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Seasonal Acceptance of Fourwing Saltbush by Sheep When Crested Wheatgrass is the Alternative

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Summary

Many sagebrush-grass ranges have been seeded to crested wheatgrass [*Agropyron desertorum* (Fischer ex Link) Shultes]. These ranges are generally nutritionally inadequate for sheep (*Ovis aries* L.), except for short grazing periods in the spring and fall. To increase production and diversity, particularly crude protein for late-season grazing, fourwing saltbush [*Atriplex canescens* (Pursch.) Nutt.] was planted in an existing stand of crested wheatgrass. Quantification of sheep forage preferences on these improved ranges aids in determining the length of the grazing season and the extent to which shrubs provide the supplemental nutrition required. This seasonal grazing study was conducted on a characteristic wheatgrass-saltbush, mixed-range pasture to determine sheep acceptance of fourwing saltbush when crested wheatgrass was the alternative available forage. Sheep preferences for grass and shrub in spring and winter were similar, averaging 84 percent grass and 16 percent shrub. Summer dietary preferences ranged from 69 percent to 93 percent grass and 7 percent to 31 percent shrub. Preference for fourwing saltbush was consistently lower than crested wheatgrass in all seasons. Sufficient amounts of the mixed pasture were grazed to reduce the need for supplemental feed, when compared to crested wheatgrass monoculture. The results of these grazing trials suggest fourwing saltbush can be useful in improving pasture nutrition for sheep in different grazing seasons.

Introduction

Sheep ranchers in the United States comprise the smallest, yet most dependent fraction of public land grazing permittees (Gentner and Tanaka, 2002). For sheep producers in the Intermountain Region, federal forage is critical for summer and early winter grazing (Gentner and Tanaka, 2002). Lower elevation sagebrush-grass ranges are commonly used for sheep grazing, especially in the early spring and throughout the winter. Limited carrying capacity of these ranges (Blaisdell and Holmgren, 1984) suggests sheep may need supplemental feed earlier in the grazing season due to decreased nutritional quality of the grasses.

Shrub-grass ranges may be a possible solution for improving summer and winter grazing. Unfortunately, some of these lands have been historically overgrazed resulting in the domination of perennial grasses by thick stands of shrub species (Provenza and Richards, 1984). Efforts to improve ranges have led to the seeding of 5 million ha of range with crested wheatgrass, often in monoculture (Rumbaugh et al., 1982; Pendery and Provenza, 1987). In recent years, planting a more diverse array of forage species has been a frequent approach to improve forage quality and extend the grazing period. One common practice worldwide has been to interseed crested wheatgrass ranges with palatable shrub species (Pendery and Provenza, 1987).

Appropriate supplementation levels for sheep foraging grass-shrub mixtures are difficult to determine due to variable preference for shrubs during different seasons. Several successes with exclusive feeding of fourwing saltbush have been reported. Fourwing saltbush has been introduced as winter-maintenance forage for small ruminants in Pakistan (Rasool et al., 1996). Fourwing saltbush is readily consumed by sheep, goats, and cattle (Rumbaugh et al., 1982; Atiq-ur-Rehman et al., 1990) when other feed is limited. In Iran, palatability of fresh cuttings of fourwing saltbush to sheep was found to be intermediate between prostate kochia [*Kochia prostrata* (L.) Shad.] and wild armoise (*Artemesia herba alba* Asso; Nemati, 1977). However, to completely fulfill dietary requirements, Otsyina et al. (1982) calculated fourwing saltbush would have to comprise a minimum of 56 percent of a sheep's daily intake. The preference of sheep for fourwing saltbush, when crested wheatgrass is the available alternative, is unknown.

Range sheep demonstrate preference by selecting among available forages to regulate nutrition (Launchbaugh and Provenza, 1991). If selection is quantified and the nutritional quality of vegetation available is known, ranchers may establish appropriate levels of supplemental feed or grazing management to compensate for nutritional deficiencies. Determining the seasonal contribution of fourwing saltbush to the range sheep diet will aid in estimating the length of the grazing season and formulating appropriate supplements for sheep grazing ranges composed of crested wheatgrass and fourwing saltbush.

This series of grazing trials was initiated to test the hypothesis that sheep preference for fourwing saltbush does not vary among seasons when crested wheatgrass is the alternative forage.

Materials and Methods

Study Site

The study was conducted at the Brigham Young University-Sam and Aline Skaggs Research Ranch, 14.4 km north of Malta, Cassia County, Idaho, in the Raft River Valley. The experimental site consisted of a 4-ha pasture in the NE 1/4 of the NW 1/4, Section 22, Township 11 South, Range 26 East (Salt Lake Baseline and Meridian). This 4-ha fourwing saltbush parcel was further divided into 10 pastures, each 0.4 ha in size. Preferences of sheep for individual plant species (crested wheatgrass and fourwing saltbush) and forage production were evaluated as influenced by season. Pastures were grazed in May, July, and December in 2000 and 2001.

At 1,340 m in elevation, the site receives an average of 22.8 cm of precipitation annually, with 45 percent as rain during the period April through June. The average daily temperature is 2 degrees C in January and 18.5 degrees C in July. Soils at the site are characterized in the Bahem silt loam series—fine-loamy, mixed, mesic, Xerollic calciorthids with a pH of 8.0 and a semi-hard pan layer at approximately 38 cm (Stevens, 1992). Crested wheatgrass seeding followed historic overgrazing of the site.

In 1985, existing shrubs were removed with 2,4-D (2,4-dichlorophenoxyacetic acid). In addition, 25 rows, 1.5-m wide, were mechanically treated to remove crested wheatgrass. Fourwing saltbush seedlings were transplanted at 1.5-m spacing within the cleared strips. This resulted in 3-m wide strips of undisturbed grass and 1.5-m wide rows of transplanted shrubs. After a two-year establishment period, cattle were allowed to graze the area up to 50 percent utilization in a series of palatability trials. At the commencement of our study, saltbush was mature and had not been grazed during the previous 10 years.

Pastures were randomly assigned by intended season of use. Each grazing season consisted of three replicates. Because the same pasture randomization scheme was used in both years, changes in forage production from one year to the next that may have resulted from the season of initial defoliation could be accounted for.

Vegetation Sampling

Vegetation samples were taken in each pasture to determine current year forage production prior to sheep grazing. Ten transects, spanning the entire length of each pasture, were placed at equal intervals. At each interval, one transect was placed in the untreated grass strip and one in the transplanted shrub row for a total of five transects in each forage class. A sampling frame (1 m^2) was used to sample vegetation along each transect.

In grass strips, the current annual growth in the sampling frame was clipped to stubble height of 2.5 cm at a previously determined random point along each transect. Old growth, because it was easily recognized, was removed from the samples. Grasses between transplanted shrubs along the shrub row transects were sampled similarly.

Shrub sampling consisted of clipping one-fourth of the current annual growth from the shrub located closest to a random point along each transect. Height and crown measurements were taken prior to clipping each shrub. All samples were weighed in the field immediately after clipping and set out to air dry while awaiting transport to the laboratory. Fifteen to 30 green weights were recorded for each vegetation class each grazing season. Dry weights were recorded in the laboratory following a minimum of 24 hr in a 65 degrees C oven and annual forage production was expressed in kg ha^{-1}.

To estimate the relative value of these species in the diet of sheep, we utilized the extensive nutritional data derived from samples taken at this site at two-week intervals from May through December by Memmott (1995). These data were assumed to be representative for grazable vegetation.

Sheep Response Measurements

The U.S. Sheep Experiment Station near Dubois, Idaho (Clark County) provided 30 randomly selected, white-faced, dry, non-pregnant range ewes for each of the six grazing periods (180 ewes total). The sheep were Columbia-Targhee crosses accustomed to foraging on Idaho rangelands (Gade and Provenza, 1986). For each grazing period, sheep were randomly divided into three groups of 10 and distributed among the three replicated pastures previously designated for that grazing period (May, July, or December). Sheep were individually identified by different colors of tape secured around their necks as well as unique numbers painted on their backs.

At the beginning of each grazing period, at least three days were allotted for sheep to become familiar with pasture characteristics. Even though they had previous exposure to both forages, this adaptation period was intended to reduce social factors that reportedly override food preferences of sheep in a novel environment (Scott et al., 1996). During this adjustment period, field technicians spent at least six hours a day among the sheep to accustom them to the presence of humans during observation (Martin and Bateson, 1986).

Recorded observation commenced on the designated day at dawn. One unconcealed person observed sheep in each pasture for 30 minutes of continuous grazing, two times each day, in the morning at dawn and evening an hour prior to dusk. The actual time of day varied with the season.

Either focal-animal or scan sampling methods were used to estimate sheep preference for available forage. Focal-animal sampling, in the form of bite counts, estimates the percentage of bites taken in each available forage class, as well as the percentage of time spent grazing in each class (Altmann, 1974; Martin and Bateson, 1986; Lehner, 1987). Each of six randomly selected ewes was observed for a five-minute period of undisturbed, continuous grazing each morning and evening session. The total number of bites of each forage class was recorded using a hand-held tally device. Bites were classified as either grass or shrub. The event of taking a bite was defined as the visible and audible prehension of food. If sheep paused or went out of sight, the clock was stopped and started again when activity resumed or the observer changed positions. This method was used successfully in the 2000 spring and summer trials, in which the get-acquainted period worked well and we were able to get within 1 to 2 m of the dry ewes without disturbing their grazing. The winter 2000 grazing period was not so successful, however, since the sheep delivered were flighty and unapproachable by the investigators. Due to the inherent difficulties in using this method of observation with unruly animals (Martin and Bateson, 1986; Kronberg and Walker, 1999) we decided to switch to scan sampling in 2001 to prevent the loss of further data due to state of the sheep.

Instantaneous scan sampling estimates the percentage of time spent grazing each forage class (Tyler, 1979; Martin and Bateson, 1986; Lehner, 1996). This method also allows a record of behavioral synchrony among gregarious animals to be kept. An instantaneous scan of the entire group of 10 sheep in each pasture was made at one-minute intervals for a 20-minute period in the morning and evening of each day. The state of each animal at that instant, eating grass or shrub, was recorded.

Sheep Selection, Data Presentation, and Statistical Analyses

Random selection of three new groups of 10 sheep from the population for each grazing period was done to avoid introducing bias as the sheep aged over the two-year period. It is recognized that bias may have been introduced by the method we followed, but we concluded that randomly selected groups for each grazing period would represent the population and would not introduce as much bias as would aging. A second reason for following this protocol was the impracticality of trying to maintain the same 30 head of ewes throughout the two-year experimental period.

Preference indices were tabulated based on a ratio of diet composition in 2000 and time spent in each forage class to availability of each species on the range (% composition) in 2001. A value greater than 1.0 indicated a preference, whereas values less than 1.0 indicated avoidance by the animals (Ali and Sharrow, 1994).

Data were analyzed within years using SAS procedures for general linear models (Littell, et. al., 2002).

Results and Discussion

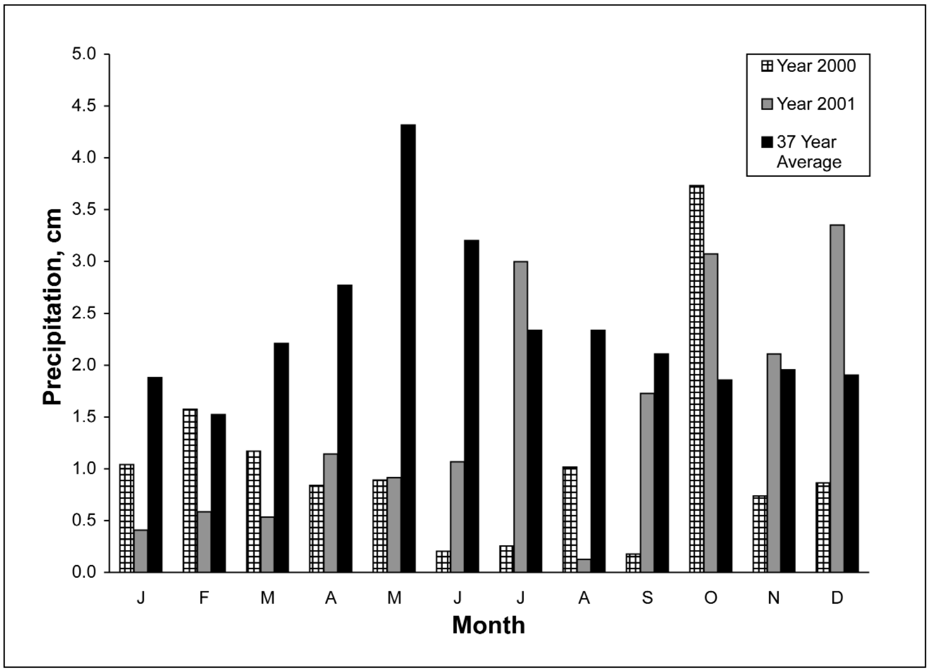
Except for winter 2000, data were successfully collected for each planned grazing period. The sheep provided for winter 2000 were extremely flighty and were unapproachable. Satisfactory alternative plans for animal preference measurements were not determined in time to collect data for this period.

Seasonal Forage Production and Sheep Preference

Sporadic growing conditions during the study make it difficult to describe trends in forage production. Generally, forage production was below normal. Low potential and actual yields at this site may be due to a combination of below-average precipitation during the growing season (Figure 1) and decadence, i.e., stand age and the 10-year rest period prior to study initiation.

Forage Production. Total biomass (dry-weight basis) ranged from 332 kg ha^{-1} to 688 kg ha^{-1} across the two years (Table 1). Biomass available for each sheep was sufficient, though not plentiful, in each grazing season (Table 1). Forage class distribution was somewhat variable within years across pastures with grasses making up 42 percent to 65 percent of the total biomass in 2000 and 53 percent to 87 percent in 2001. Crested wheatgrass yielded an average of 324 kg ha^{-1}. A 35-yr study conducted in the same valley reported an average crested wheatgrass yield of 560 kg ha^{-1} (Sharp et al., 1992) when grown in monoculture. A primary factor in successful production of seeded crested wheatgrass stands is precipitation levels from April to June (Rauzi, 1975; Leyshon and Campbell, 1992). Precipitation during these three

Fig. 1. Monthly precipitation at the Brigham Young University-Sam and Aline Skaggs Research Ranch near Malta, Idaho, during 2000 and 2001 compared to the 37-year average in the area.



months accounted for 72 percent of the variability in crested wheatgrass production over a 35-year period (Sharp et al., 1992). During our study, precipitation levels during this period, in both years, were less than 35 percent of the 37-year average for the area (Figure 1). Within years, grass growth was related to precipitation patterns—decreasing from spring to summer in 2000, and increasing from spring to summer in 2001, when above-average precipitation occurred in July.

Bleak and Plummer (1954) reported seeded crested wheatgrass pastures yielded 55 percent less biomass by the ninth year of age due to decadence. The current study was conducted in a 25-year-old stand. Crested wheatgrass when grown in association with fourwing saltbush, compared to grass grown in monoculture, has been reported to produce increased dry matter yields (Rumbaugh et al., 1982; Pendery and Provenza, 1987). In our study, grasses in shrub rows did not have higher average yields than grasses in grass strips, suggesting all grasses were within a beneficial proximity of the shrubs.

Shrubs yielded an average of 239 kg ha^{-1}. Potential production of fourwing saltbush as high as 1,480 kg ha^{-1} has been reported (Rumbaugh et al., 1982). In addition to lower than normal rainfall during the study period, the generally low shrub production may be due, in part, to the 10-year period without grazing. Price et al. (1989) reported saltbushes rested more than one year began to decline in growth and that dry matter yields of shrubs protected for 20 years were similar to those subjected to continuous grazing. Pieper and Donart (1978) reported fourwing saltbush shrubs protected for four years, or not browsed at all, did not produce basal leaders because terminal buds were left intact. In the current study, shrub height ranged from 12 to 162 cm with an average of 94 cm. Crowns ranged from 8 to 343 cm with an average of 144 cm. The average canopy volume calculated was 479,328 cm^3. The bulk of the new growth was concentrated near the top of the canopy, and sheep were only able to graze peripheral growth. New growth above a height of 110 cm was considered inaccessible to the sheep (Mbabaliye et al., 1999).

Greater variation in growth production occurred in saltbush than in grasses. Time of initial defoliation, as well as precipitation patterns, may account for much of the growth variation. In general, saltbush yields increased from spring to summer within years (Rumbaugh et al., 1982) and decreased in all treatments between years (Buwai and Trlica, 1977).

Spring Grazing Periods 2000 and 2001. The highest grass yields were recorded prior to the first spring grazing trail. The lowest forage amounts were recorded in the same spring-grazed pastures the following year (Table 1), a decline in grass production of 36 percent from 2000 to 2001. Miller et al. (1990) also observed defoliation during mid May through early June reduced crested wheatgrass production by 50 percent to 55 percent in the subsequent year.

Similar to grasses, the lowest average shrub yield of 43 kg ha^{-1} was recorded in the spring-grazed pastures prior to grazing the second year (Table 1). This 82 percent decrease in production from 2000 to 2001 indicates little regrowth occurred after spring defoliation in 2000. Similar to this, Trlica and Cook (1971) and Buwai and Trlica (1977) have reported little regrowth in saltbush heavily defoliated during this same growth period (about 10 May). Price et al. (1989) suggested browsing of fourwing plants before leader bases become woody results in the

Table 1. Total biomass production of crested wheatgrass and fourwing saltbush and biomass available per day for each of 10 sheep.

Grazing Period	Grass[a]	Shrub[a]	Total	Per Pasture	Per Sheep-day
	(................kg ha^{-1}	....	................)	(...........kg	.............)
Spring 2000	449^{a}	240^{a}	688^{a}	172	2.2
Spring 2001	289^{b}	43^{b}	332^{b}	83	1.4
Summer 2000	287^{b}	401^{a}	687^{a}	172	2.5
Summer 2001	297^{b}	252^{a}	548^{ab}	137	2.7
Winter 2001	298^{b}	261^{a}	559^{ab}	140	1.8

[a] Means within a column followed by the same letter do not differ, P = 0.05

(Student-Newman-Keuls Multiple-Range Test) entire leader being pulled off, leaving few axillary buds intact from which regrowth may occur. Trlica et al. (1977) reported that 14 months of rest was not sufficient for recovery of heavily defoliated saltbush. This suggests the 11 months of rest in our study between the 2000 and 2001 spring grazing period may have been inadequate for these shrubs to reach production levels in 2001 similar to those attained in 2000.

Summer Grazing Periods 2000 and 2001. Unlike pastures defoliated in spring, pastures grazed in summer showed no differences in 2000 and 2001 biomass production (Table 1). This result supports the finding of Leyshon and Campbell (1992) that highest-mean yields of crested wheatgrass occur when the first defoliation is between June and July.

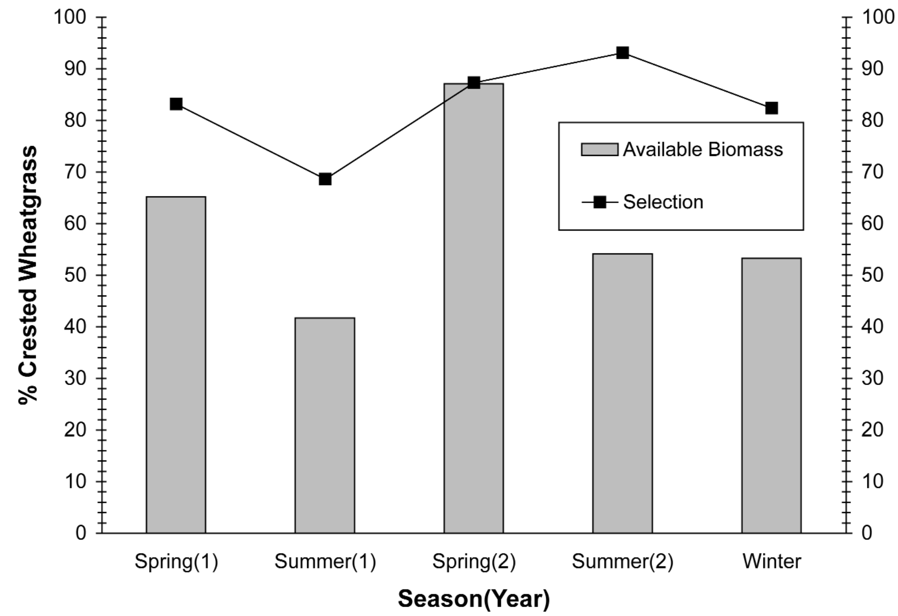
The highest shrub yield (401 kg ha-1) was recorded in the summer-grazed pastures prior to grazing initiation in 2000 (Table 1). Saltbush biomass in summer-grazed pastures decreased 37 percent ($P \leq 0.10$) from 2000 to 2001 (Table 1). Trlica et al. (1977) showed defoliation of fourwing saltbush near maturity stage to be most detrimental to subsequent growth, even after a 14- to 26-month rest period.

Winter Grazing Period 2001. Grass production in winter-grazed pastures was not significantly different from spring 2001 and summer-grazed pastures (Table 1). Biomass was not recorded for the failed winter trial of 2000; however, 10 sheep grazed these pastures for a similar number of days as the other trials. In 2001, shrub production by these winter-grazed pastures did not differ from production in pastures grazed in the other seasons (Table 1).

Sheep Preference. As in similar studies (Reppert, 1960; de Vries and Daleboudt, 1994; Bartolome et al., 1998), sheep preference for grass or shrub was related to their respective availability. In this study, preference for grass was consistently higher than the proportion of available biomass (Figure 2) and preference for shrub was lower than the proportion available (Figure 3), similar to observations by de Vries and Daleboudt (1994).

In 2000, sheep spent from 69 percent to 83 percent of their time grazing grass (Figure 2). Preference indices computed for each season within 2000 indicated a strong preference for grass over shrub (Table 2). In 2001, sheep spent from 82 percent to 93 percent of their time grazing grass (Figure 2). Unlike 2000, preference indices in 2001 did not consistently indicate a preference for grass in all grazing seasons (Table 2) since preferences for grass and shrubs were equal in spring 2001.

Fig. 2. Percentage of sheep selection devoted to crested wheatgrass compared to the percentage of available biomass composed of crested wheatgrass.



