammon nitr.	Lb			\$0.10	176	\$16.85
Lime	Ton	\$20.00	\$21.05	\$20.53	0.25	\$5.13
Fert. appl.	Acre	\$5.50	\$5.04	\$5.27	1	\$5.27
Paraquat	Qt	\$8.38	\$8.31	\$8.34	2	\$16.69
Herb. appl.	Acre	\$5.50	\$5.29	\$5.40	2	\$10.79
Grazing lbr.	Hr	\$5.00	\$5.31	\$5.16	1	\$5.16
Seeder rent	Acre	\$12.08	\$12.08	\$12.08	1	\$12.08
Total Cost per Acre						\$77.31
Stocking rate, lact. ewes/ac				14		
Stocking rate, dry ewes/ac				19		
Cost per lactating ewe						\$5.52
Cost per dry ewe						\$4.16

Table A.15.a Forage use calendars for Non-weaned, Spring-lambing ewes

Ewes not weaned, Yr1/2 (Sept wean)

<u>Group</u>	<u>Period</u>	<u>Forage type</u>	<u>Cost / ewe</u>	<u>Cost / lamb</u>	<u>Western lamb drop</u>	<u>Cost/ West.ewe</u>	<u>%-Finn lamb drop</u>	<u>Cost/ Finn ewe</u>
Lact.ewe	Mar15-Apr15	Rye	\$3.06			\$2.84		\$2.87
Lact.ewe	Apr15-Jun1	BG/WC	\$0.40			\$0.37		\$0.37
Open ewe	Apr15-Jun1	BG/WC	\$0.15			\$0.01		\$0.01
Lact.ewe	Jun, Jul, Aug	BG/WC	\$1.24			\$1.15		\$1.16
Open ewe	Jun, Jul, Aug	BG/WC	\$0.79			\$0.06		\$0.05
Breed ewe	Sept1-Nov1	BG/WC	\$0.57			\$0.57		\$0.57
Gest.ewe	Nov1-Mar15	Fesc	\$6.02			\$6.02		\$6.02
						<u>\$11.02</u>		<u>\$11.05</u>

Ewes not weaned, Yr3 (paddocks and Aug wean)

<u>Group</u>	<u>Period</u>	<u>Forage type</u>	<u>Cost / ewe</u>	<u>Cost / lamb</u>	<u>Western lamb drop</u>	<u>Cost/ West.ewe</u>	<u>%-Finn lamb drop</u>	<u>Cost/ Finn ewe</u>
Lact.ewe	Mar15-Apr15	Rye	\$3.06			\$2.84		\$2.87
Lact.ewe	Apr15-Jun1	BG/WC	\$0.28			\$0.26		\$0.26
Open ewe	Apr15-Jun1	BG/WC	\$0.15			\$0.01		\$0.01
Lact.ewe	Jun, Jul	BG/WC	\$0.82			\$0.77		\$0.77
Open ewe	Jun, Jul	BG/WC	\$0.52			\$0.04		\$0.03
Dry ewe	Aug	BG/WC	\$0.29			\$0.29		\$0.29
Weaned lamb	Aug	BG/WC		\$0.44	1.45	\$0.64	1.75	\$0.77
Breed ewe	Sept1-Nov1	BG/WC	\$0.57			\$0.57		\$0.57
Gest.ewe	Nov1-Mar15	Fesc	\$6.02			\$6.02		\$6.02
						<u>\$11.43</u>		<u>\$11.60</u>

Table A.15.b Forage use calendars for Weaned, Spring-lambing ewes

Ewes weaned, Yr1 (no millet)

<u>Group</u>	<u>Period</u>	<u>Forage type</u>	<u>Cost / ewe</u>	<u>Cost / lamb</u>	<u>Western lamb drop</u>	<u>Cost/ West.ewe</u>	<u>%-Finn lamb drop</u>	<u>Cost/ Finn ewe</u>
Lact.ewe	Mar15-Apr15	Rye	\$3.06			\$2.84		\$2.87
Lact.ewe	Apr15-Jun1	BG/WC	\$0.40			\$0.37		\$0.37
Open ewe	Apr15-Jun1	BG/WC	\$0.15			\$0.01		\$0.01
Weaned ewe	Jun, Jul, Aug	BG/WC	\$0.79			\$0.79		\$0.79
Weaned lamb	June	BG/WC		\$0.12	1.45	\$0.18	1.75	\$0.22
Weaned lamb	July, Aug	BG/WC		\$0.25	1.45	\$0.36	1.75	\$0.43
Breed ewe	Sept1-Nov1	BG/WC	\$0.57			\$0.57		\$0.57
Gest.ewe	Nov1-Mar15	Fesc	\$6.02			\$6.02		\$6.02
						\$11.14		\$11.29

Ewes weaned, Yr2 (millet)