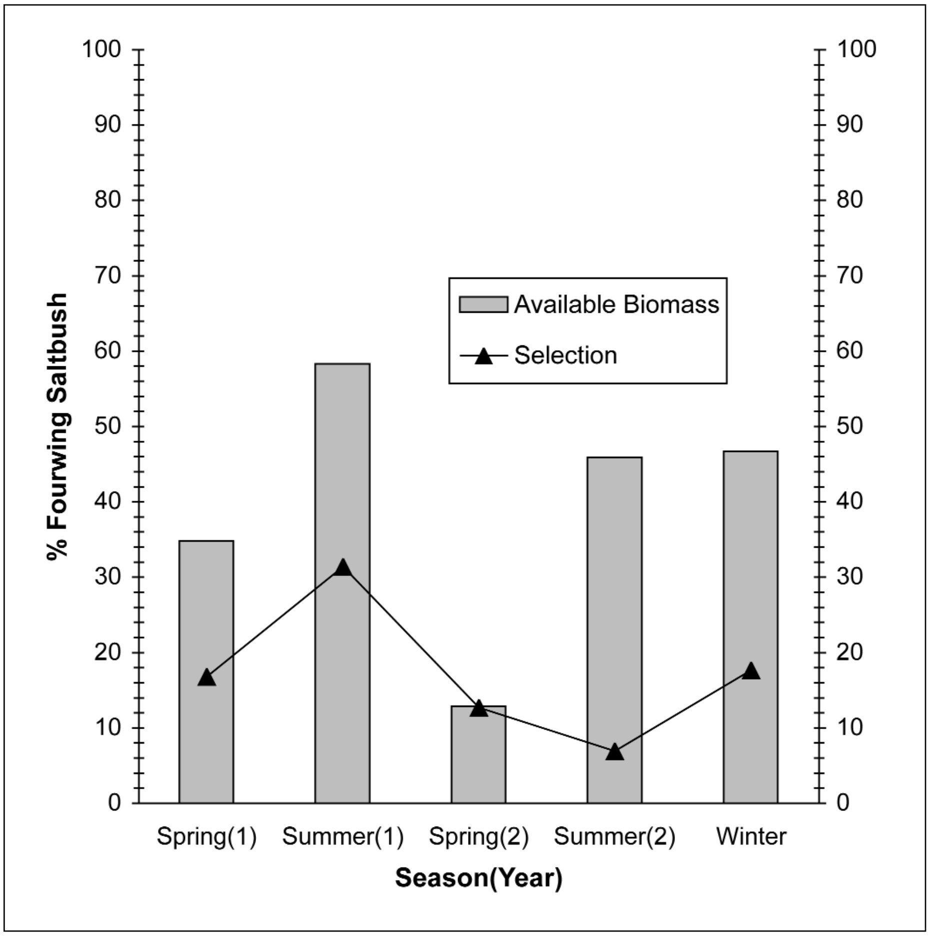
Summer grazing exhibited the most variable preference for shrubs in this grazing trial (Figure 3). Preference in summer 2000 and summer 2001 were different ($P \leq 0.01$). Within 2000, preference for shrub increased nearly 50 percent from spring to summer. When shrub production was at its highest in summer 2000, preference for shrub peaked at 31 percent. Eleven months later in summer 2001, the lowest shrub intake was recorded at 7 percent, a decrease of 60 percent from spring to summer and 24 percent from 2000 summer levels. Biomass availability decreased 21 percent during the same period. At that time (summer 2001), grass preference increased by 36 percent (Figure 2). Sheep "avoidance" of shrubs, as indicated by the computed preference indices for summer 2001, may be due to poor shrub condition or inability of the sheep to reach the higher crown growth. Despite the apparent improved growing conditions, sheep spent 9 percent less time grazing grasses and 8 percent more time browsing shrubs in winter 2001 than in summer 2001 (Table 2).

Table 2. Relative preferences indices of sheep for crested wheatgrass and fourwing saltbush.

Grazing Period	Crested Wheatgrass	Fourwing Saltbush
	(..............Preference Indices[a]	..............)
Spring 2000	1.24	0.53
Spring 2001	1.00	1.00
Summer 2000	1.89	0.36
Summer 2001	1.72	0.15
Winter 2001	1.55	0.38

[a] Indices greater than 1 indicate a preference for a forage; equal to 1, no preference or random selection; and less than 1, avoidance (Ali and Sharrow, 1994)

Fig. 3. Percentage of sheep selection devoted to fourwing saltbush compared to the percentage of available biomass composed of fourwing saltbush.



During winter 2001, sheep dug through the snow to reach the green portions at the base of bunchgrasses. Harrison and Thatcher (1970) reported sheep dug through snow for needleand-thread grass (*Stipa comata* Trin. and Rupr.), but basically avoided more readily available sagebrush. Even though sheep increased their preference of fourwing saltbush, compared to other times of the year, preference was still approximately 82 percent for grass and 18 percent for shrub (Table 3). The lower preference for shrub during this period supports the suggestion that the digestibility of fourwing saltbush during dormancy may be lower than grasses (Shoop et al., 1985).

The initial hypothesis of this study that preference for fourwing saltbush did not differ when crested wheatgrass is the alternative forage was rejected. Differences among the grazing seasons existed ($P \leq 0.05$) within each year (Tables 2 and 3). Selection of fourwing saltbush more than doubled from spring to summer 2000 and selection among the three grazing seasons in 2001 also differed ($P \leq 0.05$).

Seasonal Forage Nutrient Content

Using previously published data (Memmott, 1995) the comparative nutritive values of crested wheatgrass and fourwing saltbush were evaluated by estimating their apparent ability to supply nutritional requirements of sheep. These requirements are categorized according to the main physiological functions of maintenance, flushing and breeding, early to mid gestation, late gestation, early lactation, and late lactation (Cook, 1971). Metabolizable energy, crude protein, calcium (Ca), and phosphorus (P) are most often limiting factors on rangelands (NRC, 1985). Similar to other forage and browse plants, crested wheatgrass and saltbush are high in nutrients during the first part of the growing season, but these progressively decline with maturity as lignification occurs (Figures 4 and 5).

Crested wheatgrass, by itself, did not satisfy energy and protein requirements of ewes at any time during the season (Figure 4). However, crested wheatgrass contained enough Ca and P in all phenological stages of development to meet ewe requirements in each stage of the sheep production cycle (Figure 5; Murray, 1984).

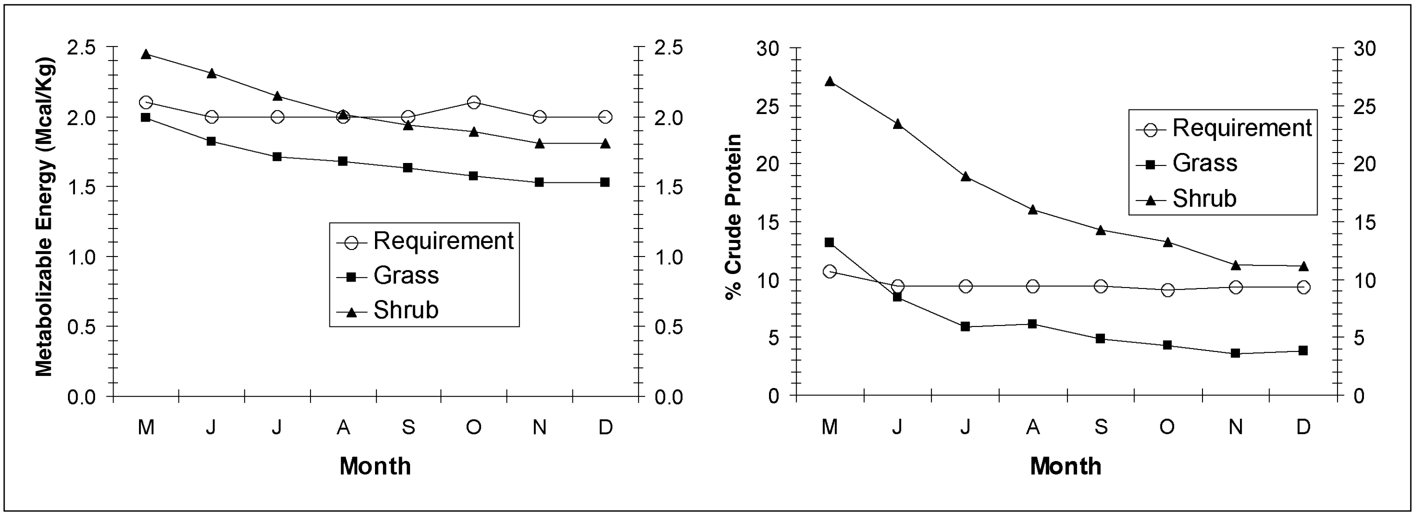
Fourwing saltbush contained higher nutrient levels than crested wheatgrass at all sampling dates. At each phenological stage of development, saltbush met all nutrient requirements for sheep except for metabolizable energy, which became deficient in late summer (Figure 4). These results support those in other studies (Chatterton et al., 1971; Schweitzer et al., 1993). Nutrient values for December may be extrapolated for January and

Table 3. Average number of bites taken per minute or the average number of sheep grazing each forage class each minute.

Grazing Period	Number of Bites			Grazing Period	Sheep Foraging on		
	Grass	Shrub	Total		Grass	Shrub	Total
	(.........bites min^{-1}.........)				(.........Sheep min^{-1}.........)		
Spring 2000	104[a]	20[b]	124[b]	Spring 2001	8.7[b]	1.3[b]	10
Summer 2000	107[a]	45[a]	152[a]	Summer 2001	9.3[a]	0.7[c]	10
Winter 2000	—	—	—	Winter 2001	8.2[c]	1.8[a]	10

[ab] Means within a column followed by the same letter do not differ, P=.05 (Student-Newman-Keuls, Multiple-Range Test).

Fig. 4. Metabolizable energy (left) and protein content (right) of crested wheatgrass and fourwing saltbush. Metabolizable energy and protein content data collected by Memmott (1995) and shown here compared to requirements of 70-kg ewes (NRC, 1995).



February as little change occurs in the nutritive value during plant senescence (Oelberg, 1956).

The estimated ability of crested wheatgrass and fourwing saltbush to supply nutrient requirements of sheep during different times of the year is summarized in Table 4. Under the conditions experienced in this study, deficiencies in protein were most pronounced in the winter when 4.21 percentage points, 45.3 percent of protein required, must come from supplement. Requirements for metabolizable energy would not have been met for any of the physiological stages of the sheep in any of the grazing periods.

Need for Supplementation

Ueckert et al., (1990) reported ewes grazing fourwing saltbush-crested wheatgrass pastures without supplementation have low performance. However, this same study determined performance of ewes grazing fourwing saltbush-grass combination pastures was superior to performance of ewes grazing grass monocultures without supplementation.

In the current study, sheep did consume shrub, and at the prevailing nutrient levels (Memmott, 1995) and dietary proportions, the need for supplementation could be reduced, although not eliminated. Considering an average ewe live weight of 70 kg and rearing a single lamb as given in NRC data (1985), simple Pearson-square calculation of nutrients required would reduce the need for supplementation when shrubs are incorporated into the diet (Table 4). A need for crude protein supplement would have occurred in summer and winter 2001 grazing periods only; but the need for additional protein could be reduced by 14 percent and 25 percent, respectively.

Table 4. The estimated contribution of grass and shrub to fulfilling sheep nutrient requirements for a 70 kg ewe with a single lamb at different stages of production. Calculations are based on the requirement (NRC, 1985), nutrient content of forage (Memmott, 1995) and selection of either grass or shrub measured each grazing period.

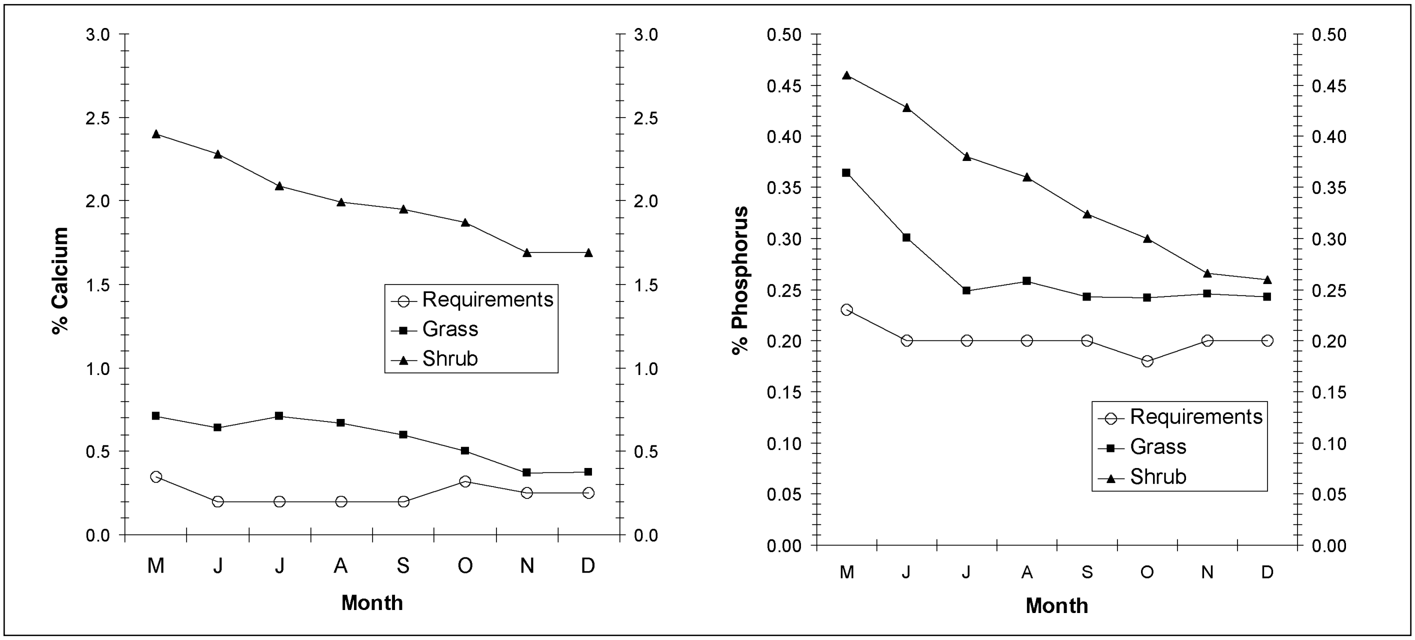
Production Stage Requirement		Grass	Shrub	Deficient
		% of Required Crude Protein Derived from[a]		
Early Lactation	13.4			
Spring 2000		11.65	4.57	0.00
Spring 2001		11.48	3.45	0.00
Maintenance	9.42			
Summer 2000		4.06	5.94	0.00
Summer 2001		5.51	1.31	2.60
Early Gestation	9.30			
Winter 2001		3.12	1.97	4.21
		Metabolizable Energy (Mcal kg^{-1}) Derived from[a]		
Early Lactation	2.40			
Spring 2000		1.66	0.41	0.33
Spring 2001		1.74	0.31	0.35
Maintenance	2.00			
Summer 2000		1.17	0.68	0.15
Summer 2001		1.59	0.15	0.26
Early Gestation	2.00			
Winter 2001		1.26	0.32	0.42

[a] The contribution of each forage class to fulfilling sheep dietary requirements and any needed supplement was calculated thusly:

Shrub contribution in meeting protein needs = ((% shrub in diet)/100) ((% protein in shrub)/100) (100). Grass contribution was calculated in a similar manner.

Grass contribution to metabolizable energy = ((% grass in diet)/100) (metabolizable energy in grass), etc.

Fig. 5. Calcium (left) and phosphorus (right) content of crested wheatgrass and fourwing saltbush. Nutrient content data were collected by Memmott (1995) and are shown here compared to the calcium requirements of 70-kg ewes (NRC, 1985).



An energy supplement was needed in every trial, but the requirement would have been reduced by 8 percent to 34 percent, depending on the grazing season. Calcium and phosphorus supplements would not have been required. Levels of supplementation required to meet the nutritional needs of sheep grazing a crested wheatgrass-fourwing saltbush range may have been overestimated since sheep have the ability to selectively choose the more nutrient-rich portions of plants (Hanley, 1982; O'Reagain, 1993; Ramirez-Perez, 2000), which may not have been as meticulously sampled by humans for nutrient analysis (Wilson, 1956).

Conclusions

Productivity and length of grazing season on crested wheatgrass range may be improved by establishing high-quality shrubs in perennial grass monocultures. Quantifying sheep acceptance and intake levels of these shrubs when grass is available is necessary for calculation of grazing season length and the formulation of appropriate supplements.

Despite the relatively high nutrient content of fourwing saltbush and the nearly uniform distribution of grass and shrubs in this study, sheep consistently preferred crested wheatgrass to fourwing saltbush. However, addition of fourwing saltbush to crested wheatgrass monocultures can improve the diet quality of range sheep, extend the grazing season, and reduce, but not eliminate, the need for supplementation in the spring, summer, and winter grazing seasons evaluated.

Preference or selection of fourwing saltbush differed among grazing seasons each year.

Literature Cited

Ali, E., and S.H. Sharrow. 1994. Sheep grazing efficiency and selectivity on Oregon hill pasture. J. Range Manage. 47:494-497.

Altmann, J. 1974. Observational study of behavior: sampling methods. Behavior 49:227-265.

Atiq-ur-Rehman, S. Raflique, A. Ali, and M. Munir. 1990. Nutritive evaluation of fourwing saltbush in growth and digestibility trials with harnai lams in upland Balochistan. Asian-Austral. J. Anim. Sci. 3:299-303.

Bartolome, J., J. Franch, J. Plaixats, and N.G. Seligman. 1998. Diet selection by sheep and goats in Mediterranean heathwoodland range. J. Range Manage. 51:383-391.

Blaisdell, J.P., and R.C. Holmgren. 1984. Managing Intermountain rangelands—salt-desert shrub ranges. General Technical Report INT-163, USDA/FS, Intermountain Forest and Range Experiment Station. p. 52. Ogden, UT. U.S.A.

Bleak, A.T., and A.P. Plummer. 1954. Grazing crested wheatgrass by sheep. J. Range Manage. 7:63-68.

Buwai, M., and M.J. Trlica. 1977. Multiple defoliation effects on herbage yield, vigor, and total nonstructural carbohydrates of five range species. J. Range Manage. 30:164-171.

Chatterton, N.J., J.R. Goodin, C.M. McKell, R.V. Parker, and J.M. Rible. 1971. Monthly variation in the chemical composition of desert saltbush. J. Range Mange. 24:37-40.

Cook, C.W. 1971. Comparative nutritive values of forbs, grasses and shrubs. p. 303-310. In: Proceedings – Wildland shrubs: Their Biology and Utilization. An International Symposium, July 1971, Utah State University, Logan, Utah. Forest Service Technical Report INT-1, 1972. USDA/FS, Intermountain Forest and Range Experiment Station. Ogden, Utah 84401.

de Vries, M.F.W., and C. Daleboudt. 1994. Foraging strategy of cattle in patchy grassland. Oecologia 100:98-106.

Gade, A.E., and F.D. Provenza. 1986. Nutrition of sheep grazing crested wheatgrass versus crested wheatgrass-shrub pastures during winter. J. Range Mange. 39:527-530.

Gentner, B.J., and J.A. Tanaka. 2002. Classifying federal public land grazing permittees. J. Range Mange. 55:2-11.

Hanley, T.A. 1982. The nutritional basis for food selection by ungulates. J. Range Mange. 35:146-151.

Harrison, J.J., and A.P. Thatcher. 1970. Winter sheep grazing and forage preferences in southwestern Wyoming. J. Range Manage. 23:109-137.

Kronberg, S.L., and J.W. Walker. 1999. Sheep preference for leafy spurge from Idaho and North Dakota. J. Range Manage. 52:39-44.

Launchbaugh, K.L., and F.D. Provenza. 1991. Learning and memory in grazing livestock application to diet selection. Rangelands 13:242-244.

Lehner, P.N. 1987. Design and execution of animal behavior research: an overview. J. Anim. Sci. 65:1213-1219.

Lehner, P.N. 1996. Handbook of ethological methods. 2nd ed. Cambridge Univ. Press, Great Britain.

Leyshon, A.J., and C.A. Campbell. 1992. Effect of timing and intensity of first defoliation on subsequent production of 4 pasture species. J. Range Manage. 45:379-384.

Littell, Ramon C., Walter W. Stroup, Rudolf J. Freund. 2002. SAS® for linear models, 4th ed. SAS Institute Inc. Cary, NC.

Martin, P., and P. Bateson. 1986. Measuring behaviour: an introductory guide. Cambridge Univ. Press, Great Britain.

Mbabaliye, T., J.L. Kinger, and J.C. Mosely. 1999. Early summer vs. late summer diets of sheep grazing in a conifer plantation. Sheep Goat Res. J. 15:34-40.

Memmott, K.L. 1995. Seasonal dynamics of forage shrub nutrients and seasonal grazing impact on cryptogamic crusts. M.S. Thesis. Brigham Young Univ., Provo, Utah.

Miller, R.F., M.R. Haferkamp, and R.F. Angell. 1990. Clipping date effects on soil water and regrowth in crested wheatgrass. J. Range Manage. 43:253-257.

Murray, R.B. 1984. Yields, nutrient quality, and palatability to sheep of fourteen grass accessions for potential use on sagebrush-grass range in southeastern Idaho. J. Range Manage. 37:343.

Nemati, N. 1977. Comparative palatability of *Atriplex canescens*. J. Range Manage. 30:368-369.

NRC (National Res. Coun.). 1985. Nutrient requirements of sheep, 6th rev. ed. National Academy Press, Washington, D.C.

Oelberg, K. 1956. Factors affecting the nutritive value of range forage. J. Range Manage. 9:220-225.

O'Reagain, P.J. 1993. Plant structure and acceptability of different grasses to sheep. J. Range Manage. 46:232-236.

Otsyina, R., C.M. McKell, and G. Van Epps. 1982. Use of range shrubs to meet nutrient requirements of sheep grazing on crested wheatgrass during fall and early winter. J. Range Manage. 35:751-753.

Pendery, B.M., and F.D. Provenza. 1987. Interplanting crested wheatgrass with shrubs and alfalfa: effects of competition and preferential clipping. J. Range Manage. 40:514-519.

Pieper, R.D., and G.B. Donart. 1978. Response of fourwing saltbush to periods of protection. J. Range Mange. 31:314-315.

Price, D.L., G.B. Donart and G.M. Southward. 1989. Growth dynamics of fourwing saltbush as affected by different grazing management systems. J. Range Manage. 42:158-162.

Provenza, F.D., and J.H. Richards. 1984. Interseeding crested wheatgrass ranges. Utah Sci. Fall 1984:73-77. Utah State Agric. Exp. Stn, Logan, Utah.

Ramirez-Perez, A.H., S.E. Buntinx, C. Taipa-Rodriquez, and R. Rosiles. 2000. Effect of breed and age on the voluntary intake and the micromineral status of non-pregnant sheep: estimation of voluntary intake. Appl. Anim. Beh. Sci. 37:223-229.

Rasool, E., S. Raflique, I.U. Haq, A.G. Khan, and E.F. Thompson. 1996. Impact of fourwing saltbush on feed and water intake and on blood serum profile in sheep. Austral. J. Agric. Sci. 9:123-126.