<u>Group</u>	<u>Period</u>	<u>Forage type</u>	<u>Cost / ewe</u>	<u>Cost / lamb</u>	<u>Western lamb drop</u>	<u>Cost/ West.ewe</u>	<u>%-Finn lamb drop</u>	<u>Cost/ Finn ewe</u>
Lact.ewe	Mar15-Apr15	Rye	\$3.06			\$2.84		\$2.87
Lact.ewe	Apr15-Jun1	BG/WC	\$0.40			\$0.37		\$0.37
Open ewe	Apr15-Jun1	BG/WC	\$0.15			\$0.01		\$0.01
Weaned ewe	June & Aug	BG/WC	\$0.53			\$0.53		\$0.53
Weaned ewe	July	Millet	\$2.76			\$2.76		\$2.76
Weaned lamb	June	BG/WC		\$0.12	1.45	\$0.18	1.75	\$0.22
Weaned lamb	July, Aug	BG/WC		\$0.25	1.45	\$0.36	1.75	\$0.43
Breed ewe	Sept1-Nov1	BG/WC	\$0.57			\$0.57		\$0.57
Gest.ewe	Nov1-Mar15	Fesc	\$6.02			\$6.02		\$6.02
						\$13.64		\$13.78

Ewes weaned, Yr3 (paddocks and millet)

<u>Group</u>	<u>Period</u>	<u>Forage type</u>	<u>Cost / ewe</u>	<u>Cost / lamb</u>	<u>Western lamb drop</u>	<u>Cost/ West.ewe</u>	<u>%-Finn lamb drop</u>	<u>Cost/ Finn ewe</u>
Lact.ewe	Mar15-Apr15	Rye	\$3.06			\$2.84		\$2.87
Lact.ewe	Apr15-Jun1	BG/WC	\$0.28			\$0.26		\$0.26
Open ewe	Apr15-Jun1	BG/WC	\$0.15			\$0.01		\$0.01
Weaned ewe	June & Aug	BG/WC	\$0.53			\$0.53		\$0.53
Weaned ewe	July	Millet	\$2.76			\$2.76		\$2.76
Weaned lamb	June	BG/WC		\$0.09	1.45	\$0.13	1.75	\$0.16
Weaned lamb	July, Aug	BG/WC		\$0.44	1.45	\$0.64	1.75	\$0.77
Breed ewe	Sept1-Nov1	BG/WC	\$0.57			\$0.57		\$0.57
Gest.ewe	Nov1-Mar15	Fesc	\$6.02			\$6.02		\$6.02
						\$13.76		\$13.95

Table A.15.c Forage use calendars for Fall-lambing ewes

Yr 1/2 (turnip)

<u>Group</u>	<u>Period</u>	<u>Forage type</u>	<u>Cost / ewe</u>	<u>Cost / lamb</u>	Western lamb <u>drop</u>	<u>Cost/ West.ewe</u>	%-Finn lamb <u>drop</u>	<u>Cost/ Finn ewe</u>
Lact.ewe	Sept1–Oct15	Alf	\$3.06			\$1.80		\$2.11
Lact.ewe	Oct15–Dec1	Turn	\$5.52			\$3.26		\$3.81
Open ewe	Sept1–Nov1	BG/WC	\$0.57			\$0.23		\$0.18
Dry ewe	Dec1–Apr15	Fesc	\$6.02			\$6.02		\$6.02
Gest.ewe	Apr15–Jun15	BG/WC	\$0.50			\$0.50		\$0.50
Gest.ewe	Jun15–Sept1	BG/WC	\$0.66			\$0.66		\$0.66
						<u>\$12.48</u>		<u>\$13.28</u>

Yr 3 (no turnip)

<u>Group</u>	<u>Period</u>	<u>Forage type</u>	<u>Cost / ewe</u>	<u>Cost / lamb</u>	Western lamb <u>drop</u>	<u>Cost/ West.ewe</u>	%-Finn lamb <u>drop</u>	<u>Cost/ Finn ewe</u>
Lact.ewe	Sept1–Nov20	Alf	\$6.11			\$3.61		\$4.22
Open ewe	Sept1–Nov1	BG/WC	\$0.57			\$0.23		\$0.18
Dry ewe	Nov20–Apr15	Fesc	\$6.02			\$6.02		\$6.02
Gest.ewe	Apr15–May15	BG/WC	\$0.22			\$0.22		\$0.22
Gest.ewe	May15–Sept1	BG/WC	\$0.93			\$0.93		\$0.93
						<u>\$11.01</u>		<u>\$11.56</u>

VITA

Bee (Kirsten) Tolman, daughter of a forester and a science teacher, was raised in Nelson, New Hampshire. In 1982, after receiving a Liberal Arts degree from Williams College in Williamstown, Massachusetts, she began a career in sheep production as a shepherd in Peebleshire, Scotland. There she learned the merits of working at a job that is challenging, demanding, sometimes thankless, but nevertheless, inevitably rewarding. She continued to work as a shepherd in New England until she began graduate school in the Animal Science department at Virginia Tech in 1990. Upon completion of her Master's thesis, she will be emigrating to New Zealand with her fiancé, to further her experience in the business of sheep production.

Bee Tolman