Rauzi, F. 1975. Seasonal yield and chemical composition of crested wheatgrass in southeastern Wyoming. J. Range Manage. 28:219-221.
Reppert, J.N. 1960. Forage preference and grazing habits of cattle at the eastern Colorado Range Station. J. Range Manage. 13:58-65.
Rumbaugh, M.D., D.A. Johnson, and G.A. Van Epps. 1982. Forage yield and quality in a great basin shrub, grass and legume pasture experiment. J. Range Manage. 35:604-609.
Scott, C.B., R.E. Banner, and F.D. Provenza. 1996. Observations of sheep foraging in familiar and unfamiliar environments: familiarity with environment influences diet selection. Appl. Anim. Beh. Sci. 49:165-171.
Schweitzer, S.H., F.C. Bryant, and D.B. Wester. 1993. Potential forage species for deer in the southern mixed prairie. J. Range Manage. 46:70-75.
Sharp, L.A., K. Sanders and N. Rimbey. 1992. Variability of crested wheatgrass production over 35 years. Rangeland 14:153-168.
Shoop, M.C., R.C. Clark, W.A. Laycock, and R.M. Hansen. 1985. Cattle diets on shortgrass ranges with different amounts of fourwing saltbush. J. Range Manage. 38:443-449.
Stevens, A.R. 1992. Establishment and distribution of forage kochia seedlings within crested wheatgrass stands. M.S. Thesis. Brigham Young University, Provo, Utah.
Trlica, J.J., and C.W. Cook. 1971. Defoliation effects on carbohydrate reserves of desert species. J. Range Manage. 24:418-425.
Trlica, M.J., M. Buwai, and J.W. Menke. 1977. Effects of rest following defoliations on the recovery of several range species. J. Range Manage. 30:21-27.
Tyler, S. 1979. Time-sampling: a matter of convention. Anim. Beh. 27:801-810.
Ueckert, D.N. J.L. Petersen, J.E. Huston, and M.W. Wagner. 1990. Evaluation of fourwing saltbush as a forage for sheep and angora goats. USDA/FS, Intermountain Res. Stn, 276:300-304. Ogden, Utah.
Wilson, A.D. 1956. A review of browse in the nutrition of grazing animals. J. Range Manage. 22:23-28.

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Feedlot Performance and Carcass Characteristics of Lambs Sired by Texel, Romanov, St. Croix or Dorset Rams from Polypay and St. Croix Ewes

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Summary

Over a 2-year period, crossbred lambs resulting from the mating of Texel (T), Romanov (R), and St. Croix (S) rams with Polypay (P) and S ewes, were finished during the summer and late fall to determine feedlot performance and carcass characteristics. A total of 175 wether lambs of the five genotypes (R x P, R x S, S x S, T x P and T x S) were fed a high-energy diet for an average of 110 d (Experiment 1). Purebred St. Croix lambs weighed less ($P < 0.05$) at the beginning and end of the finishing period, had the lowest average daily gain (ADG) ($P < 0.05$), and the lowest Gain:Feed ($P < 0.10$) of the five genotypes evaluated. All five genotypes produced carcasses with a quality grade ≥ Choice. In a subsequent 2-year experiment (Experiment 2), 251 lambs sired by either Dorset or St. Croix rams from the ewes created in Exp.1 were used. Dorset-sired lambs were heavier ($P < 0.10$) at the end of the feeding period and had greater ADG ($P < 0.10$) than lambs sired by St. Croix rams. Wether lambs were heavier ($P < 0.10$), grew faster ($P < 0.10$) and ate more ($P<0.05$) feed than female lambs. Lambs from crossbred ewes were heavier ($P <0.05$) at the beginning and end of the finishing period and grew faster ($P < 0.10$) than lambs from purebred St. Croix ewes. When Dorset rams were used as the terminal sire, lamb feedlot performance was similar among the five ewe genotypes used in this study.

Key words: Lambs, Crossbreeding, Feedlot, Carcass Quality, Carcass Cutability.

Introduction

Per capita lamb consumption has steadily declined over the past three decades due to changes in eating habits of U.S. consumers and a widening gap between the retail prices of lamb meat in comparison with other meat choices, particularly beef (Schroeder et al., 2001). To be more competitive, retail lamb prices must be lowered, which means lowering lamb production cost either by increasing lamb productivity per ewe or decreasing the cost of production inputs (Lewis et al., 1996). Crossbreeding programs can be used to exploit differences in breeds, to increase heterosis and to match genetic and environmental resources for the most efficient production (Freking et al., 2000; Leymaster and Jenkins, 1993). Texel sheep were imported into the United States for evaluation as a new terminal sire breed. Leymaster and Jenkins (1993) reported that Texel-sired lambs produce carcass that were leaner, distributed fat differently and had a different carcass shape than Suffolk-sired lambs.

Hair sheep breeds have been considered in the past for crossbreeding programs with wool sheep breeds (Burke and Miller, 2004; Notter et al., 2000 and 2003). Bunch et al. (2004) reported that overall sensory acceptance ratings were higher for purebred St. Croix lambs than for lambs from wool breeds. They concluded that hair sheep could be used in a cross-breeding program to improve meat palatability. During the development of crossbred females, crossbred males are also produced. The majority of these males do not go into breeding programs but are placed in feedlots for finishing. The objectives of the experiments reported in this paper were 1) to compare the feedlot performance and carcass characteristics of purebred St. Croix lambs to lambs containing 50 percent St. Croix breeding (Experiment 1), and 2) to compare the feedlot performance and carcass characteristics of lambs sired by Dorset or St. Croix rams from purebred St Croix or crossbred ewes (Experiment 2).

Materials and Methods

Experiment 1:

A total of 175 wether lambs were used to determine feedlot performance and carcass characteristics of spring born lambs sired by St. Croix (S), Romanov (R) or Texel (T) rams from either St. Croix or Polypay (P) ewes. Lambs of RxP, RxS, SxS, TxP, TxS genotypes (genotypes refer to both purebred and crossbred lambs) were born in the spring of 1993 (Year 1; n=72) and 1994 (Year 2; n=103) and reared at the USDA-ARS Dale Bumpers Small Family Farm Research Center at Booneville, Ark. Male lambs were surgically castrated shortly after birth. All lambs were weaned in July at approximately 90 d of age and transported (360 km) to the USDA-ARS Grazinglands Research Laboratory, El Reno, Okla. Prior to entering the feedlot, lambs were individually weighed, treated for internal parasites and vaccinated for *Clostridium perfringens* type C and D. Lambs were randomly assigned within genotype to one of two pens. In year 1, the number of SxS lambs was limited and only one pen was used. A total of 9 pens were used in year 1 and 10 pens were used in year 2. Each pen was 5.5 m x 21.5 m and the surface was concrete. A roof covered 35 percent of the pen, including a self-feeder that was 2.4 m in length. Lambs had ad libitum access to the feed in the self-feeder and to water provided by a fountain in each pen. Initially, a starter diet (Table 1) was fed. The proportion of alfalfa hay in the starter diet was decreased, and the proportion of corn in the starter diet was increased by 5 percentage units at 5-d intervals until alfalfa hay content was < 16 percent (Table 1).

Lambs were individually weighed at the beginning and end of the feeding period after a 16-h fast without feed and water. Lambs were considered finished when the mean final body weight of the pen was 50 kg or greater. Lambs were fed for 114 d (Year 1) or 105 d (Year 2). At the end of the feeding period, one lamb with a body weight equal to the average body weight of that pen was chosen for detailed carcass evaluation. Selected lambs were transported (130 km) to the Oklahoma State University, Stillwater, Okla. to determine cold-carcass weight and weight of wholesale cuts (leg, loin, shoulder and rack).

Data were analyzed using the PROC MIXED procedure of SAS (1999). The model contained year, genotype and year x genotype. Pen was used as the experimental unit and was considered to be random. Orthogonal contrasts were conducted to test the following effects; 1) purebred St. Croix lambs (SS) vs all other lambs, 2) Romanov sired lambs (RP and RS) vs Texel sired lambs (TP and TS), and 3) lambs from Polypay

Table 1. Composition of starter and finishing diets used in Experiments 1 and 2.

	Diet	
Ingredient	Starter diet	Finishing diet
Ingredient composition	------------------ %	------------------
Alfalfa hay	40.7	15.4
Corn	50.8	77.0
Soybean meal	2.0	0.7
Molasses	5.0	5.0
Limestone	0.9	1.2
Salt	0.5	0.5
Dicalcium phosphate	0.1	
Nutrient composition[a]		
Crude protein, %	13.2	10.9
NE_m, Mcal/kg	1.71	1.95
NE_g, Mcal/kg	1.07	1.27
Ca, %	1.4	1.2
P, %	0.3	0.3

[a] Nutrient composition was calculated from feed composition values in NRC, 1985 and as expressed on a dry matter basis.

ewes (RP and TP) vs lambs from St. Croix ewes (RS and TS). Carcass and cutout data were analyzed using the same model and contrasts, but *animal* was used as the experimental unit. Means are reported as least squares means.

Experiment 2:

A total of 251 ewe and wether lambs were used to determine the impact of sire breed and ewe genotype on feedlot performance and carcass characteristics. Female lambs generated during Exp. 1 were retained at the USDA-ARS Dale Bumpers Small Family Farm Research Laboratory and used to create a flock of ewes of five different genotypes (RxP, RxS, SxS, TxP and TxS). Ewes were bred to either Dorset or St. Croix rams in the fall of 1994 and Dorset rams in the fall of 1995. Lambs were born in the spring of the subsequent year, were managed as described in Exp. 1 and shipped to El Reno, Okla. on August 1, 1995 (n=128) and July 9, 1996 (n=123). Lambs were processed and fed in the same pens as described in Exp. 1. Lambs were grouped by ewe genotype (n =5) and sex (n=2) then each group was randomly assigned to one of ten pens. In 1995, Dorset- and St. Croix-sired lambs were fed in the same pen. Lambs were fed the same diets and body weights were collected as described in Exp. 1. In 1995, a total of 10 Dorset-sired lambs were selected (two lambs from each pen of wether lambs) to determine cold-carcass weight, weight of wholesale cuts (leg, loin, shoulder and rack) and carcass characteristics. Lambs were selected based on a body weight close to the average body weight for the Dorset-sired lambs in that pen.

Initially, feedlot performance was analyzed within each year using *lambs* as the experimental unit. Data collected in 1995 was analyzed with a model containing sire breed, ewe genotype, sex of lamb, and all two and three way interactions. The residual was used as the error term. Sire breed was dropped from the model used to analyze the data collected in 1996 (only one sire breed was used). Data from both years were analyzed using PROC MIXED procedure of SAS (1999) using *pen* as the experimental unit. The model contained sex of lamb, ewe genotype and sex of lamb x ewe genotype interaction. Year was considered random and orthogonal contrasts were conducted to test the following effects; 1) lambs from purebred St. Croix ewes vs all other lambs, 2) lambs from Romanov-sired ewes (RxP and RxS) vs lambs from Texel-sired ewes (TxP and TxS), and 3) lambs from crossbred Polypay ewes (RxP and TxP) vs lambs from crossbred St. Croix ewes (RxS and TxS), and 4) the interaction of sire breed and crossbred ewes (RxP and TxS vs RxS and TxP). Means are reported as least squares means.

Results and Discussion

Experiment 1

In Exp. 1, lambs were fed for 114 d in 1993 (August 8 to November 30) and for 105 d in 1994 (July 12 to October 25). Lambs used in year 2 were heavier ($P < 0.01$) at the beginning of the experiment than the lambs used in year 1, (27.6 vs. 23.0 kg, respectively), but ADG (213 g) was not different ($P = 0.29$) between years. As a result lambs reached the target finished body weight of 50 kg sooner in year 2 than in year 1.

No significant ($P > 0.10$) genotype x year interaction was observed for feedlot performance or carcass measurements. Data was then analyzed by PROC MIXED procedure (SAS, 1999) using a model containing genotype. Year and pen (year) were considered random. The same orthogonal contrasts as previously described were used with this new model. Data are presented as least squares means (Table 2). Purebred St. Croix lambs were lighter ($P < 0.01$) at the beginning and end of the finishing period as compared to all other lambs. A final body weight (BW) of 50 kg was reached by all genotypes with the exception of the purebred St. Croix. At the observed ADG, purebred St. Croix lambs would have needed an additional 43 d to reach a BW of 50 kg. Purebred St.Croix lambs had lower ADG ($P < 0.01$) and lower gain:feed ($P < 0.05$) ratio lambs than the other four genotypes. Because initial BW was different between the purebred St. Croix lambs and the other lambs, initial BW was used as a co-variant in an additional analysis. Initial BW was not a significant ($P > 0.10$) factor affecting final BW or ADG.

Average daily gains ($P = 0.79$) and final BW ($P = 0.59$) were similar among

Table 2. Least squares means for feedlot performance and carcass cutability of wether lambs sired by Romanov (R), St. Croix (S) or Texel (T) rams from Polypay (P) or St. Croix (S) ewes (Exp. 1).

	RP	RS	SS	TP	TS	SE
Feedlot performance[a]						
Number of pens	4	4	4	4	4	
Initial BW, kg[bd]	26.2	25.2	20.4	27.1	24.9	1.5
Final BW, kg[bd]	51.0	48.7	39.6	51.3	49.6	2.5
ADG, g[b]	225	216	180	220	226	7.0
Feed intake, kg/d	1.42	1.35	1.36	1.43	1.45	0.08
Gain:Feed[b]	0.160	0.159	0.133	0.156	0.157	0.011
Carcass cutability						
Number of lambs	4	4	4	4	4	
Final BW, kg[b]	50.8	49.9	41.8	50.8	50.8	0.8
Cold carcass wt, kg[b]	23.8	23.9	20.9	23.8	24.7	2.0
Leg, kg	7.08	7.26	6.08	7.22	7.54	0.77
Loin, kg	2.44	2.57	2.17	2.79	2.49	0.18
Rack, kg[b]	2.56	2.77	2.33	2.70	2.52	0.12
Shoulder, kg[b]	5.31	5.11	4.54	6.17	5.63	0.31

[a] Feedlot performance was calculated using pen data.
[b] Contrast of purebred SS lambs vs all other genotypes, $P < 0.05$.
[c] Contrast of lambs sired by Romanov rams (RP and RS) vs lambs sired by Texel rams (TP and TS), $P < 0.05$.
[d] Contrast of lambs from Polypay ewes (RP and TP) vs lambs from St. Croix ewes (RS and TS), $P < 0.05$.

Romanov- and Texel-sired lambs. Lambs from Polypay ewes were heavier ($P < 0.05$) at the beginning (26.6 vs. 25.0 kg) and end (51.2 vs. 49.2 kg) of the experiment than lambs from St. Croix ewes. Daily feed intake was similar ($P = 0.87$) among the five genotypes, but feed efficiency (Gain: Feed) was different ($P < 0.05$) reflecting the differences in ADG.

Hair sheep are smaller and weigh less than wool sheep (Notter et al., 2003; Shelton, 1991). Lambs with small frame size, such as hair sheep, can be fed to heavier body weights to yield heavier carcasses, but the additional weight gain is predominately fat (Nichols et al., 1993). In this experiment, feeding purebred St. Croix lambs to heavier final body weights would only increase carcass fat and further depress feed efficiency. Snowder et al. (1994) established an optimal slaughter weight of 45 to 47 kg for Polypay wethers to yield a carcass with a quality grade of Choice and a Yield Grade between 2 and 3. However, with current industry slaughter weights of > 60 kg, Yield Grades would no doubt be much higher if these lambs were fed to heavier carcass weights.

Carcass measurements shown in Table 2 were recorded on four wether lambs of each genotype. The number of observations for each genotype is small and the data should be considered preliminary. Differences in cold-carcass weight are a reflection of differences in final BW. Purebred St. Croix lambs had lower ($P < 0.05$) cold carcass, leg, rack and shoulder weights than those observed for the other four genotypes. Lambs sired by Texel rams had greater amounts ($P < 0.05$) of shoulder than lambs sired by Romanov rams, reflecting differences in carcass conformation. However with the exception of Texel-sired lambs vs. Romoanov-sired lambs, when wholesale cuts are expressed as a percentage of the cold carcass weight none of the contrasts were significant ($P > 0.15$). The Texel-sired lambs yielded more shoulder ($P < 0.05$) as a percentage of the cold- carcass weight than Romanov-sired lambs (25 percent vs. 22 percent, respectively). Overall the percentage of leg, loin, rack and shoulder was 30.1 percent, 10.9 percent, 11.2 percent and 23.2 percent, respectively.

Table 3. Least squares means for feedlot performance of female (F) and wether (W) lambs sired by Dorset or St. Croix rams from Romanov x Polypay (RxP), Romanov x St. Croix (RxS), St. Croix x St. Croix (SS), Texel x Polypay (TxP), Texel x St. Croix (TxS) ewes (Exp.2).

Item	Sex	N	Initial BW	Final BW	ADG
Year 1					
Dorset sired	F	29	19.3 kg	49.3^{b} kg	208^{b} g
	W	32	21.6 kg	53.3^{a} kg	268^{a} g
St. Croix sired	F	37	18.3 kg	44.1^{b} kg	168^{c} g
	W	30	18.9 kg	43.4^{b} kg	194^{b} g
SE			0.7 kg	1.3 kg	6.5 g
Year 2					
Dorset sired	F	69	24.9 kg	45.9^{a} kg	155^{a} g
	W	54	25.3 kg	50.2^{b} kg	185^{b} g
SE			0.5 kg	0.9 kg	3.7 g

[abc] Means in the same year and column with different superscripts are different $P < 0.01$.

Experiment 2

In Exp. 2, lambs used in Year 1 (1995) were sired by either Dorset or St. Croix rams and lambs used in Year 2 (1996) were sired by Dorset rams (Table 3). Among ewe and wether lambs fed in Year 1, Dorset-sired lambs had greater ADG (239 g vs 179 g; $P < 0.01$) and were heavier (51.4 kg vs 43.5 kg; $P < 0.01$) at the end of the finishing period than lambs sired by St. Croix rams. There was a sex-of-lamb x breed-of-sire interaction for lambs fed in Year 1 for final body weight ($P < 0.10$) and ADG ($P < 0.01$). Differences in final body weight and ADG were greater between ewe and wether lambs sired by Dorset rams than between ewe and wether lambs sired by St. Croix rams (Table 3).

In general, female lambs weighed less ($P = 0.11$) at the beginning of the feeding period, had lower ADG ($P < 0.01$), and consumed less feed ($P = 0.14$)

Table 4. Least squares means for feedlot performance of lambs sired by Dorset and St. Croix rams from Romanov x Polypay (RxP), Romanov x St. Croix (RxS), St. Croix x St. Croix (SS), Texel x Polypay (TxP), Texel x St. Croix (TxS) ewes (Exp. 2).

	Ewe genotype					
	RP	RS	SS	TP	TS	SE
Feedlot performance						
Number of pens	4	4	4	4	4	
Initial BW, kg[bd]	22.1	20.4	21.3	24.9	23.8	2.6
Final BW, kg[abcd]	48.2	45.4	44.7	52.6	50.9	1.04
ADG, g[d]	202	181	169	222	198	23
Feed intake, kg/d[c]	1.43	1.18	1.23	1.52	1.34	0.07
Gain:Feed	0.147	0.147	0.135	0.151	0.149	.008

[a] Contrast of lambs from purebred St. Croix ewes vs lambs from crossbred ewes, $P<0.05$

[b] Contrast of lambs from ewes sired by Romanov rams (RP and RS) vs lambs from ewes sired by Texel rams (TS and TP), $P<0.05$.

[c] Contrast of lambs from ewes with Polypay breeding (RP and TP) vs lambs from ewes with St. Croix breeding (RS and TS), $P<0.05$.

[d] Contrast of lambs from SS and RS ewes vs lambs from RP, TP and TS ewes, $P < 0.01$.

Table 5. Least squares means for carcass cutability of wether lambs sired by Dorset rams bred to Romanov x Polypay (RxP), Romanov x St. Croix (RxS), St. Croix x St. Croix (SS), Texel x Polypay (TxP), Texel x St. Croix (TxS) ewes (Exp. 2).

	Ewe genotype					
	RP	RS	SS	TP	TS	SE
Number of lambs	2	2	2	2	2	
Final BW, kg[bc]	54.2	47.9	51.3	53.1	53.6	1.5
Cold carcass wt, kg	28.1	25.1	28.3	27.9	28.6	1.4
Wholesale cuts						
Leg, kg[ac]	7.22	6.27	7.17	7.35	7.76	0.29
Loin, kg[c]	2.42	2.04	2.23	2.25	2.38	0.40
Rack, kg	2.77	2.62	2.60	2.46	2.58	0.09
Shoulder, kg[ac]	5.31	4.30	5.06	5.23	5.58	0.21

[a] Contrast of lambs from ewes sired by Romanov rams (RP and RS) vs lambs from ewes sired by Texel rams (TS and TP), P<0.05.
[b] Contrast of lambs from ewes with Polypay breeding (RP and TP) vs lambs from ewes with St. Croix breeding (RS and TS), P<0.10.
[c] Contrast of lambs from RP and TS ewes vs RS and TP ewes, P<0.10

than wether lambs. We concluded that female lambs grow at a slower rate and are less efficient than male lambs. Notter et al. (2003) and Phillips et al. (2002) reported similar observations made on wether and female lambs from hair and black-faced sheep. We also concluded that Dorset-sired lambs gain weight more rapidly than St. Croix-sired lambs.

In Exp. 2, the breed-of-sire x ewe-genotype interaction in Year 1 was not significant (P > 0.38). Therefore, sire breed was dropped from the model. Using pen as the experimental unit, data were analyzed to determine the impact of ewe genotype on feedlot performance (Table 4). Lambs from purebred St. Croix ewes gained weight at a slower rate (P < 0.05) and were lighter (P>0.01) at the end of the finishing period than lambs from crossbred ewes. Lambs from Texel-sired ewes (TP and TS) had heavier (P < 0.01) initial and final BW as compared to lambs from Romanov-sired ewes (RP and RS). Also, ADG tended to be greater (P = 0.12). Lambs from Polypay crossbred (RP and TP) ewes had heavier (P<0.10) initial BW and final BW and greater ADG than lambs from St. Croix crossbred ewes (RS and TS). In this experiment, feed intake followed the same pattern as ADG. Lambs that consumed more feed had higher ADG. As a result, Gain:Feed was not different (P > 0.70) among lambs from the five ewe genotypes used in this study.

In the present experiments, feedlot performance was similar to previous reports from this laboratory using comparable diets and the same feeding facilities (Phillips 1990 and 1993; Phillips and VonTungeln, 1991). In previous experiments, ADG ranged from 185 to 280 g, daily feed intake ranged from 1.06 to 1.72 kg, and Gain:Feed from 0.108 to 0.180.

In Exp 2, carcass-cutout data was collected only during year 1 and only from Dorset-sired lambs (Table 5). The number of observations for each ewe genotype is small and the data should be considered preliminary. Lambs from purebred St. Croix ewes produced as much cold carcass weight and wholesale cuts as lambs from crossbred ewes. Lambs from Texel sired ewes (TP and TS) produced heavier (P < 0.05) leg and shoulder wholesale cuts than lambs from Romanov sired (RP and RS) ewes. Using a Dorset rams to sire lambs from purebred St. Croix ewes mitigated the negative effects of a hair sheep breed on carcass cutability.

The amount of leg, loin, rack and shoulder harvested from lambs in Exp. 2 was similar to that reported in Exp. 1 (Table 5). Because the number of observations per genotype are small (n=2), data was averaged across genotype and presented as descriptive statistics for each experiment (Table 6). Lambs used in both experiments yielded carcasses that had a quality grade of choice or better. Yield Grades were greater than 3 but less than 4 and fat thickness averaged 0.67 cm. Based on these observations, we concluded that the lambs were fed long enough to produce carcasses that would have a quality grade ≥ Choice and have a Yield Grade ≥ 3.

The amount of longissimus muscle produced in Exp. 1 and Exp. 2 was 12.4 cm^2 and 14.5 cm^2, respectively. The amount of longissimus muscle is proportional to carcass weight. Snowder et al. (1994) reported longissimus muscle area of 12.3 cm^2 or 0.445 cm^2/kg of carcass from purebred Polypay lambs. In Exp. 1 and 2 longissimus muscle per kg of carcass was 0.454 and 0.474, respectively. These observations are less than values of 0.577 cm^2/kg of carcass reported by Neary, et al. (1995) and 0.526 cm^2/kg reported by Shelton (1991). In small-framed lambs, extending the feeding period to produce a heavier carcass increases the amount of carcass fat and will decrease the amount of muscle/kg of carcass (Nichols et al., 1993).

Table 6. Carcass characteristics (mean ± SE) of crossbred wether lambs from Exp. 1 (1994 only) and 2 (1995 only).

	Experiment 1	Experiment 2
Final BW, kg	46.3 ± 0.09	52.2 ± 0.6
Cold carcass wt, kg	24.9 ± 0.4	27.6 ± 0.6
Dressing percent, %	59.1 ± 0.9	58.6 ± 0.9
Quality grade[a]	12.7 ± 0.3	12.7 ± 0.2
Fat thickness, cm	0.71 ± 0.1	0.64 ± 0.04
Longissimus muscle, cm^2	12.4 ± 0.4	14.5 ± 0.7
Yield grade	3.4 ± 0.1	3.2 ± 0.2

[a] Choice – = 11, Choice = 12 and Choice + = 13.

Implications

Cross breeding programs used to produce F1 females also produce F1 males that are finished in feedlots using high-energy diets. From these data, we concluded that crossbred-wether lambs produced from mating Texel, Romanov, St. Croix and Polypay breeds could be efficiently finished under conventional confinement feeding of a high-energy diet. However, purebred St. Croix lambs were smaller and grew slower than crossbred lambs. Wether lambs are more efficient and grow at a faster rate than female lambs. The differential between male and female lambs was greater when Dorset rams were used as the terminal sire. Lambs from ewes with St. Croix breeding performed as well as lambs from ewes with Polypay breeding. Lambs from ewes with Texel breeding were heavier at the start and end of the finishing period. In terms of growth and feed efficiency, Dorset rams were a better terminal sire than St. Croix rams. When Dorset rams were used as the terminal sire, lamb feedlot performance was similar among the different ewe genotypes used in this experiment.

Literature Cited

Bunch, T.D., R.C. Evans, S. Wang, C.P. Brennand, D.R. Whitter, and B.J. Taylor. 2004. Feed efficiency, growth rate, carcass evaluation. Cholesterol level and sensory evaluation of lambs of various hair and wool sheep and their crosses. Small Rumin. Res 52:239-245.

Burke, J.M. and J. E. Miller. 2004. Relative resistance to gastrointestinal nematode parasites in Dorper, Katahdin, and St. Croix lambs under conditions encountered in southeastern region of the United States. Small Rum. Res. 54:43-51.

Freking, B.A., K.A. Leymaster, and L.D. Young. 2000. Evaluation of Dorset, Finnsheep, Romanov, Texel, Montadale breeds of sheep: I. Effect of ram breed on productivity of ewes of two crossbred populations. J. Anim. Sci. 78:1422-1429.

Lewis, R.M., D.R. Notter, D.E. Hogue, and B.H. Magee. 1996. Ewe fertility in the STAR accelerated lambing system. J. Anim. Sci. 74:1511-1522.

Leymaster, K.A. and T.G. Jenkins. 1993. Comparison of Texel- and Suffolk-sired crossbred lambs for survival, growth, and compositional traits. J. Anim. Sci. 71:859-869.

Neary, M.K., M.J. Cecava, and E. P. Berg. 1995. Effect of fishmeal on growth and carcass traits of finishing lambs. Sheep and Goat Res. J. 11:106-110.

Nichols, M.E., H.G. Dolezal, G.Q. Fitch, and W.A. Phillips. 1993. Feedlot performance and carcass characteristics for small, medium, and large framed wethers backgrounded on wheat pasture. Sheep Res. J. 9:82-85.

Notter, D.R. 2000. Effects of ewe age and season of lambing on prolificacy in US Targhee, Suffolk, and Polypay sheep. Small Rumin. Res. 38:1-7.

Notter, D.R., S.A. Andrew, and A.M. Zajac. 2003. Responses of hair and wool sheep to a single fixed dose of infective larvae of *Haemonchus contortus*. Small Rumin. Res. 47:221-225.

Phillips,W.A. 1990. The effect of additional dietary zinc on feeder lamb performance. SID Sheep Res. J. 6:18-23.

Phillips,W.A. 1993. Feedlot performance of feeder lambs fed diets containing different proportions of wheat, corn, and sorghum. Sheep Res. J. 9:71-75.

Phillips,W.A., R.R. Reuter, M.A. Brown, J.Q. Fitch, S.R. Rao, and H. Mayeux. 2002. Growth and performance of lambs fed a finishing diet containing either Alfalfa or Kenaf as the roughage source. Small Rumin. Res. 46:75-79.

Phillips,W.A. and D.L. VonTungeln. 1991. Feedlot performance of lambs fed lactic acid-producing bacteria. Prof. Anim. Sci. 7:19-23.

SAS. 1999. SAS/SAT. Users Guide (Release 7.0) SAS Inst. Cary , NC.

Schroeder, T.C., R.J. Jerrick, R. Jones, and C.S. Spaeth. 2001. U.S. lamb demand. Sheep and Goat Res J. 17:14-19.

Shelton, M. 1991. Hair sheep production under temperate and tropical conditions. In: Hair Sheep Research: Proceeding of Symposium June 28, 1991. St. Croix, U.S. Virgin Islands.

Snowder, G.D., H.A. Glimp, and R.A. Field. 1994. Carcass characteristics and optimal slaughter weights in four breeds of sheep. J. Anim. Sci. 72:932-937.

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Cost of a Maedi Visna Flock Certification Program and the Changes in Productivity and Economic Return

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Summary

Maedi Visna (MV) has been identified as a common viral infection in Ontario sheep. The Maedi Visna Flock Status Pilot Project (MVFSP) sets a protocol for control and eradication of this disease. A static normative model was designed to measure the economic benefit of such a program. Of the 16 producers enrolled on the program in 2002, 15 cooperated and were surveyed.

Two benefits were identified from being MV free: 1) higher purebred sheep sale prices and 2) improved ewe productivity. The benefits to purebred sheep breeders warrant eradication within sheep flocks. With only a 10 percent improvement in purebred price, even on only 25 percent of lambs sold for breeding stock, a producer should expect to breakeven on the added costs associated with the MVFCP program just shortly after becoming 'A' Status. This outcome was robust for all combinations of flock size, ewe and purebred sheep sale values, and bleeding costs.

Commercial sheep producers did not find the same positive outcome. With low prevalence of the disease, few benefits accrued. Only with prevalence levels over 10 percent with low bleeding costs and large flocks would commercial producers show a reasonable payback period of about six years, and then only with the Monitored Program. Payback would never be reached on the Whole-Flock Program for commercial sheep producers.

Key Words: Sheep, Maedi Visna, Costs, Culling

Introduction

Maedi Visna (MV) is a common viral infection in Ontario sheep flocks and has been identified as causing significant production losses, including poorer reproductive performance, lower birth weights, reduced growth of lambs, and increased mortality and culling of ewes (Bruere and West, 1993). Eradication of MV also has significant costs associated with it, such as testing, depreciation on sheep that are removed, record keeping and facilities. The Maedi Visna Flock Status Program (MVFSP) identifies serologically positive sheep to MV viral infection, using a recombinant enzyme-linked immunosorbant assay (ELISA) and requires their subsequent removal from the flock to decrease the prevalence of MV to a level of insignificant risk.

The benefits of enrolling in an MV-status program can be divided into two areas: 1) reduction of productivity losses described above are critical to the commercial lamb producer; and 2) breeders of replacement animals (e.g. purebred producers) may derive an additional benefit of being able to claim that their stock is low risk of MV infection and thus may be able to increase price in the face of increased demand. When considering MV flock level status, residual disease cannot be tolerated as the infection will quickly spread within the flock again. The producer either buys into eradication with the goal to achieve low risk status, or attempts to control the disease through biosecurity.

Davies (1980) recognizes four significant elements that contribute to the costs of a disease-eradication program: the prevalence of disease present in the flock; the cost of culling a diseased animal and replacing it with a healthy animal, including the lost income associated with detecting and removing the diseased animal; the lost markets because the flock is diseased; and the ongoing cost of detection of the diseased animals within the flock, e.g. sampling, laboratory testing and time. It is important to continue to consider the costs associated with assurance that the flock maintains its low risk status. Repeated sampling of an apparently non-diseased flock must occur at some level in order to be sure that the disease status has not changed. This is particularly true when biosecurity and the sensitivity of the test are not perfect (Houwers et al, 1984). Although considerable work has been done with respect to MV-control programs, there is little research concerning their economic consequences. The costs and benefits of a disease-eradication program have a direct influence on whether the program will be implemented and followed by producers.

Copious amounts of literature document the effects of MV-serological status on flock performance. Sero-positive status has a negative effect on ewe fertility, fecundity, weaning rates and growth (Dohoo et al 1987, Keen et al, 1996, G.J. Gunn et al 1998). Keen summarizes the total effect of decreased lamb production due to serological MV status, as a loss of 4.95 kg per infected ewe exposed to the ram. This figure does not take into account losses from premature ewe death and culling for which there are no published estimates but is often reported in the lay literature as an important effect of the disease whether because of the effects of clinical disease or failure to raise lambs.

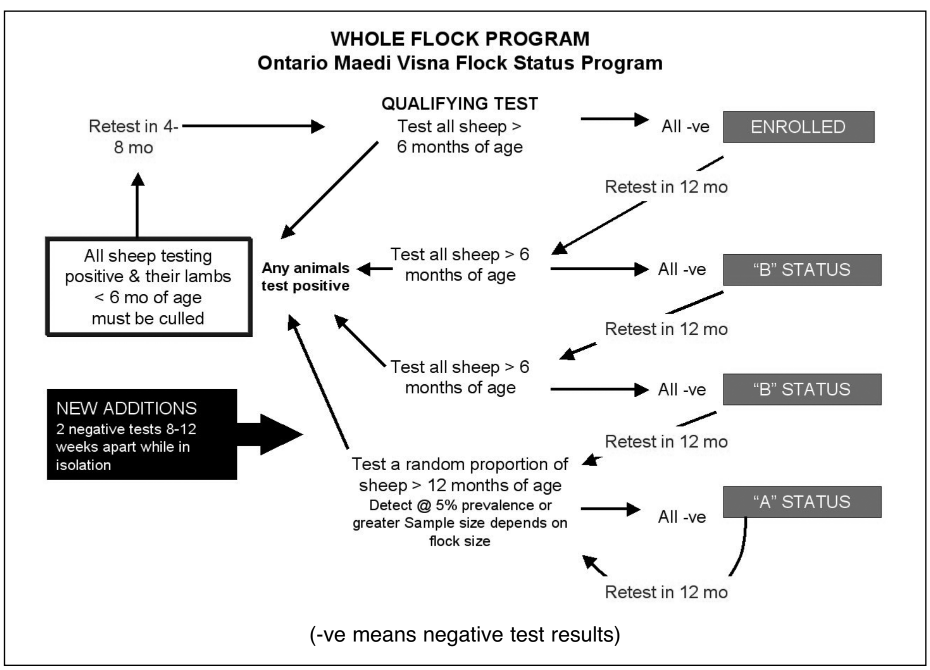
Dijkhuizen et al. (1991) and Renkema (1980) refer to positive and normative approaches to the costs of a disease-control program. A positive approach will evaluate the field data directly, using statistical/epidemiological models. The normative approach makes predictions based on existing knowledge and generates results using system modeling, enabling a simulation of the effects of various management decisions and control strategies, often using data derived from the field. Putt et al (1988) further break down types of models into dynamic versus static and deterministic versus stochastic. While static models often deal with the average of a set of values once a system has reached equilibrium, dynamic models take into account daily values over a certain period of time. In contrast, a deterministic model describes the situation that would arise if all the variables had average values, while a stochastic model allows the variables to take values from a range of values according to some probability distribution. In the case of MV, a normative/static/stochastic model is chosen as the best way to measure the costs of an eradication program.

The objective of this project was to quantify the costs associated with a Maedi Visna Flock Status Program and to determine the conditions under which this program would provide net economic benefits for the commercial and purebred sectors of the sheep industry.

Methodology

The MVFSP had been available to producers at the time of this study for less than three years. The program is administered by the Ontario Sheep Marketing Agency, with a partnership between the University of Guelph and

Figure 1. Schematic of the Maedi Visna Flock Status Program – Whole Flock.



the Canadian Food Inspection Agency (CFIA), which provides the MV ELISA testing. The program is comprised of two different schemes: the Whole-Flock program, which has three levels, “Enrolled” – after the initial negative whole flock test, “B” status – after two negative whole-flock tests and “A” status after three negative whole-flock tests and a negative test of a subset of the adult flock (Figure 1); and the Monitored Flock program designed for large, commercial flocks with two levels, Monitored and Monitored Low Risk (Figure 2). All sheep and goats greater than 180 days of age must be tested on the Whole-Flock Program. For the Monitored Program or when achieving or maintaining “A” status, a subset of the flock, greater than one year of age, is tested. This subset is a randomly selected portion of the flock, of sufficient size to detect MV at a flock prevalence of 5 percent or greater with a 95 percent probability. In addition to annual adult flock testing, producers are required to comply with specific biosecurity measures, which include isolation and testing of additions. Enrollment in the MVFSP is voluntary and costs are borne by the producer.

Numbers of flocks enrolled in the MVFSP at the time of this study were too low to statistically evaluate annual business reports. Instead a static normative model of the MVFCP was designed using field-derived data. Phone interviews were conducted with 15 producers enrolled in the program. Data included reported costs associated with the MVFCP. All dollar amounts shown are Canadian. [As of 12/05 Canadian dollar was .857 US dollars] Written feedback was provided to the participants after the interview was conducted, and consisted of a schematic of the MVFCP, copies of the programs pertaining to their individual situation, and a letter explaining the findings. This served as a beta test for the model.

The following flock characteristics were incorporated into the model: flock size, i.e. 100 breeding ewes vs. 500 breeding ewes; type of sales, i.e. commercial in which only market lambs were sold vs. purebred in which replacement stock is also sold; and type of MVFSP enrolled in, i.e. whole flock vs. monitored vs. no program. Data derived from the participants on the following variables associated with being enrolled in the MVFSP were summarized and incorporated into the model. These variables were: observed increase in the quantity of purebred sales and value of those sales; value of ewes; costs of sampling the sheep, including laboratory costs; labour costs; prevalence of the disease; and the occurrence of a positive test (i.e. loss of low-risk status) later in the process. The dependant variables observed included cost to reach ‘A’ or ‘B’ Status and how long it would take to breakeven, given the costs and benefits of the MVFCP program. The computer model was programmed in *Lotus 123, Release 5.* The models were simple, accounting for cycles involved in the program protocols (Figures 1 and 3). The model assumes that the producers had similar levels of flock-health management, which is termed Level 1 Health Status[1]. All producers were enrolled in a provincial, flock-health scheme, the Ontario Sheep Health Program (OSHP) and so are representative of more progressive producers in terms of the general health of the flock, e.g. vaccination, parasite control, biosecurity. By doing this we have removed many complicating issues for comparing productivity gains due to this program versus the effects of better man-

Figure 2. Schematic of the Maedi Visna Flock Status Program – Monitored Flock.

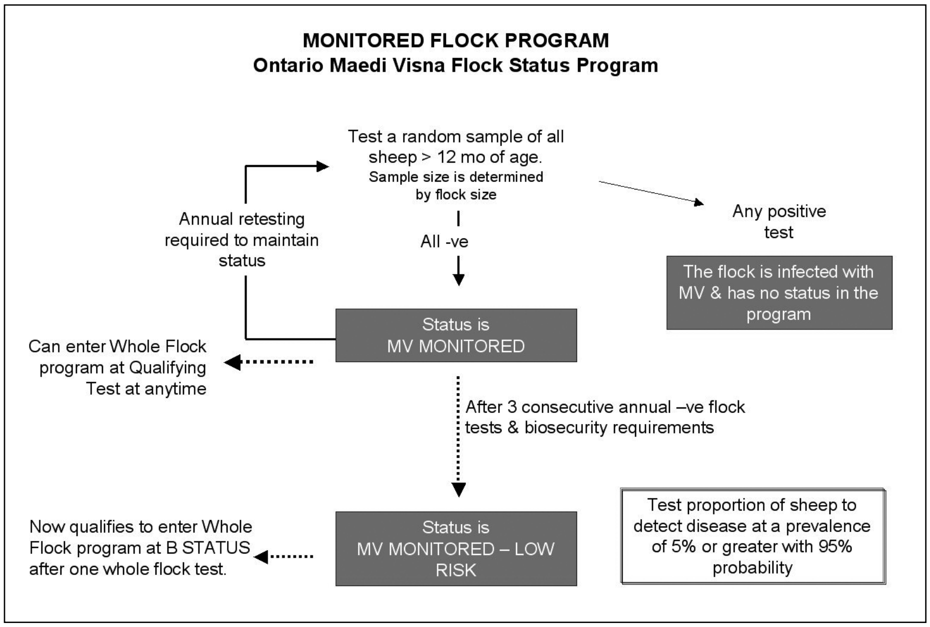
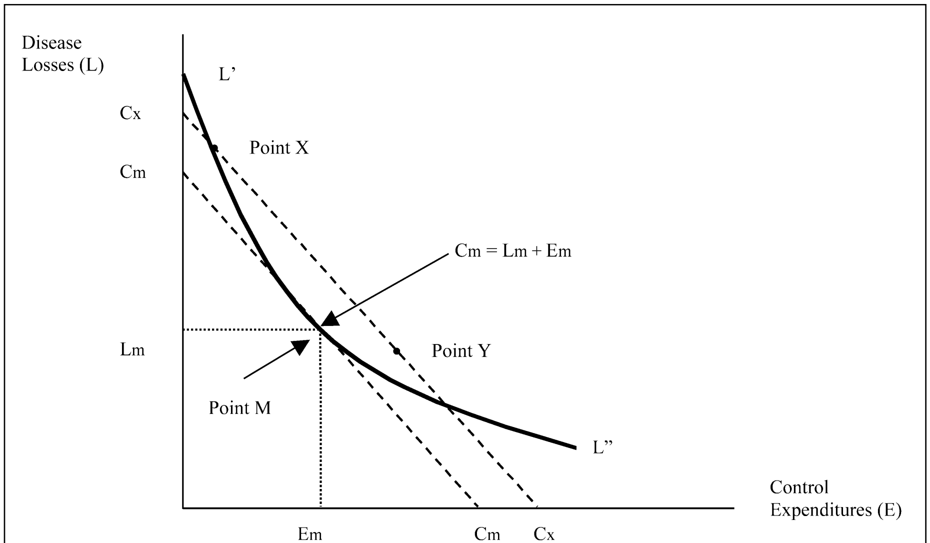


Figure 3: Disease Efficiency Frontier Including Isocost Lines - Conceptual.



Source: McInerney, J. (1996).

agement. Therefore, just the costs of MV testing and the benefits from this testing need be modeled.

The variables of importance to the economic success of the MVFCP program appear to be flock size (as flock size increases, a smaller proportion of the flock is sampled, so the cost is spread over more animals), sampling costs, ewe value and purebred breeding sales value. To summarize the effects of these variables on the costs/benefit of the MVFCP, scenarios were presented for four groups of producers; purebred breeder and commercial producers in either the Whole-Flock Program or the Monitored Program. The standard scenario included isolation facilities at $125, ear tags at $0.36, OSHP at $75, education at $150, salvage at $69, isolation labour at $13.33 per animal, age at 3.8 years, 6.75 years of use for ewes, 5 years in added productivity, 10 percent improvement in breeding sales, two lambs per ewe per year, 25 percent of sales as breeding, and commercial sales at $100. Sampling costs varied between $4.50 and $15.00 per test, while ewe value varied between $200 and $600 per ewe. Direct-sampling costs consist of six items including: lab charges, vet supplies, and labour for record keeping, help, operator and veterinarian. To reflect the value of ewes as this affects the value of her lambs, the value of purebred breeding sales were set to be the same as the ewe value, so these two variables acted together. Breakeven (years) shows how long it would take for the producer to cover the direct expenditures with reduced loses.

Results and Discussion

Of the 15 producers surveyed, 12 purebred breeding flocks and two commercial flocks were enrolled on the Whole-Flock Program, and one purebred flock was enrolled on the Monitored Program. Table 1 displays the average and range of the 14 flocks enrolled on the Whole-Flock Program. The one flock enrolled on the Monitored Program was excluded. All of the producers sold some breeding stock. Average flock size was variable. Some expenses were invested in isolation facilities, although these were not elaborate. Double ear tags were required; so cost for one additional tag per animal was added. Participants were required to register in the OSHP that costs $75, and most partook in some sort of education program concerning flock health or MV specifically. Sampling charges include laboratory fees, as well as veterinary services and labour. Laboratory fees range from no charge[2] ; $2.50 per test for producers enrolled in the MVFHP; to $8.50, which is the cost recovery rate proposed by the CFIA. Veterinary services are based on the costs of sampling 30 sheep per hour. Sufficient labour is needed to assure this flow rate and included one operator and one record keeper per veterinarian. Veterinary services and labour at less than these rates were shown because the research team did some bleeding at no charge. Ewe depreciation is assumed to be a straight line. Benefits from MV eradication were two fold: a productivity increase or an improvement in purebred breeding sales from displaying a MV free status. The literature states a commercial benefit of 4.95 kg of lamb per infected ewe (Keen et al, 1996), which may underestimate the true impact of the disease. Purebred breeders, who advertise various flock health credentials, found it easier to sell stock to shepherds when able to state the flock was low risk for infection with MV. Those surveyed reported a significant improvement in

Table 1. Input data from Participants of MVFCP Whole Flock Program.

(n=14)	Mean	Range
Number of ewes ...	149	60-600
Separate flock health equipment & Isolation facilities	$125	0-$500
Ear Tags (per ewe)	$0.36	0-$0.60
OSHP Registration and Binder	$75	$75
Education & Expert Advice on Maedi Visna	$150	0-$200
Laboratory Charges (per test)	$2.50	0-$8.50
Veterinary Supplies for Sampling (per test)	$0.25	$0.16-$0.25
Labour for Record Keeping (per ewe)	$0.75	$0.75
Labour for Vet to Sample Sheep (per test)	$1.46	0-$4.00
Labour for Help to Sample Sheep (per test)	$0.17	0-$0.50
Labour for Operator to Sample Sheep (per test)	$1.05	$0.50-$2.00
Labour for Isolation Unit (per positive ewe)	$13.33	0-$20.00
Value of Average Animal (per ewe)	$374	$180-$1,000
Salvage Value of Average Cull Animal	$69	$50-$100
Age of Average Cull Animal	3.8	3-6
How many years are ewes usually kept	6.75	5-10
Number of sheep in a random sample	48	38-56
Added Productivity per ewe per year without MV - 11 lbs (4.95 kg) is assumed (Keen et al, 1996)	11	11
Average Improvement in Breeding Sales	11%	2%-50%
Average Lambs per Ewe Per Year (assumes 100 lb lambs)	2.04	1.6-2.8
Percent of lambs sold as breeding stock per year	26%	2%-50%
Value of breeding lambs per each	$373	$200-$1,000
Value of commercial lambs per each	$130	$100-$250

[1] Level I Health Status can be described as 'best management practices for producing sheep, including nutrition, facilities, records, medicines and health procedures'. For a complete description reference Menzies P.I., Fisher J.W., *Economics of Flock Health Management*. 2001. *www.kemptvillec.uoguelph.ca/*

[2] Up until recently, the CFIA would test individual sheep for MV as part of their export mandate and would on occasion test the entire flock if time allowed. This has since been discontinued.

Table 2. Breeding Flock/Whole Flock Enrollment showing Breakeven[3] in Years (no sero-positive then one sero-positive).

	Sampling Costs			
100 Ewes	**$4.50**		**$15.00**	
Ewe Value — $200	-1.4	-1.2	+0.8	+1.9
$600	-2.0	-1.9	-1.5	-1.2
500 Ewes	**$4.50**		**$15.00**	
Ewe Value — $200	*-1.5*	*-1.3*	*+0.1*	*+0.9*
$600	-2.0	-1.9	-1.5	-1.2

[3] Using breakeven as the dependant variable, showed that to become 'A' Status with no sero-positive tests (will take four years), the number of years either before (a negative number) or after (a positive number) becoming 'A' Status the scenario would breakeven. To become 'A' Status with one sero-positive test would usually take 5 years. To become 'B' Status under the Monitored Program usually takes three years with no sero-positive tests, and four years with one sero-positive test. For example in Table 2, the first scenario broke even 1.4 years <u>before</u> becoming 'A' Status.

the value of breeding sales, in either price per animal or quantity sold.

The mean number of positive results of purebred producers enrolled on the Whole Flock Program on the first test was 7.25 resulting in 5.83 culls, and the cost to achieve "A" status was $5,207. Reported accrued benefits were $14,851. Based on these data, this group would break even 1.5 years <u>before</u> the earliest opportunity of achieving 'A' Status, i.e. after five years if the first test resulted in some animals testing positive. Most of the benefits come from improved purebred breeding sales. In fact only a 3.7 percent improvement in breeding sales (on 26 percent of lambs being sold for breeding stock) is required to breakeven by the time 'A' Status is achieved. This assumes a farmer can achieve a price premium soon after enrolling in the MVFCP.

All scenarios for purebred producers on the Whole-Flock Program had very early payback periods of either just before becoming 'A' Status or just shortly after, regardless of flock size, cost of sampling, ewe value or prevalence of sero-positive ewes (Table 2). Although the payback period is slightly longer for the smaller flock size, this difference is slight and does not significantly impede the financial success of a program for breeding flocks. This is important, as most breeding flocks in Ontario are less than 100 ewes.

Breeding flocks' enrolled in the Monitored Program (Table 3) again showed very encouraging payback periods. Certainly the Monitored Program was cheaper because it used random samples; however it took one additional test to achieve "Monitored-Low Risk" status. The status is not as high a level as "A" status. If the flock is small, the sample size is relatively large compared to the flock size. So cost savings for purebred breeders with small flocks between the Whole Flock and the Monitored Programs are minimal.

Commercial flocks in contrast, don't have the opportunity to breakeven given the standard scenario presented with either the Whole-Flock or Monitored Programs. The annual cost of testing is always greater than disease losses (Table 4). This is because without sufficient level of infection, there is no benefit to eradication. However, commercial operations will breakeven after 308 years, when disease prevalence is greater than 3.6 percent with large flocks (500 ewes) and low bleeding costs. At a 10 percent prevalence the payback would be 5.9 years <u>after</u> becoming 'B' Status. The recommendation would be to commercial flock owners who do not know the sero-prevalence of disease in their flock, would be to enroll in the Monitored-Flock Program to determine prevalence. If greater than 10 percent, then there may be an economic justification to enrolling in the Monitored Program to eradicate MV and derive the benefits from increased productivity. If the prevalence is less than 10 percent, then the producers should not enroll in either program.

McInerney (1996) defined the responsibility of economists in the question of disease control as those who will help set the boundary to controls. Some systemic diseases, for example mastitis, may optimally exist at some level if we consider the balance between control

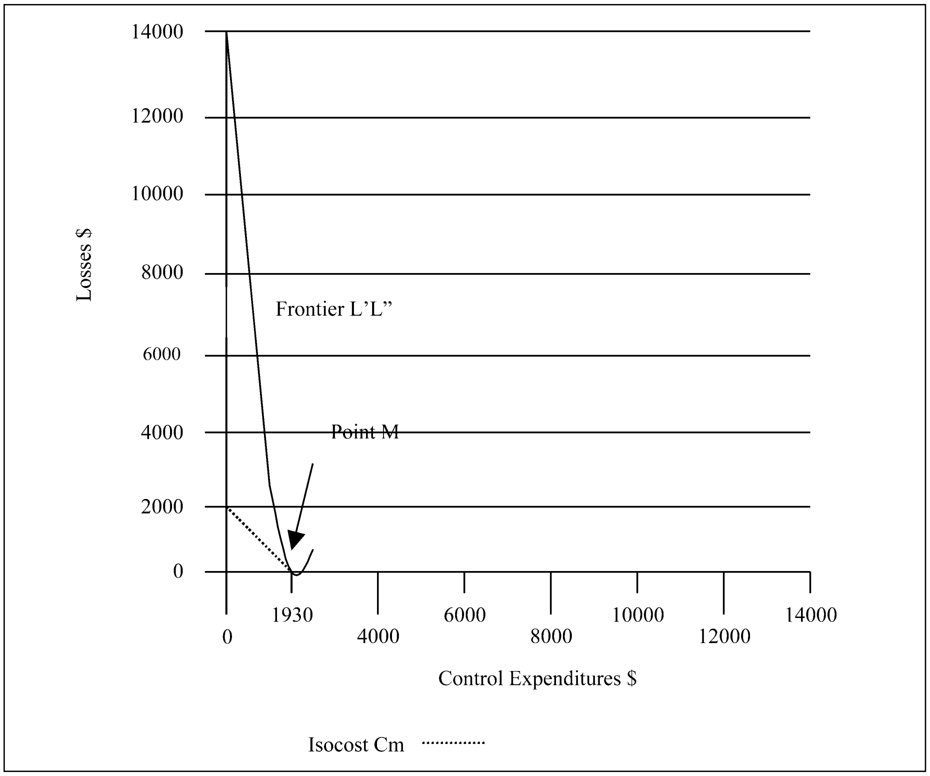
Table 3. Breeding Flock/Monitored Enrollment showing Breakeven in Years (no sero-positive then one sero-positive).

	Sampling Costs			
100 Ewes	**$4.50**		**$15.00**	
Ewe Value — $200	-1.4	-1.4	+0.6	+0.6
$600	-1.8	-1.8	-1.6	-1.5
500 Ewes	**$4.50**		**$15.00**	
Ewe Value — $200	*-1.9*	*-1.9*	*-1.8*	*-1.7*
$600	-2.0	-1.9	-1.9	-1.9

Table 4. Commercial Flock/showing Breakeven in Years. (no sero-positive then one sero-positive).

	Sampling Costs			
Whole Flock Enrolment	***$4.50***		***$15.00***	
Number of Ewes — 100	never	never	never	**never**
500	never	never	never	never
Monitored Enrolment	**$4.50**		**$15.00**	
Number of Ewes — 100	*never*	*never*	*never*	never
500	never	never	never	never

Figure 4: Disease Efficiency Frontier – Purebred Sheep with Maedi Visna (Ontario, 2002).



costs and controllable losses due to the disease. Where a disease is not systemic and can be controlled only by eradication, such as with MV, then the optimal level will exist (if the losses are great enough) or it will not exist at all for that particular economic environment.

Taken directly from McInerney (1996), Figure 3 shows a hypothetical efficiency frontier for a disease, below which is impossible to achieve. The y-axis represents production losses due to the disease, which includes loss of productivity, death loss, loss of markets, etc. The x-axis represents expenses to control and fight the disease, such as veterinary services and medicines. When eradication is necessary, the efficiency frontier L'L" will intersect the x-axis. MV is such a disease. Isocost lines are, by definition, a 45° angle to the x-axis and represent combinations of equal cost to the disease if we accept the basic premise that the cost of the disease is equal to the losses plus the control expenditures. McInerney argues that the optimal disease level is seldom at zero. The isocost line that is tangent to the efficiency frontier defines the optimal level of disease loss and control expenditure, at point M.

This study has identified the production losses (y-axis) and the expenditures (x-axis) for disease efficiency frontiers given specific farms (and scenarios) in Ontario. Specifically:

1. Purebred Breeding operations on the Whole-Flock Program show potential losses of $13,500 (Canadian $) and expenditures of $1,930 to become 'A' Status (100 ewes with value on ewes/sales at $600), (Figure 4). This has an average slope of -7, which is less than an isocost's slope of -1 (45° angle). As long as the curve of the efficiency frontier L'L" touches the isocost Cm at the x-axis intercept, then the point of the x-axis intercept is the optimal control point for this farm. And as such this demonstrates that eradication is the most economical option in this case, point M in Figure 4.

2. A commercial operator on a Monitored Program with 500 ewes, low bleeding costs and 10 percent prevalence would save production losses of $1,100 and incur control expenditure costs of $3,209 to achieve a 'B' Status, (Figure 5). This is the scenario where breakeven will occur in 5.9 years after becoming a 'B' Status (which would take four years). Over these 5.9 years the efficiency frontier #1 for this producer will shift, frontiers #2 and #3, until its slope becomes equal to -1. The frontier shifts because the annual costs of testing are less than the annual benefits after the first year or so during which all sero-positive animals

Figure 5: Disease Efficiency Frontiers, Commercial Sheep - Conceptual.

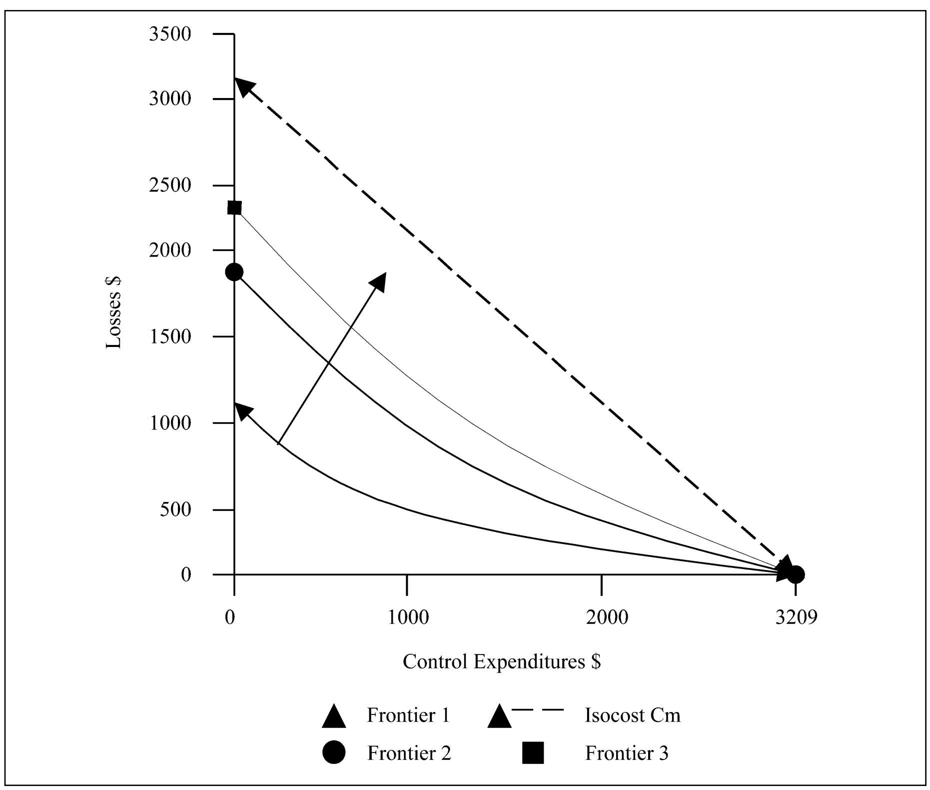
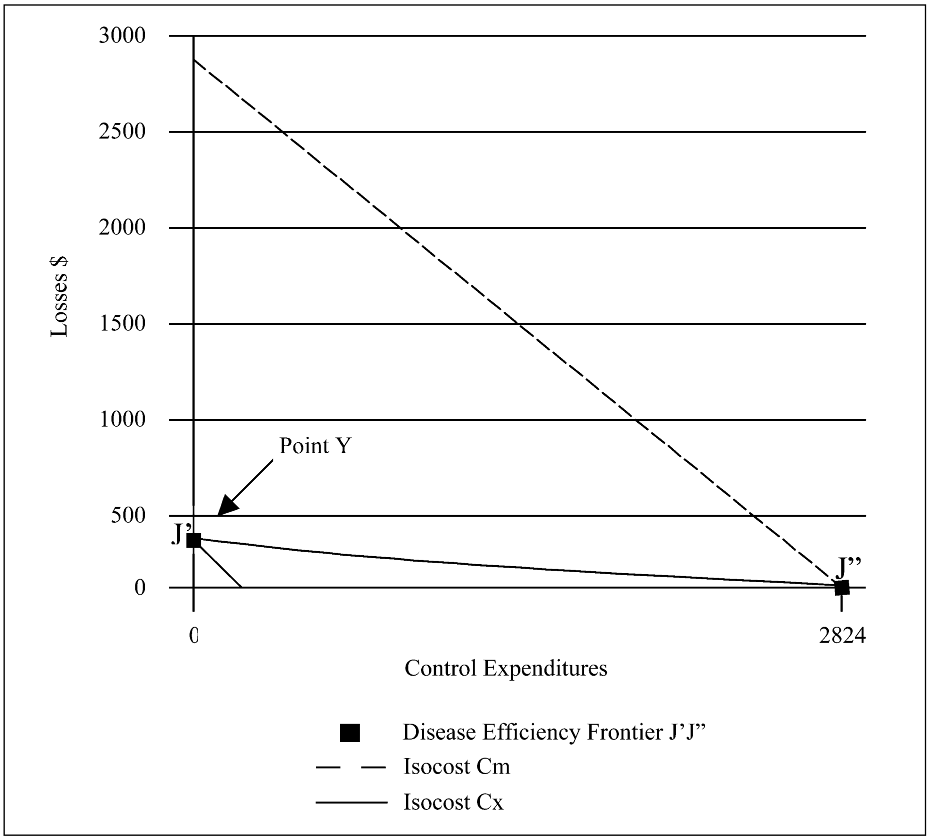


Figure 6: Disease Efficiency Frontier, Commercial Sheep.



are disposed. Eventually the frontier will be above the isocost Cm where again, the optimal point will be at the x-axis intercept (as is the case in Figure 4).

3. Also for a commercial operator (Figure 6) on the Whole-Flock Program (100 ewes, low bleeding costs and 10 percent prevalence) the savings from production losses would be $275 and control expenditures would be $2,824 with no potential to breakeven. This is because the annual costs exceed the annual returns, even as time goes on. The efficiency frontier J'J" has a slope that is more than -1 and will never shift lower than a slope of -1. Therefore the isocost Cx will intersect the efficiency frontier J'J" at an optimal point Y, which does not represent eradication. Actually, point Y is very close to the y-axis intercept, suggesting that very little control expenditure is economically warranted in MV control, for this scenario. The implication is that commercial producers with low prevalence should practice selective culling and good biosecurity and not enroll in the Whole-Flock Program of the MVFCP.

This analysis varies slightly from that of McInerney (1996) and that of Chi et al (2001), in that the costs of this disease (production losses plus control expenditures) will not have a particular time frame. A minimum of four years is needed to gain 'A' Status, three years for a Monitored 'B' Status and breakeven can happen over any number of years thereafter. And so the efficiency frontiers presented here are not time specific. This should not affect their use to explain the concept of optimal disease control.

MV testing involves a few other issues that need special attention. Depending on the organization of the farm, pre-bleeding assembly of animals may be easy or arduous. Meticulous record keeping needs to be done, and strict biosecurity measures must be followed to prevent reintroduction of the disease. Once 'A' Status is attained, if at some point the disease is reintroduced at greater than 5 percent prevalence, the status is lost and the program starts at the beginning. The dollar cost of this positive test would be that a whole-flock test would be required the next time and the culprits culled. Because the 'A' Status would be lost for a time, the designation for promotion would need to be removed, which in turn would reduce sales for purebred breeders. The implication of the reintroduction of disease is financially large.

Conclusions

The MVFCP program assumes that producers will enroll in the Ontario Sheep Health Program, educate themselves about controlling disease, test their sheep on a regular basis, cull all sero-positive animals, and practice good flock-health management, including biosecurity. Without this type of protocol, the eradication program would not work. Eradication is currently the only way to prevent losses from the disease (i.e. 4.95 kg less lamb weaned per ewe) and achieving low-risk status is the best way to derive benefits from being low risk of infection (i.e. improved sales of breeding stock).

Within these parameters, there seemed to be a solid economic return for purebred breeders in Ontario. These farms need not be large, the costs of sampling can reach $15.00 per test, and only a portion of lambs need to be sold as breeding stock. Breakeven occurred just before or shortly after becoming 'A' Status for all combinations of flock size, ewe and breeding sale values, and bleeding costs. Commercial producers, however derive no benefit from the program if their flocks do not have disease. At levels above 10 percent prevalence level, with low bleeding costs, commercial producers on the Monitored Program began to show a reasonable payback of about six years. While useful for purebred producers, some MVFSP protocols need to be adjusted if more participation from commercial producers is expected.

More research is needed in the assessment of production losses due to this disease. The commercial loss of 4.95 kg per ewe per year is not sufficient to warrant eradication without high prevalence levels. In many countries MV is a reportable disease, some national eradication programs have occurred over the years, all of which suggest this disease to be more destructive than described in the literature.

References

Bruere, A.M. and D.M. West (1993). The Sheep: Health Diseases and Production. Veterinary Continuing Education, Massey University, Palmerston North, New Zealand.

Chi, J., A. Weersink, J.A. Van Leeuwen, and G.P. Keefe (2001). The Economics of Controlling Infectious Diseases on Dairy Farms. Working Paper 02/03. *www.agecon.lib.umn.edu/cgi-bin/pdfview.pl?paperid=4022&ftype=.pdf*

Davies, G. (1980). The costs of benefits of eradication Enzootic Bovine Leucosis from Great Britain. In Animal Health and Economics: Technical Series No 3. (pp. 19-23). Paris, France: Office International des Épizooties.

Dijkhuizen, A.A., J.A. Renkema, and J. Stelwagen (1991). Modeling to support animal health control. Agricultural Economics, 5, 263-277.

Dohoo, I.R., D.P. Heaney, R.G. Stevenson, B.S. Samagh, and C.S. Rhodes (1987). The effects of Maedi-Visna virus-infection on productivity in ewes. Preventive Veterinary Medicine 4, 471-484

Gunn G. J., A.W. Stott, C.E. Milne, and A. Sime (1998) Economic impact of maedi-visna for commercial sheep flocks. In: Proceedings of the Sheep Veterinary Society Volume 22 99-101.

Houwers, D.J., J. Schaake, Jr., and G.F. de Boer (1984). Maedi-visna control in sheep II: Half-yearly serological testing with culling of positive ewes and progeny. Veterinary Microbiology 9:445-451.

Keen, J.E., L.L. Hungerford, E.T. Littledike, T.E. Wittum, and J. Kwang (1996) Effect of ewe ovine lentivirus infection on ewe and lamb productivity. Preventive Veterinary Medicine 30 155-169.

McInerney, J. (1996). Old Economics for New Problems - Livestock Disease: Presidential Address. Journal of Agricultural Economics: 47 (3) (1996) 295-314.

Putt, S.N.H., A.P.M. Shaw, A.J. Woods, L. Tyler, and A.D. James (1988). Estimating the costs of diseases and the benefits of their control. In Veterinary epidemiology and economics in Africa: A manual for use in the design and appraisal of livestock health policy (pp. 83-94). Berkshire, England: Veterinary Epidemiology and Economics Research Unit, Department of Agriculture, University of Reading.

Renkema, J.A. (1980). Economic aspects of disease in animals, with special refernece to the assessment of losses. In Animal Health and Economics: Technical Series No3. (pp. 47-60). Paris, France: Office International des Épizooties.

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Post-weaning Growth and Carcass Traits of St. Croix White and Dorper X St. Croix White Lambs Grazing Pasture During the Dry and Wet Seasons in the U.S. Virgin Islands

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Summary

This study was conducted to evaluate post-weaning growth, carcass traits and parasite burdens St. Croix White (STX) and Dorper X St. Croix White (DRP) lambs grazing guinea grass pastures during the wet and dry seasons. Lambs (77 d of age) were placed in guinea grass pastures (0.5 ha) in a rotational grazing system. Fecal egg count (FEC), packed cell volume (PCV) and BW were measured weekly. Lambs were slaughtered at a BW of 30 kg. Carcass weight, fat thickness, rib eye area (REA), KPH and leg circumference were measured. Data were analyzed by SAS procedures. Total rainfall was 647.7 mm and 1495.3 mm for the dry and wet seasons, respectively. Forage availability was 432.5 ± 64.6 kg DM/ha and 1051.0 ± 261.9 kg DM/ha during the dry and wet seasons, respectively. The DRP lambs reached target weight sooner ($P < 0.0008$) than STX lambs (178.2 ± 6.3 d vs. 210.9 ± 6.7 d, respectively). Average daily gain was higher ($P < 0.0002$) for DRP than for STX lambs (90.3 ± 1.9 g/d vs. 79.1 ± 2.0 g/d, respectively). Carcass weight was not different ($P > 0.10$) between breed type (13.5 ± 0.1 kg). The REA of DRP lambs was greater ($P < 0.01$) than that of STX lambs (9.36 ± 0.19 cm^2 vs. 8.63 ± 0.21 cm^2, respectively). Fat thickness was greater ($P < 0.02$) in DRP than in STX lambs (1.92 ± 0.10 mm vs. 1.57 ± 0.10 mm, respectively). Leg circumference was larger ($P < 0.03$) for DRP than for STX lambs (38.2 ± 0.3 cm vs. 37.3 ± 0.3 cm, respectively). There was no difference ($P > 0.10$) between DRP and STX lambs in FEC or PCV. Dorper-sired lambs reared under an extensive management system will reach market weight sooner than St. Croix White lambs and can tolerate parasite burdens similar to those found in the indigenous hair sheep in the U.S. Virgin Islands.

Key words: Hair Sheep, Parasites, Tropics, Carcass, Cross-Breeding

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Introduction

Caribbean agriculture is marked by limited land availability, variable rainfall throughout the year and year round exposure of livestock to parasites. In locations where the amount of land available for agriculture is limited, sheep can be the only feasible option for large-scale livestock production. The predominant breeds of sheep found throughout the Caribbean region consist of hair breeds, such as the St. Croix White and Barbados Blackbelly, as well as crosses of these two breeds. These hair breeds produce relatively small lambs with light carcass weights at slaughter. Attempts to increase carcass weight by crossing with wool breeds have met with limited success (Godfrey and Collins, 1999; Godfrey et al., 2000). These studies also reported that crossbred lambs (Suffolk X St. Croix White) had higher lamb mortality, higher fecal egg counts and lower hematocrit values while grazing guinea grass (*Panicum maximum*) pasture during the rainy season, when compared to purebred St. Croix White lambs.

Previous research has determined that hair sheep lambs on St. Croix raised during the dry season of the year have lower weaning weights (Wildeus et al., 1988). Low forage quality and quantity was thought to be the main reason for the decrease in lamb weight during the dry season. Wildeus and Collins (1993) also reported that lamb survival was lower during the rainy season on St. Croix. During the wet season the forage quantity increases, but quality may not be at desirable levels. The grasses are growing rapidly and contain a high level of moisture that may limit the lamb's grass consumption so that they cannot meet their nutritional requirements for growth due to limited rumen capacity. Each of the aforementioned studies indicates that there are negative aspects of both the dry and rainy seasons with regards to raising lambs on tropical grasses.

The introduction of Dorper sheep into the United States has led to a high level of interest in this breed in the U.S. Virgin Islands for use in crossbreeding programs. Several farms in the U.S. Virgin Islands have purchased Dorper sheep to incorporate into their hair sheep flocks, and interest about the performance of the breed under the local conditions is increasing. The Dorper was selected for use in crossbreeding with Caribbean hair sheep in this project due to its heavy muscling and the fact that it was developed for use in arid, tropical areas and that Dorpers have a fiber type more typical of hair than wool. There is very little information available on the ability of purebred and crossbred Dorper sheep to be productive under the conditions found in the Caribbean. Their ability to survive in an area of elevated parasite burdens is unknown. This project was designed to evaluate the post-weaning growth, carcass traits and parasite burdens of St. Croix White and Dorper X St. Croix White lambs raised on guinea grass pastures during two times of the year. The study was conducted during the dry (January through May) and the wet (September through December) seasons on St. Croix, U.S. Virgin Islands.

Materials and Methods

Animals

St. Croix White (STX) and Dorper X STX (DRP) lambs sired by two rams within each breed type were born in either July or November 2003. Lambs were weaned at 63 ± 3 d of age, kept in drylot pens (3.1 X 6.1 meters) and fed a commercial pelleted diet (PMI Nutrition, Mulberry, FL) at 2 percent BW•hd^{-1}•d^{-1} with ad libitum access to guinea grass hay and water for two weeks. Ram lambs were surgically castrated at 70 d of age. All lambs were treated with ivermectin (Ivomec®, 0.2mg/kg) and placed in pastures as they individually attained 77 d of age in October (wet season) or February (dry season). Lambs were dewormed with ivermectin once during the wet season grazing at day 84 of grazing, but not during the dry season. Distribution of lambs by breed and gender during the wet and dry grazing seasons is shown in Table 1.

Grazing treatments

A rotational-grazing system was utilized to move the lambs through a set of five pastures (0.5 ha each) that contained guinea grass with less than 10 percent leucaena (*leucaena leucocephela*). The timing of pasture rotation was determined by visual evaluation of forage quantity in each pasture. Wet-season grazing began in October, 2003 and dry-season grazing began in February, 2004. Herbage mass was measured at the start and the end of the grazing period in each pasture. Six 0.25 m^2 plots, randomly selected in each pasture, were harvested to a stubble height of 75 mm. Sub-samples (0.2 kg) were dried at 60° C for 48 h to determine forage dry matter per hectare (kg DM/ha). Quality traits of forage, determined on sub-samples collected at the start of grazing in a pasture, included percentage of CP, TDN and DM. Samples were sent to a commercial laboratory (Dairy One, Ithaca, NY) for analysis. Daily precipitation and high and low temperatures were also measured throughout the grazing period.

Animal sampling

Lambs were weighed, fecal samples were collected to determine fecal egg counts (FEC) and jugular blood samples were collected to determine packed cell volume (PCV) at weekly intervals during grazing. The FEC were determined using the modified McMaster's technique. Total gain was determined as the difference between BW at the start and end of grazing. Average daily gain (ADG) was calculated as total gain/day to reach market weight.

Carcass data

Lambs were slaughtered at a body weight of 30 kg, which is the preferred weight for the local market. Cold carcass weight, rib eye area measured between the 12th and 13th rib (REA),

Table 1. Distribution of lambs during wet and dry season grazing.

	Wet		Dry	
	DRP	STX	DRP	STX
Male	8	6	8	8
Female	6	6	7	6
Sub-total	14	12	15	14
Total	26		29	

fat thickness over the 12th rib, KPH percent and leg circumference were measured. Dressing percent was calculated as (cold carcass weight divided by live weight) x 100.

Economic analysis

Economic data was calculated for the three local markets available to producers. Lambs could be sold as live animals for religious slaughter at a rate of $2.21/kg (live). Carcasses could be sold to retail outlets at a rate of $3.96/kg (commercial) or to individual customers for personal consumption at a rate of $4.41/kg (individual). A variable to provide an indicator of efficiency (how many days it took to generate $1 of revenue) was created by dividing the number of days to reach market weight by the sale price.

Statistical analysis

Data were analyzed using general linear models procedures (SAS, 1996). Body weight, FEC and PCV were analyzed using repeated measures procedures. The model contained the effects of breed, sex, days grazing, season and the appropriate interactions. The values for FEC were transformed using $\log_{10}(FEC + 1)$ prior to analysis but results are presented as the untransformed least squares means. Carcass traits, ADG and economic data were analyzed using breed, sex and season and the appropriate interactions in the model. Mean separations were done using the PDIFF option of SAS. There was no significant effect of sex or the sex X breed and breed x season interactions for any trait so only breed and season effects are reported. Results are reported as least square means ± SEM.

Results and Discussion

Total rainfall during the dry season was 583.4 mm and 1495.30 mm during the wet season. This seasonal variation in rainfall affects both availability and quality of forage and can be a limiting factor to livestock production in the Caribbean. The dry period usually lasts from January through April, and September through December is considered the wettest time of the year (Godfrey and Hansen, 1996). Forage quantity was greater ($P < 0.008$) during the wet season than during the dry season (Table 2) but there was no difference ($P > 0.10$) in quality as indicated by CP or TDN between seasons. Lambs spent more time ($P < 0.03$) in each pasture during the wet season than during the dry season (Table 2).

The DRP lambs were heavier ($P < 0.01$) than the STX lambs in both seasons (Figure 1). Lambs allotted during the dry season were on pasture for 245 days, and during the wet season they were on pasture for 287 days. The number of days it took to reach target weight (30 kg) was less ($P < 0.0008$) for DRP than for STX lambs, but there was no difference ($P > .10$) between seasons (Table 3). Total gain was not different ($P > 0.10$) between DRP and STX lambs but was greater ($P < 0.03$) during the dry than the wet season (Table 3). The starting weight of lambs was lower ($P < 0.02$) during the dry season than the wet season (13.1 ± 0.5 kg vs. 14.9 ± 0.5 kg, respectively), which explains why total gain was greater during the dry season. Average daily gain was higher for DRP than for STX lambs ($P < 0.0002$) and higher ($P < 0.002$) during the dry season than the wet season (Table 3). Even though the total weight gain was not different between breed type, ADG was different due to the shorter time it took DRP lambs to reach the target weight. The difference in ADG between seasons is due to the combination of a lack of difference in time to reach market weight and the higher total weight gained during the dry season.

In semi-arid areas with long periods of little or no precipitation, tropical grasses can be low in energy and protein content, and growing lambs would be susceptible to under nutrition during these periods of low forage quality or quantity (Johnson et al., 1990). Wildeus et al. (1988) reported that hair sheep lambs on St. Croix have lower weaning weights when they are raised on pasture during the dry season of the year. This decrease in weaning weights is thought to be related to the low forage quality and quantity. The predominant forage, guinea grass, has an average crude protein content of 8 percent (on a DM basis), which is acceptable for maintenance of animals, but is not considered adequate for lactating ewes (Wildeus et al., 1988). The legume leucaena (*Leucaena leucocephela*) was reported to have crude protein content of 28 percent (Wildeus et al., 1988), but it was estimated to account for less than 10 percent of available forage in pastures in the present study. In the present study, the quality of the forage was similar between seasons, with quantity being the only difference. The nutritional analysis showed that the forage had 11 percent CP during both seasons. Kawas and Huston (1990) recommend that hair lambs gaining 100 g/d require 29 percent to 75 percent TDN and 9.5 to 14.9 percent CP, on a DM basis, depending on BW of the lamb. The forage quality during both the dry and wet season exceeded these levels, which indicates that nutritional quality was adequate for the lambs at both times.

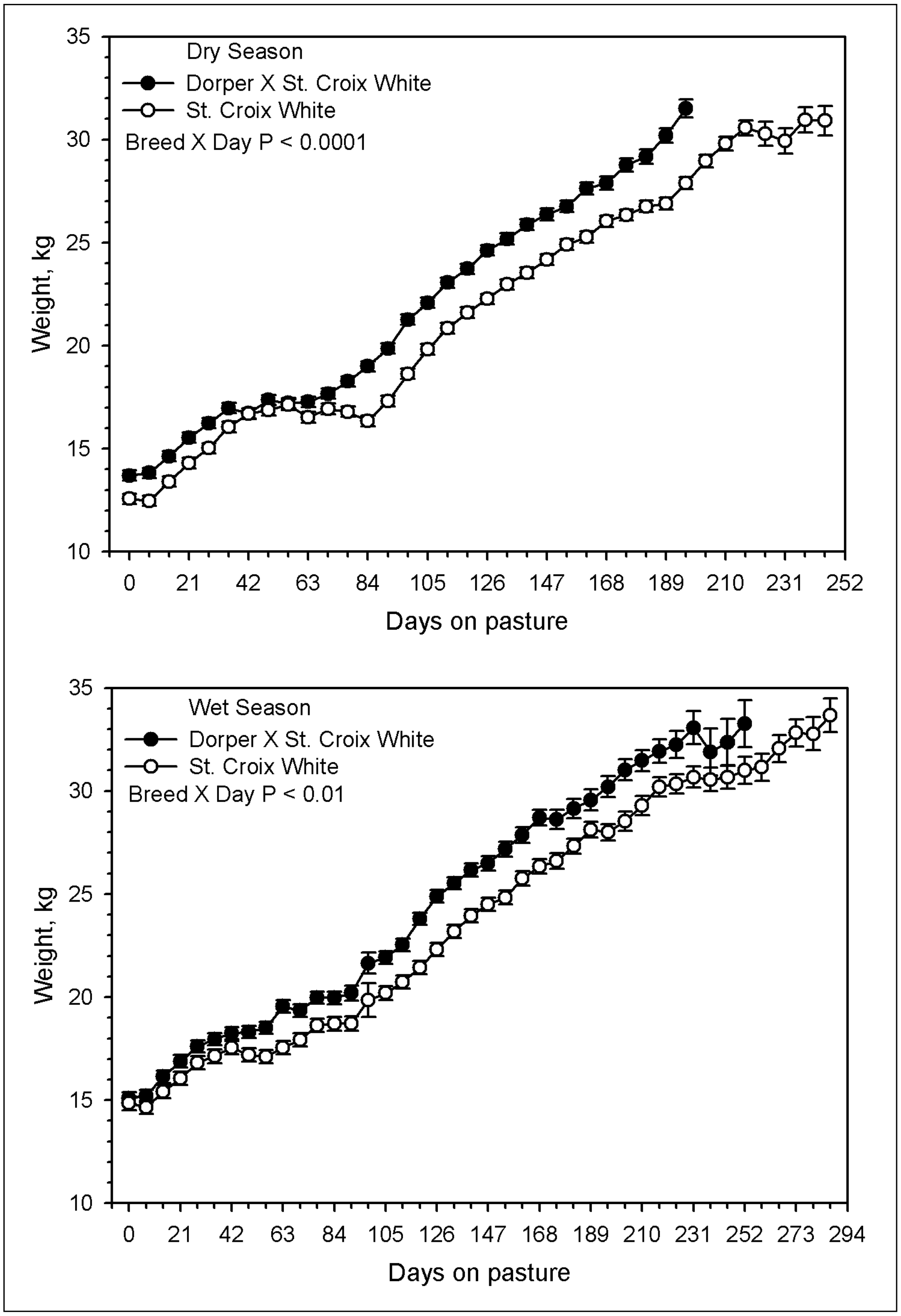
Table 2. Pasture rotation frequency and forage quality.

	Season	Mean ± SEM	Minimum	Maximum
Rotation frequency[a,d]	Wet	18.2 ± 2.0[c]	6	33
	Dry	11.2 ± 2.1[d]	2	36
Dry matter, %	Wet	29.7 ± 1.8	21.6	50.3
	Dry	32.2 ± 1.6	18.2	49.1
Crude proteinb, %	Wet	11.3 ± 0.7	6.9	15.2
	Dry	11.7 ± 0.9	6.2	20.8
TDN[b], %	Wet	60.8 ± 0.4	59.0	65.0
	Dry	60.9 ± 0.3	59.0	64.0
Forage DM , kg/ha	Wet	1051.0 ± 261.9[e]	121.3	3339.3
	Dry	432.5 ± 64.6[f]	20.7	1123.3

[a] Lambs were rotated through five 0.5 ha pastures
[b] DM basis

Means within a trait different superscripts are different: [c,d] $P < 0.03$; [e,f] $P < 0.008$

Figure 1. Weight of St. Croix White (open circles) and Dorper X St. Croix White (closed circles) lambs grazing guinea grass pastures during the dry (upper panel) and wet (lower panel) seasons on St. Croix. The dry season grazing lasted for 245 d and the wet season grazing lasted for 287 d. During both seasons the Dorper lambs were heavier than the St. Croix White lambs (P < 0.01).



We have previously reported that Suffolk X STX lambs had higher average daily gain, but lower feed efficiency, when compared to purebred St. Croix White lambs being fed a concentrate ration after weaning (Godfrey and Collins, 1999). In a subsequent study conducted to evaluate one quarter Suffolk x three quarter St. Croix White lambs grazing pasture, mortality was too high (57.1 percent) to accurately evaluate their rate of gain (Godfrey et al., 2000). In a review of South African Sheep Performance Testing Scheme records, Schoeman (2000) found the Dorper had the highest feed efficiency and ADG of all breeds tested, except for the Finnish Landrace composites. The crossbred lambs in the present study had greater ADG than the local hair sheep which is most likely due to breed differences between the Dorper and St. Croix White.

The DRP lambs had larger REA ($P < 0.01$), more back fat ($P < 0.02$), lower KPH ($P < 0.06$) and greater leg circumference ($P < 0.0001$) than STX lambs (Table 4). Results from our laboratory (Godfrey and Collins, 1999; Godfrey et al., 1999) have shown that St. Croix White lambs fed a concentrate diet tended to store fat in the body cavity as KPH and had very little external fat, compared to wool or hair crossbred lambs. In agreement with the present study, Godfrey and Weis (2005) reported that DRP lambs had higher KPH than the STX lambs did, but there was no difference in back fat when lambs were fed a concentrate diet. The trimness of hair sheep carcasses may be useful when marketing the meat to consumers who are interested in purchasing leaner cuts of meat for dietary or perceived health reasons. Notter et al. (2004) also reported an increase in muscling in Dorper-sired lambs. The larger REA and leg circumference of the DRP lambs compared to the STX lambs in the present study is indicative of more muscling on the carcass.

There was no difference in FEC or PCV ($P > 0.10$) between DRP and STX lambs. In both groups of lambs there was an elevation of FEC and a decrease in PCV between days 21 and 84 during the dry season. This corresponded to a period where the weight gain was decreased (Figure 1). The lambs were not treated with anthelmintic during this time and FEC and PCV returned to levels that were similar to those at the start of the grazing, and BW began increasing. The DRP lambs had elevated FEC around day 161, but this may have been due to the fact that by then 40 percent of the DRP lambs had reached market weight and were removed from the pasture, and an increase in FEC of one or two lambs could account for the elevated mean. During the wet season there was only a slight elevation in FEC between day 21 and 42 (Figure 2), and there was a decrease in weight gain at that time as well (Figure 1). Burke and Miller (2002) reported that Dorper crossbred lambs were less tolerant than hair-breed lambs when faced with an elevated-parasite challenge. This is in contrast to the cur-

Table 3. Growth traits of STX and DRP lambs during the dry and wet seasons.

	Breed		Season	
Trait	DRP	STX	Dry	Wet
Days to target weight	178.2 ± 6.3[a]	210.9 ± 6.7[b]	188.8 ± 6.3	200.4 ± 6.6
Total gain, kg	15.8 ± 0.5	16.5 ± 0.5	16.9 ± 0.5[c]	15.4 ± 0.5[d]
ADG, g/d	90.3 ± 1.9[e]	79.1 ± 2.0[f]	90.6 ± 1.9[e]	78.8 ± 2.0[f]

Means in a row within breed or season are different: [a,b] $P < 0.0008$; [c,d] $P < 0.03$; [e,f] $P < 0.0002$

Table 4. Carcass traits of STX and DRP lambs during the dry and wet seasons.

	Breed		Season	
Trait	DRP	STX	Dry	Wet
Hot carcass weight, kg	13.7 ± 0.1	13.3 ± 0.1	13.6 ± 0.1	13.4 ± 0.1
Dressing percent	43.3 ± 0.4	42.2 ± 0.4	42.9 ± 0.4	42.7 ± 0.4
Rib eye area, cm^2	9.36 ± 0.19[a]	8.63 ± 0.21[b]	8.8 ± 0.2	9.2 ± 0.2
Back fat, mm	1.92 ± 0.10[c]	1.57 ± 0.1[d]	1.92 ± 0.10[c]	1.57 ± 0.10[d]
KPH, %	2.5 ± 0.2[e]	3.0 ± 0.2[f]	3.1 ± 0.2[c]	2.4 ± 0.2[d]
Leg circumference, cm	38.2 ± 0.3[g]	37.3 ± 0.3[h]	38.6 ± 0.2[i]	36.9 ± 0.3[j]

Means in a row within breed or season are different: [a,b] $P < 0.01$; [c,d] $P < 0.02$; [e,f] $P < 0.06$; [g,h] $P < 0.03$; [i,j] $P < 0.0001$

rent study where both the STX and DRP lambs exhibited an elevation in FEC during grazing in the dry season that was temporary, even though the lambs were not treated with anthelmintic at that time.

During the dry season FEC was higher ($P < 0.001$) than during the wet season (Figure 2), but there was no difference ($P > 0.10$) in PCV (Figure 3). The higher FEC during the dry season was unexpected, but it may have played a role in the lower ADG (Table 3), as well as the plateau in BW between day 21 and 84 (Figure 1). Neither FEC nor PCV reached levels that were deemed abnormal during either season. However, three lambs (1 DRP and 2 STX) died of parasitism between day 81 and day 88 of the wet season, even though FEC was low and PCV was within the normal range for our sheep at this time (Figure 2). Parasitism was confirmed based on the large numbers of adult worms found in the gastrointestinal tract of these lambs during necropsy. During the 45-day period prior to the deaths, 626 mm of rain fell, accounting for 64 percent of the total rainfall during the 245-day, wet-season grazing period. One possible explanation for the lack of an increase in FEC during this time is that the *Haemonchus contortus* entered a diapause or arrested development phase during the wet season (Johnson et al., 1990; Wildeus and Collins, 1993) and were not shedding eggs that could be detected in the feces. If the parasites were in a dormant state, that would also explain why there was no detected decrease in PCV at that time as well. Gerisch and Antebi (2004) have studied the nematode *Caenorhabditis elagans* as a model of molecular mechanisms of environmental signaling due to its ability to arrest at the third larval stage (L3) in response to sensory inputs. Perhaps *Haemonchus contortus* possesses some ability to detect environmental cues outside of the host and can regulate its reproductive pattern to suit the environmental conditions. The only differences detected between the wet and dry seasons were forage quantity and rainfall amount. Whether or not *Haemonchus contortus* has the ability to respond to these environmental signals is unknown at the present time.

In our lab, we have reported that even with just 25 percent wool genetics, crossbred hair lambs were unable to tolerate the high parasite loads experienced by native hair sheep in the tropics during the wet season (Godfrey et al., 2000). In a study comparing the Dorper to the Red Maasai (Schoeman, 2000), the Dorper had higher mortality rates due to suspected parasitism by *Haemonchus contortus*. The Dorper had higher FEC and

Figure 2. Fecal egg counts (FEC) of St. Croix White (open symbols) and Dorper X St. Croix White (closed symbols) lambs grazing guinea grass pastures during the dry (triangles) and wet (circles) seasons on St. Croix. FEC was higher during the dry season than during the wet season (P < 0.001).

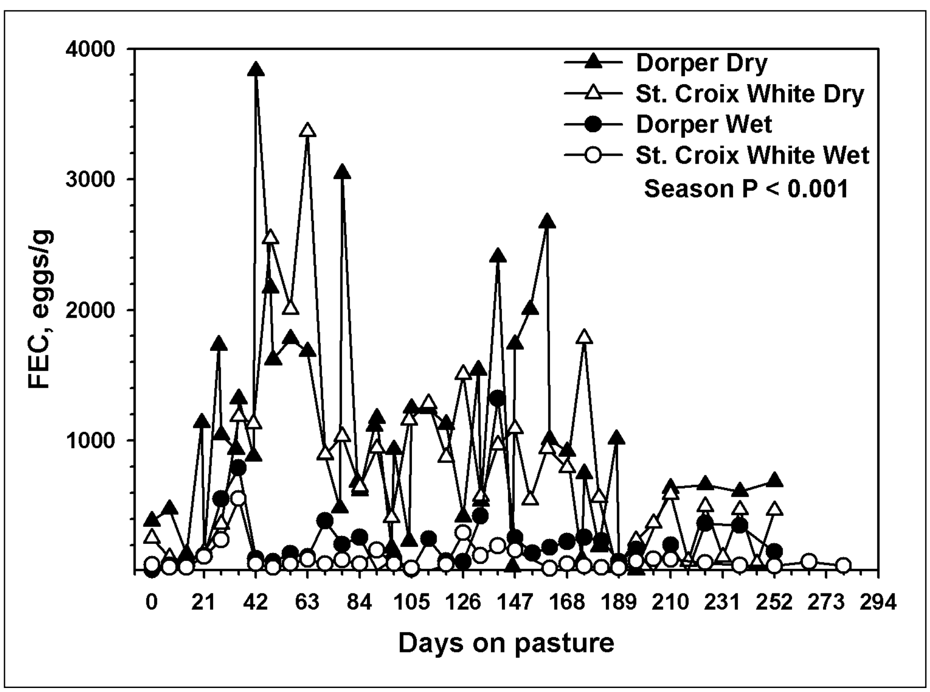


Table 5. **Revenue generated from sales and efficiency of St. Croix White and Dorper X St. Croix White lamb production.**

Revenue	Breed DRP	Breed STX
Live[a]	\$66.72 ± 0.15	\$66.64 ± 0.16
Commercial[b]	\$50.85 ± 0.52	\$51.92 ± 0.55
Individual[c]	\$56.63 ± 0.58	\$57.82 ± 0.61
Efficiency[d] (number of days to produce \$1 of revenue)		
Live	2.7 ± 0.1[e]	3.2 ± 0.1[f]
Commercial	3.5 ± 0.1[g]	4.1 ± 0.1[h]
Individual	3.2 ± 0.1[g]	3.6 ± 0.1[h]

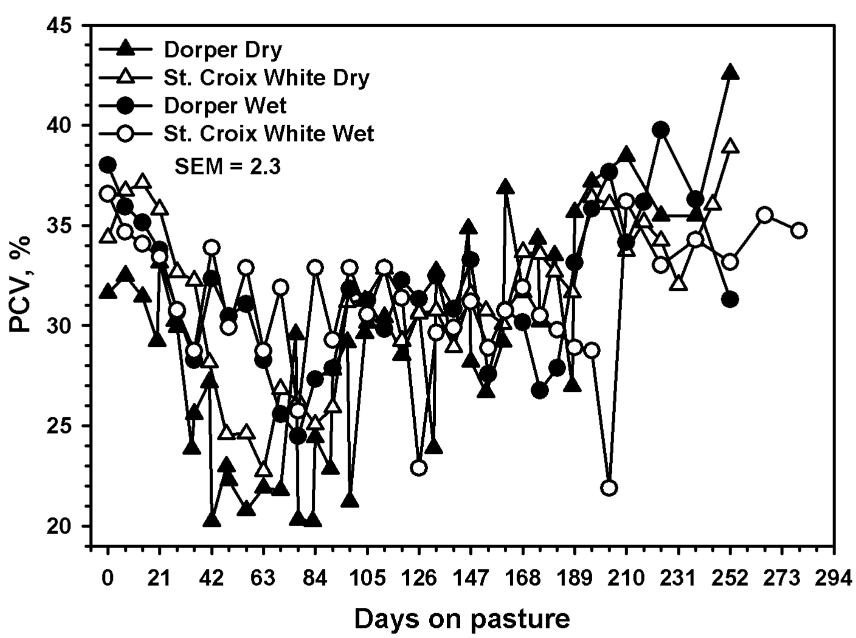
[a] Sold as live animal to ethnic consumers for \$2.21/kg
[b] Sold as carcass to local grocery stores at \$3.96/kg
[c] Sold as carcass to individual consumers ate \$4.41/kg
[d] Efficiency = number of days to slaughter / sale price

Means in a row are different: [e,f] $P < 0.0007$; [g,h] $P < 0.002$

lower PCV and subsequently higher mortality rates (Baker et al., 1999; Schoeman, 2000). Burke and Miller (2004) have reported that Dorper crossbred lambs were less resistant and required anthelmintic treatment sooner than St. Croix White lambs, when exposed to a high parasite load. In contrast, St. Croix White sheep have demonstrated tolerance to high parasite loads during the tropical rainy season (Godfrey et al., 2000).

Because all the lambs in the present study were slaughtered at a target weight (30 kg) there were no differences ($P > 0.10$) in the revenue generated among the three markets that are available to local sheep producers (Table 5). In the previous study by Godfrey and Collins (1999) where wool x hair and hair lambs were fed a concentrated ration, the crossbred lambs had higher ADG. However, the lower feed efficiency of the crossbreds and the high cost of the imported feed eliminated any economic advantage of the growth and size of the wool-sired lambs. There were differences detected in the efficiency of the lambs for the three markets. In each market the efficiency was greater ($P < 0.002$) for the DRP than for the STX lambs (Table 5). Since this variable is a measure of how many days the lambs take to produce \$1 of revenue, the shorter time to reach target weight and the higher ADG of the DRP lambs contributed to the difference in efficiency.

Figure 3. Packed cell volume (PCV) of St. Croix White (open symbols) and Dorper X St. Croix White (closed symbols) lambs grazing guinea grass pastures during the dry (triangles) and wet (circles) seasons on St. Croix. There was no difference (P > 0.10) between breeds or seasons.



Conclusion

Forage differed between seasons by amount but not quality. The DRP lambs had higher ADG, shorter time to reach target weight and heavier muscled carcasses, based on REA and leg circumference but more back fat than STX lambs. Regardless of season, DRP lambs reached the target weight approximately 30 days sooner that STX lambs. This did not impact their sale value, but was reflected in an increased efficiency. The DRP lambs grew rapidly and could tolerate parasite burdens similar to those found in the indigenous hair sheep. The heavier crossbred lambs can lead to an increase in the amount of marketable product for sheep producers without increasing costs for parasite control in an extensive management system in the U.S. Virgin Islands. Further studies need to be done using a larger sampling of sires within each breed type so that inferences are not being made from a small sample size.

Literature Cited

Baker, R.L., D.M., Mwamachim J.O., Audho, E.O. Aduda, and W. Thorpe. 1999. Genetic resistance to gastro-intestinal nematode parasites in Red Maasai, Dorper and Red Maasai X Dorper ewes in the sub-humid tropics. Anim. Sci. 69: 335-344.

Burke, J.M, and J.E. Miller. 2004. Relative resistance to gastrointestinal nematode parasites in Dorper, Katahdin, and St. Croix lambs under conditions encountered in the southeastern region of the United States. Sm. Rum. Res. 54:43-51.

Gerisch, B., and A. Antebi. 2004. Hormonal signals produced by DAF-9/cytochrome P450 regulate *C. elegans* dauer diapause in response to environmental cues. Development 131: 1765-1776.

Godfrey, R.W., H.A. Buroker, and B.M. Pannagl. 1999. Growth and carcass traits of St. Croix White (SCW) and Barbados Blackbelly x SCW (BBSC) lambs in the tropics. J. Anim. Sci. 77(Suppl. 1): 239.

Godfrey, R.W., and P.J. Hansen. 1996. Reproduction and milk yield of Holstein cows in the US Virgin Islands as influenced by time of year and coat color. Archivos Latinoamericanos de Produccion Animal. 4:31 44.

Godfrey, R.W., and J.R. Collins. 1999. Post-weaning growth and carcass traits of hair and wool x hair lambs in the US Virgin Islands. Sheep & Goat Research Journal 15:100-105.

Godfrey, R.W., R.E. Dodson, and E. Panitz. 2000. Parasite burdens of purebred and crossbred hair lambs during the wet season in a tropical environment. J. Anim Sci. 78(Suppl. 1):306.

Godfrey, R.W., and A.J. Weis. 2005. Post-weaning growth and carcass traits of St. Croix White and Dorper X St. Croix White lambs fed a concentrate diet. Sheep & Goat Res. J. 20:33-37.

Johnson, W.L., N.N. Barros, and E.R. de Oliveira. 1990. Supplemental feed resources and their utilization by hair sheep. In: M. Shelton and E.A.P. Figueiredo (Ed.) Hair Sheep Production in Tropical and Sub Tropical Regions with Reference to Northeast Brazil and the Countries of the Caribbean, Central America, and South America. pp. 79 95. Small Ruminant Collaborative Research Support Program, Davis, CA.

Kawas, J. R., and J. E. Huston. 1990. Nutrient requirements of hair sheep in tropical and subtropical regions. Page 37 in Hair Sheep Production in Tropical and Sub Tropical Regions with Reference to Northeast Brazil and the Countries of the Caribbean, Central America, and South America. M. Shelton and E.A.P. Figueiredo ed. Small Ruminant Collaborative Research Support Program, Davis, CA.

Milne, C. 2000. The history of the Dorper sheep. Sm. Rum. Res. 36: 99-102.

Notter, D.R., S.P. Greiner, and M.L. Wahlberg. 2004. Growth and carcass characteristics of lambs sired by Dorper and Dorset rams. J. Anim. Sci. 82:1323-1328.

The SAS System for Windows (v 8) 1999. Cary, NC: SAS Institute Inc.

Schoeman, S.J. 2000. A comparative assessment of Dorper sheep in different production environments and systems. Sm. Rum. Res. 36: 137-146.

Wildeus, S., K.T. Traugott, C. Wildeus, and L.R. McDowell. 1988. Growth and lambing performance of hair sheep grazing native pastures during the dry season on St. Croix, Virgin Islands. Proc. of the Caribbean Food Crop Society. pp.109 113.

Wildeus, S., and J.R. Collins. 1993. Hair sheep performance in an extensive, native pasture system: A five year summary. UVI Research 5:1 3, University of the Virgin Islands, St. Croix.

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Post-weaning Growth and Carcass Traits of St. Croix White and Dorper X St. Croix White Lambs Fed a Concentrate Diet in the U.S. Virgin Islands

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Summary

Growth and carcass traits of St. Croix White (STX; n = 22) and Dorper X St. Croix White (DRP; n = 18) lambs fed a concentrate ration were evaluated. Starting two weeks after weaning (63 d of age) lambs were fed a commercial diet at 4 percent BW•hd^{-1}•d^{-1}. Lambs were slaughtered at a BW of 30 kg. Carcass weight, fat thickness over the 12th rib, rib eye area (REA), percent KPH and leg circumference were measured. Days on feed was greater (P < 0.01) for STX than for DRP lambs (153.2 ± 6.8 d vs. 118.9 ± 7.4 d, respectively). Total weight gained was greater (P < 0.04) for STX than for DRP lambs (16.1 ± 0.5 kg. vs. 14.6 ± 0.5 kg, respectively). The ADG of DRP lambs was higher (P < 0.01) than that of STX lambs (125.1 ± 4.7 g/d vs. 108.1 ± 4.3 g/d, respectively). Carcass weight was not different (P > 0.10) between breed type (12.6 ± 0.2 kg). The REA of DRP lambs was greater (P < 0.02) than that of STX lambs (10.4 ± 0.4 cm^2 vs. 9.0 ± 0.4 cm2, respectively). Fat thickness was not different (P > 0.10) between DRP and STX lambs (1.5 mm ± 0.2 mm). Percent KPH was higher (P < 0.001) in STX than in DRP lambs (3.6 ± 0.3 percent vs. 2.2 ± 0.3 percent, respectively). Leg circumference was greater (P < 0.007) for DRP than for STX lambs (37.3 ± 0.4 cm vs. 35.7 ± 0.4 cm, respectively). Cost of gain was higher (P < 0.05) for STX than DRP lambs (4.08 ± 0.02 S/kg. vs. 3.73 ± 0.02 $/kg, respectively). Sales of DRP resulted in greater (P < 0.03) net revenue than sales of STX in each market. Dorper X St. Croix White crossbred lambs fed a concentrate ration are economically feasible due to lower cost of gain, higher ADG and revenue.

Key words: Hair Sheep, Lambs, Crossbreeding, Growth, Carcass.

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Introduction

The Caribbean sheep industry is based on breeds of hair sheep that can be traced back to African seed stock (Shelton, 1991). The predominant breed in the U.S. Virgin Islands is the St. Croix White with a small number of Barbados Blackbelly. Carcass weight of hair sheep lambs raised under a variety of conditions in the tropics has been reported to range from 4.6 kg to 18.1 kg (Martinez et al., 1991; Wildeus and Fugle, 1991; Hammond and Wildeus, 1993; Godfrey and Collins, 1999). Attempts to produce larger carcasses from hair sheep have primarily focused on crossbreeding. McClure et al. (1991) evaluated a composite breed consisting of one-quarter to one-half hair and three-quarters to one-half wool breeds and found that the crossbred lambs had lighter carcasses than straightbred wool lambs, but they were heavier than straightbred St. Croix White lambs. In our laboratory it was found that Suffolk X St. Croix White lambs had higher ADG than St. Croix White lambs but lower feed efficiency of the crossbreds and the high cost of imported feed eliminated any economic advantage of the growth and size of the Suffolk-sired lambs (Godfrey and Collins, 1999).

The introduction of Dorper sheep into the United States has led to a high level of interest in this breed in the U.S. Virgin Islands for use in crossbreeding programs. The Dorper breed was developed in South Africa by crossing Black Head Persian with Dorset Horned sheep (Milne, 2000). The Dorper sheep was initially selected for use in arid areas of South Africa. St. Croix has a semi-arid environment with an annual rainfall of 1100 mm with the majority of the precipitation occurring during the months of September though December (Godfrey and Hansen, 1996).

There is little information in the literature describing the growth performance of Dorper X hair crossbred lambs, especially under tropical conditions. Notter et al. (2004) reported that Dorper sired lambs had slightly greater backfat thickness and larger loin eye area than Dorset sired lambs. The dams of those lambs were wool ewes, and they were not reared under tropical conditions. Snowder and Duckett (2003) determined that lambs produced by Dorper terminal sires on wool-breed ewes were suited for U.S. lamb production due to the enhanced growth rate, feed efficiency and carcass traits of the lambs.

The Dorper was selected for use in crossbreeding with the Caribbean hair sheep in this project due to its heavy muscling and the fact that it was developed for use in arid, tropical areas and its coat is more typical of hair than wool. The objectives of this study were to evaluate the growth and carcass traits of St. Croix White and Dorper X St. Croix White lambs fed a concentrate ration during the post-weaning period.

Materials and Methods

St. Croix White (STX) ewes were bred to black headed Dorper (n =2) and St. Croix White (n = 2) rams to produce STX and Dorper X St. Croix White (DRP) lambs. All lambs were weaned at an age of 63 ± 3 d. For two weeks after weaning, lambs were fed a commercial pelleted diet at 2 percent BW•hd^{-1}•d^{-1} (PMI, Mulberry, FL) and had *ad libitum* access to guinea grass (*Panicum maximum*) hay, water and mineralized salt. Male lambs were surgically castrated one week after weaning. At the end of the two-week adjustment period, the lambs (n = 40) were allotted by gender and sire breed and placed into pens (3.1 X 6.1 meters). The final distribution was seven and eight DRP and STX ewe lambs and 11 and 14 DRP and STX wethers, respectively. Lambs were fed the pelleted diet at 4 percent BW• hd^{-1}•d^{-1} and had *ad libitum* access to guinea grass hay, water and mineralized salt. Feed refusals from each pen were weighed daily. Lambs were weighed each week, and the amount of feed offered was adjusted accordingly.

Lambs were slaughtered at 30 kg BW, which is the preferred size for the local market. Cold carcass weight, rib eye area measured between the 12th and 13th rib (REA), fat thickness over the 12th rib, percent KPH and rear leg circumference were recorded. Dressing percent was also determined.

Total weight gain and ADG were determined for individual lambs within each pen. Cost of gain (U.S. $/kg) was calculated on a per pen basis using the total amount (kg) and cost of feed (U.S. $0.50/kg) provided to each pen and the total weight gain of each pen (kg). Even though all lambs were slaughtered and were sold in only two of the markets, net carcass value was calculated for each of the three market outlets available in the U.S. Virgin Islands. If animals had been sold live, for religious slaughter, the price would have been $2.21/kg live weight. Commercial sale of the carcasses to a local supermarket was at the rate of $3.96/kg carcass weight and sale of carcasses to individual consumers was at the rate of $4.41/kg carcass weight. Net-carcass value was determined as the gross-sale price for each market described minus the cost of feed and slaughter fees (fixed at $6/hd).

Data were analyzed using General Linear Model procedures (SAS, 1999). Body weight during the feeding period was analyzed using repeated measures procedures. The model consisted of breed, gender, days on feed and the appropriate interactions. Carcass and economic traits were analyzed using breed, gender and the interaction in the model. All data are reported as least squares means ± SEM.

Results and Discussion

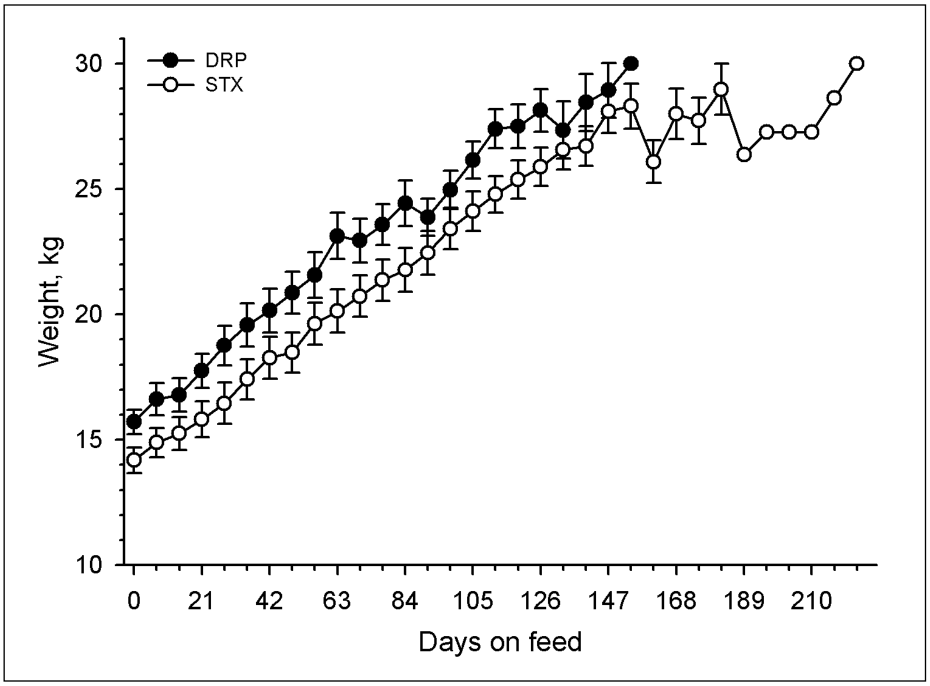
There was no effect of gender or the breed x gender interaction on any traits measured (P > 0.10) so only breed comparisons are reported. At the start of the

Table 1. Growth parameters of St. Croix White (STX) and Dorper X St. Croix White (DRP) lambs fed a concentrate diet.[a]

Breed	Days on feed	Total gain, kg	ADG, g/d
DRP	118.9 ± 7.4[b]	14.6 ± 0.5[d]	125.1 ± 4.7[b]
STX	153.2 ± 6.8[c]	16.04 ± 0.5[e]	108.1 ± 4.3[c]

[a] Lambs were provided feed (18.8% CP on DM basis) at 4% BW•hd^{-1}•d^{-1}.
[b,c] Means within a column with different superscripts are different (P < 0.01).
[d,e] Means within a column with different superscripts are different (P < 0.04).

Figure 1. Weight of St. Croix White (STX) and Dorper X St. Croix White (DRP) lambs during the feeding trial. Lambs were slaughtered at a BW of 30 kg. The DRP lambs were heavier than the STX lambs during the feeding trial (P < 0.04).



feeding trial the DRP lambs weighed more ($P < 0.007$) than the STX lambs (15.8 ± 0.5 kg. vs. 13.8 ± 0.5 kg, respectively). The number of days on feed to reach market weight ($P < 0.01$) and total weight gained ($P < 0.04$) were greater for STX than for DRP lambs (Table 1). Average daily gain was higher ($P < 0.01$) for DRP than for STX lambs (Table 1). The DRP lambs were heavier ($P < 0.04$) than the STX lambs at all times during the feeding trial (Figure 1).

Previous work in our lab has shown that crossbred (Suffolk X St. Croix White) lambs yielded heavier carcasses than St. Croix White lambs after 100 d on feed (Godfrey and Collins, 1999). This is in contrast to the present study where there was no difference in carcass weight between the STX and DRP lambs. In the previous study the crossbred lambs were heavier than the St. Croix White lambs at slaughter (34 kg vs. 29 kg, respectively), while there was no difference between breed types in slaughter weight in the present study. This is due to the fact that the lambs in the present study were slaughtered at a target weight (30 kg) and the lambs in the previous study were slaughtered after a specific number of days on feed. The ADG of the STX lambs in the present study (108 g/d) is lower than the ADG of St. Croix White lambs fed green chopped guinea grass and a coconut meal supplement (133 g/d) during a nine-week feeding trial in a previous study (Hammond and Wildeus, 1993). In a second part of the study by Hammond and Wildeus (1993) when molasses was added to the feed an even higher ADG of 142 g/d was achieved. Based on lab analysis (Dairy One, DHI Forage Testing Laboratory, Ithaca, New York) the pelleted feed used in the present study contained 18 percent CP and the hay contained 5 percent, on a DM basis. The higher ADG of the St. Croix White lambs in the study by Hammond and Wildeus (1993) is most likely due to a combination of the higher CP level in the coconut meal supplement (23 percent on a DM basis) and the guinea grass (8 percent on a DM basis; Wildeus et al., 1988). Average daily gain of the St. Croix White and Suffolk X St. Croix White lambs in a previous study (Godfrey and Collins, 1999) was higher than that of the STX and DRP lambs in the current study as well. The CP of the concentrate feed in both studies was similar (18 percent and 19 percent) but the type of hay in the diets was different. In the previous study coastal bermuda grass hay was fed, and in the present study guinea grass hay was fed. There was no nutritional analysis conducted on the coastal bermuda grass hay but it was probably higher than the 5 percent CP in the guinea grass hay used in the present study, which may account for some of the difference in ADG.

Carcass weight, either hot or cold, was not different ($P > 0.10$) between STX and DRP lambs (Table 2). The DRP lambs had greater leg circumference ($P < 0.007$) and REA ($P < 0.02$) and lower KPH ($P < 0.001$) than STX lambs (Table 2). There was no difference ($P > 0.10$) in external fat thickness or dressing percent between DRP and STX lambs.

The only differences in the carcass traits of the DRP and STX lambs were in the amount of KPH and muscle of the carcass. The STX lambs had a higher percent KPH fat than the DRP lambs,

Table 2. Carcass traits of St. Croix White (STX) and Dorper X St. Croix White (DRP) lambs.[a]

	Breed	
	DRP	STX
Hot carcass wt, kg	12.9 ± 0.2	12.9 ± 0.2
Cold carcass weight, kg	12.6 ± 0.2	12.6 ± 0.2
Leg circumference, cm	37.3 ± 0.4[b]	35.7 ± 0.4[c]
Rib eye area, cm^2	10.4 ± 0.4[d]	9.0 ± 0.4[e]
Kidney-pelvic fat, %	2.2 ± 0.3[f]	3.6 ± 0.3[g]
Backfat, mm	1.5 ± 0.2	1.4 ± 0.2
Dressing percent, %	41.3 ± 0.6	41.8 ± 0.6

[a] Lambs were slaughtered at a BW of 30 kg.
[b,c] Means within a row with different superscripts are different ($P < 0.007$).
[d,e] Means within a row with different superscripts are different ($P < 0.02$).
[f,g] Means within a row with different superscripts are different ($P < 0.001$).

Table 3. Economics of raising St. Croix White (STX) and Dorper X St. Croix White (DRP) lambs on concentrate feed.

	Breed	
	DRP	STX
Cost of gain, $/kg	3.73 ± 0.02[d]	4.08 ± 0.02[e]
Net Price		
Live market[a], $	11.77 ± 2.08[f]	0.67 ± 1.90[g]
Commercial market[b], $	-4.39 ± 2.48[f]	-15.95 ± 2.50[g]
Individual market[c], $	1.16 ± 2.53[f]	-10.42 ± 2.55[g]

[a] Sold as live animal to ethnic consumers for $2.21/kg body weight.
[b] Sold as carcass to local grocery stores at $3.96/kg carcass weight.
[c] Sold as carcass to individual consumers ate $4.41/kg carcass weight.
[d,e] Means with different superscripts within a row are different (P < 0.05).
[f,g] Means with different superscripts within a row are different (P < 0.003).

but there was very little fat deposited externally in either breed type. This pattern of fat deposition is in agreement with the results of Hammond and Wildeus (1993) and McClure et al. (1991). McClure et al. (1991) reported that hair sheep lambs were trimmer than wool lambs and deposited less fat externally. Results from our laboratory (Godfrey and Collins, 1999; Godfrey et al., 1999) have indicated that St. Croix White lambs tend to store fat in the body cavity as KPH and have very little external fat. In agreement with the present study, Dodson et al. (2005) reported that DRP lambs had higher KPH than STX lambs did, but there was no difference in back fat when lambs were raised on guinea grass pastures. The trimness of hair sheep carcasses may be useful when marketing the meat to consumers who are interested in purchasing trimmer cuts of meat for perceived dietary or health reasons. Notter et al. (2004) reported an increase in muscling in Dorper-sired lambs. The larger REA and leg circumference of the DRP lambs compared to the STX lambs in the present study is indicative of more muscling on the carcass.

The STX lambs had a higher (P < 0.05) cost of gain than DRP lambs (Table 3). In all three markets the STX lambs yielded a lower net return (P < 0.003) compared to the DRP lambs. The DRP lambs yielded a greater net price (P < 0.003) than STX lambs when they were sold as live animals or when the carcass was sold to an individual consumer (Table 3). When the carcasses were sold to a retail outlet neither group had a positive net return, but the DRP lambs yielded a smaller loss than STX lambs.

The lower net value of STX lambs in comparison to the DRP lambs in each of the markets is related to the cost of gain. The DRP lambs had higher ADG and lower days on feed, implying a greater efficiency, which contributed to the lower cost of gain and higher net value. In a previous study the higher cost of gain of the Suffolk-sired lambs contributed to them having lower economic returns compared to St. Croix White lambs even though they produced a heavier carcass (Godfrey and Collins, 1999). Because there is no local concentrate feed production, it has to be imported and this further impacts the cost of livestock production in the U.S. Virgin Islands. The cost of the feed in the present study, before shipping, was $.23/kg and the shipping added $.27/kg to the price. The high price of importing concentrated feed is the key factor in the low level of revenue reported in the present study. If the feed price, excluding shipping, is used in calculating net return, then the Dorper X St. Croix White lambs could yield net returns of $25 to $41 and the St. Croix White lambs could yield net returns $19 to $36, dependent on the market outlet. These figures are more attractive to the producer and could be realized if there was a local source of concentrated feed. Because of the low financial return obtained from growing lambs using a concentrated ration, it may not be feasible to utilize the Dorper X St. Croix White lambs, or any breed, in this type of system in the tropics. Even with the larger size and higher ADG of the Dorper X St. Croix White lambs they did not have a financial value that would support a sustainable operation based on economic analysis of sheep production in the U.S. Virgin Islands (Godfrey and D'Souza, 2001).

Conclusion

Because the crossbred lambs, sired by Dorper rams, were heavier than the straightbred hair lambs the potential exists for an increase in meat production. This weight advantage of Dorper-sired lambs allowed them to be marketed at a younger age and produce a carcass with more muscling than the straightbred hair lambs. The lower cost of gain for the Dorper-sired lambs may enhance their use under some intensive, island-management systems. While the best net value of Dorper-sired lamb carcasses was $11.77, the St. Croix White carcasses had a best net value of only $.67. This difference can be explained by the higher ADG and lower cost of gain of the Dorper-sired lambs. Further studies need to be conducted to determine if the heavier body weight of the crossbred lambs will be maintained when the lambs are raised on native pastures, instead of being fed a costly concentrated feed. In addition, further studies need to be done using a larger sampling of sires within each breed type so that inferences are not being made from a small sample size. By crossbreeding native hair sheep with the Dorper, it may be possible for sheep producers in the Caribbean to increase meat production on forage-based systems. As a precaution, Dorper rams should be limited to use as terminal sires in production systems that are raising lambs for meat and not for breeding stock. This is critical to maintain the purity of the germplasm of the indigenous hair sheep breeds in the Caribbean.

Literature Cited

Dodson, R.E., A.J. Weis, and R.W. Godfrey. 2005. Production traits of St. Croix White and Dorper X St. Croix White lambs grazing pasture during the dry and wet seasons in the US Virgin Islands. Sheep & Goat Res. J. 20:26-32.

Godfrey, R.W., H.A. Buroker, and B.M. Pannagl. 1999. Growth and carcass traits of St. Croix White (SCW) and Barbados Blackbelly x SCW (BBSC) lambs in the tropics. J. Anim. Sci. 77(Suppl. 1):239. (Abstr.)

Godfrey, R.W., and J.R. Collins. 1999. Post-weaning growth and carcass traits of hair and wool x hair lambs in the US Virgin Islands. Sheep and Goat Res. J. 15:100-105.

Godfrey, R.W., and G. D'Souza. 2001. Hair sheep production in the U.S. Virgin Islands: Management practices and economic analysis. University of the Virgin Islands, St. Croix.

Godfrey, R.W., and Hansen, P.J. 1996. Reproduction and milk yield of Holstein cows in the US Virgin Islands as influenced by time of year and coat color. Arch. Latinoam. Prod. Anim. 4:31-44.

Hammond, A.C., and Wildeus, S. 1993. Effects of coconut meal or fish meal supplementation on performance, carcass characteristics and diet digestibility in growing St. Croix lambs fed a tropical grass based diet. Sm. Rum. Res. 12:13 25.

Martinez, A., C. Burwell, K. Young, and J. Robinson. 1991. Response of lambs to concentrate feeding in Antigua. Pages 222-227 in Proc. Hair Sheep Res. Symp., University of the Virgin Islands St. Croix.

McClure, K.E., Parker, C.F. and N.A. Parrett. 1991. Feedlot performance and carcass characteristics of hair, wool and hair crossbred lambs fed high energy diets. Pages 252-256 in Proc. Hair Sheep Res. Symp., University of the Virgin Islands St. Croix.

Milne, C. 2000. The history of the Dorper sheep. Sm. Rum. Res. 36: 99-102.

Notter, D.R., S.P. Greiner, and M.L. Wahlberg. 2004. Growth and carcass characteristics of lambs sired by Dorper and Dorset rams. J. Anim. Sci. 82:1323-1328. The SAS System for Windows (v 8) 1999. Cary, NC: SAS Institute Inc.

Shelton, M. 1991. Hair sheep production under temperate and tropical conditions. Pages 65-84 in Proc. Hair Sheep Res. Symp., University of the Virgin Islands St. Croix.

Snowder, G.D., and S.K. Duckett. 2003. Evaluation of the South African Dorper as a terminal sire breed for growth, carcass, and palatability caharcteristics. J. Anim. Sci. 81:368-375.

Wildeus, S., and J.R. Fugle. 1991. Effects of supplementation on growth and carcass characteristics of hair sheep lambs grazing native tropical pasture. Pages 243-251 in Proc. Hair Sheep Res. Symp., University of the Virgin Islands St. Croix.

Wildeus, S., K.T. Traugott, C. Wildeus, and L.R. McDowell. 1988. Growth and lambing performance of hair sheep grazing native pastures during the dry season on St. Croix, Virgin Islands. Pages 109-113 in Proc. of the Caribbean Food Crop Soc.

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Growth Performance of Barbados Blackbelly, Katahdin and St. Croix Hair Sheep Lambs Fed Pasture- or Hay-based Diets[1]

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Summary

Two experiments evaluated growth of mixed-sex Barbados Blackbelly, Katahdin, and St. Croix hair sheep lambs raised on pasture or hay-based diets with moderate levels of energy supplementation. In Experiment 1, 36 ewe and wether lambs were allocated to a pasture or pen feeding group in May. Pasture animals rotationally grazed tall fescue pasture, while pen animals were offered chopped alfalfa hay, and both groups were supplemented with corn/soybean meal at 0.75% of body weight. In Experiment 2, 72 lambs were allocated to pen and pasture in April, and provided either a low or high crude protein concentration corn/soybean meal supplement at 1.5% of body weight. Pasture animals were continuously grazed, while pen animals were offered chopped mixed grass hay. In both experiments, starting and final body weights were higher ($P < 0.05$) in Katahdin than St. Croix and Barbados Blackbelly. In Experiment 1, daily gain was similar between Katahdin (84 g/d) and St. Croix (75 g/d), and higher ($P < 0.01$) than in Barbados Blackbelly (56 g/d). Daily gain was higher ($P < 0.05$) for lambs in pens (77 g/d) than for lambs on pasture (67 g/d). In Experiment 2, growth rates were higher than in Experiment 1, and Katahdin (109 g/d) grew faster ($P < 0.05$) than St. Croix (86 g/d) and Barbados Blackbelly (73 g/d). Growth was not affected ($P > 0.10$) by forage or supplement type, but wether lambs grew faster ($P < 0.05$) than ewe lambs. The growth rates in both trials were moderate and produced lambs of medium size, suitable primarily for the Muslim and Hispanic ethnic markets.

Key words: Hair Sheep, Growth, Forage, Supplementation.

This manuscript submitted as part of the Hair Sheep Workshop sponsored by the National Sheep Industry Improvement Center and the NCERA-190 research project, June 21-23, 2005 at Virginia State University.

Introduction

Hair sheep are smaller in size and have slower growth rates than most wool breeds in the United State. However, they perform well under low-input, sustainable production systems, and are able to utilize low- to moderate-quality forages. Hair sheep resources in the United States and their performance have been reviewed by Wildeus (1997). Under feedlot conditions using high-concentrate finishing diets, hair sheep had 35 percent to 40 percent slower growth rates than wool breeds in Ohio (Ockerman et al., 1982; McClure et al., 1991), 27 percent to 42 percent slower growth rates in Utah (Foote, 1983; Bunch et al., 2004), and 20 percent slower growth rates in Oklahoma (Philips et al., 1995). In contrast, Mann et al. (1987) reported that growth rates of hair sheep lambs (Barbados Blackbelly) exceeded those of wool lambs (Dorset) fed moderate-quality forage diets (Coastal bermudagrass pellets) in North Carolina.

With an expansion of ethnic lamb markets that accept smaller and leaner carcasses, there is a need to evaluate the ability of hair sheep to produce lamb for these niche and specialty markets on forage-based rations with limited grain supplementation. The experiments described here were designed to evaluate the growth performance of Barbados Blackbelly, Katahdin, and St. Croix hair sheep lambs fed forage-based rations of either pasture or hay with limited supplementation and management input.

Materials and Methods

The experiments were conducted at the Small Ruminant Program Facilities of Virginia State University, followed accepted guidelines for the care and use of animals in agricultural research and teaching (FASS, 1999), and were approved by the Institutional Animal Care and Use Committee. Katahdin and St. Croix flocks at this facility were established in 1997 and 1999, respectively, from a diverse, genetic cross-section of each breed representing a minimum of five breeders and are maintained as purebred populations with several sire lines. Polled Barbados Blackbelly sheep have a very narrow genetic base in the United States. Animals in our facility were received in 1998 from a single source and were crossed with polled rams from another unrelated flock to increase genetic diversity. All three flocks are considered representative of these breeds in the eastern United States.

Both experiments used December-born Barbados Blackbelly, Katahdin, and St. Croix lambs, produced in separate years in an 8-month, accelerated-mating system, using two single-sire mating groups per breed in each year. Different sires were used in the two years. Lambs were weaned at 63±3 days of age, maintained as one group, and ram lambs were castrated prior to use in the experiments. In Experiment 1, ewe and wether lambs (n=36) were allocated to a pasture or pen feeding group in May, stratified by breed and sex. Pasture animals were maintained on native, predominantly tall fescue (*Festuca arundinacea* Schreb.) pasture (1.5 ha; see Table 1 for nutritional quality), subdivided into three units for rotational stocking. Forage biomass availability exceeded consumption by lambs throughout the grazing season. Pen animals were allocated to six partially covered pens (26 m^2 floor space) stratified by breed and separated by sex, and offered *ad libitum* chopped alfalfa (*Medicago sativa* L.) hay (Table 1). Both groups were supplemented with a corn/soybean meal mixture (calculated composition: 15.7 percent CP and 74.7 percent TDN) at 0.75 percent of body weight. Supplement also contained 2 percent limestone and 1 percent ammonium chloride. Supplementation level was selected to improve growth rate, with forage remaining the major component of the diet.

In the second year (Experiment 2), 72 mixed-sex lambs of the same three breeds were allocated to pen and pasture groups in April, stratified by breed and sex. In Experiment 2 animals were supplemented at a higher level (1.5 percent BW) to allow breeds to more readily express their growth potential. Isocaloric supplements with either a low protein (16.8 percent CP) or high protein content (24.3 percent CP) were fed to determine the effect protein intake on parasite resilience and forage utilization. Supplement feeds were prepared from an appropriate corn/soybean meal mixture, and contained 2 percent limestone and 1 percent ammonium chloride. Pasture animals were allocated to the same pasture area as in Experiment 1, divided into two 0.8 ha units to facilitate feeding of the two supplements. Despite higher stocking rates than Experiment 1, forage biomass availability exceeded consumption by lambs throughout the grazing season. Pen animals were allocated to six partially covered pens (44 m^2 floor space), balanced by breed and sex (3 pens per supplement type), and were offered *ad libitum* chopped mixed grass hay (Table 1).

Animals remained on trial for 168 days in Experiment 1 and 180 days in Experiment 2. In both experiments body weights were recorded at 14-day intervals and supplement levels adjusted at this time. In both experiments lambs had access to trace mineralized salt blocks. Lambs were dewormed (moxidectin, oral, 0.5 mg/kg BW) once at the beginning of each experiment with no further dewormings. Packed blood cell volume (PCV) was determined in all lambs at 14-day intervals to monitor for clinical signs of gastrointestinal parasitism, but PCV never decreased below a pre-determined threshold (17 percent) to be used for strategic deworming of individual animals.

Pasture samples were collected (4 sites) at 28-day intervals throughout the grazing season, and hay samples were collected at the beginning, middle and end of the experiment to determine forage quality. Samples were dried at 60°C

Table 1. Nutritional quality of pasture and hay fed in Experiments 1 and 2

% (DM basis)	Pasture[1]	Alfalfa hay (Exp. 1)	Grass hay (Exp. 2)
CP	12-17	16.6	15.1
NDF	66-69	60.3	67.6
ADF	36-38	45.2	36.7
IVOMD	34-60	57.6	54.2

[1] range throughout the grazing season

in a forced-air oven for 48 h, and ground to pass a 1-mm screen in a Wiley mill. Ground samples were analyzed for DM and ash (AOAC, 1990); total N (Carlo-Erba Ea 1108 CHNS elemental analyzer, Fisons Instruments, Beverly, MA); neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Goering and Van Soest, 1970; Van Soest et al., 1991) using ANKOM (Ankom Technology Corp., Fairport, NY) procedures, and *in vitro* organic matter disappearance (IVOMD) (Tilley and Terry, 1963; Moore, 1970).

Initial and final body weight and daily gain were analyzed with a statistical model that included breed, forage base, sex and their interactions as main effects in Experiment 1; and breed, forage base, supplement type, sex and their interaction as main effects in Experiment 2 using the GLM procedure of SAS (1996). Pen was excluded from the final model as a non-significant effect after preliminary analysis. Contrasts between breeds were evaluated using the PDIFF option in the presence of a significant F value.

Results and Discussion

Starting body weight of lambs in both experiments were higher ($P < 0.01$) in Katahdin than Barbados Blackbelly and St. Croix, and reflected the difference in mature body weight of these breeds. At our location body weight of Barbados Blackbelly, Katahdin and St. Croix ewes range from 38 kg to 40 kg, 58 kg to 60 kg and 45kg to 50 kg, respectively. In Experiment 1, there was no difference ($P < 0.1$) in starting body weight between St. Croix and Barbados Blackbelly, but daily gain was higher ($P < 0.05$) in St. Croix than Barbados Blackbelly and actually similar to Katahdin. As a result, final body weight was different ($P < 0.05$) for all three breeds. Pen-fed lambs receiving alfalfa hay grew faster ($P < 0.05$) than lambs grazing pasture (Figure 1). There was no effect of sex of lamb on daily gain (Table 2), nor were there significant interactions between breed and forage base.

In Experiment 2, lambs were one month younger at the beginning of the experiment and had lower starting weights than in Experiment 1, but starting weights differed ($P < 0.05$) among all three breeds (Table 3). Daily gain was higher in Experiment 2 than Experiment 1, and higher ($P < 0.001$) in Katahdin than in St. Croix, which were higher ($P < 0.05$) than Barbados Blackbelly (Figure 2). No difference was observed in daily gain between pen and pasture-raised lambs, or between lambs receiving the high or low protein supplement (Table 3), but wether lambs grew faster ($P < 0.01$) than ewe lambs. Again, no significant interactions between breed, forage base, supplement type and sex were observed in Experiment 2.

Differences in growth rates between the two experiments were likely the result of the increased level of supplement feeding in Experiment 2, and possibly some faster growth in the younger, lighter animals. The higher level of supplement feeding also allowed Katahdin

Figure 1. Body weight change (LSM) in Barbados Blackbelly (BB), Katahdin (KA), and St. Croix (STX) lambs fed alfalfa hay (pen) or pasture (past) with corn/soybean meal supplement at 0.75% BW

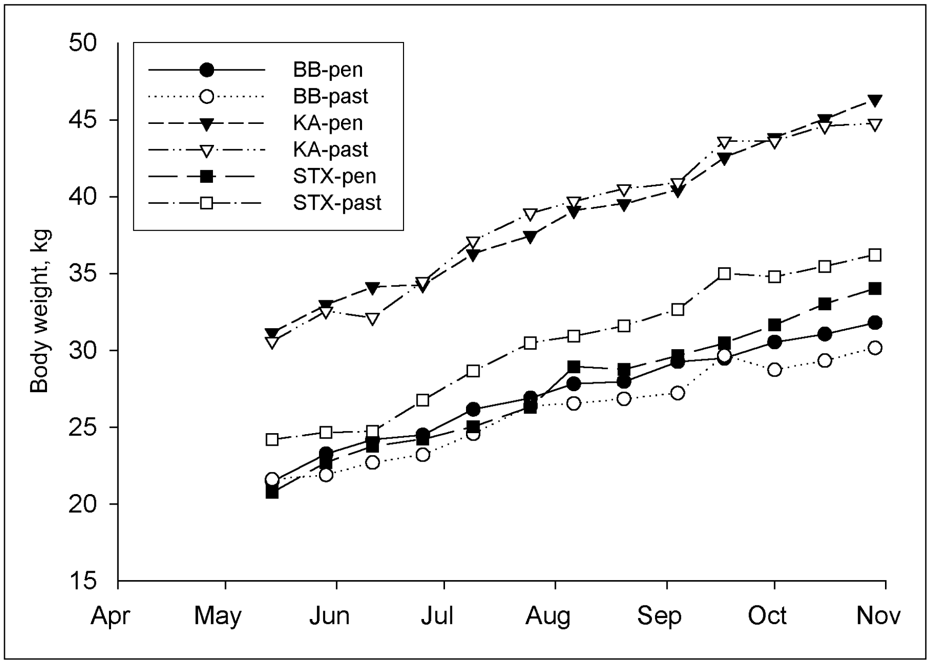
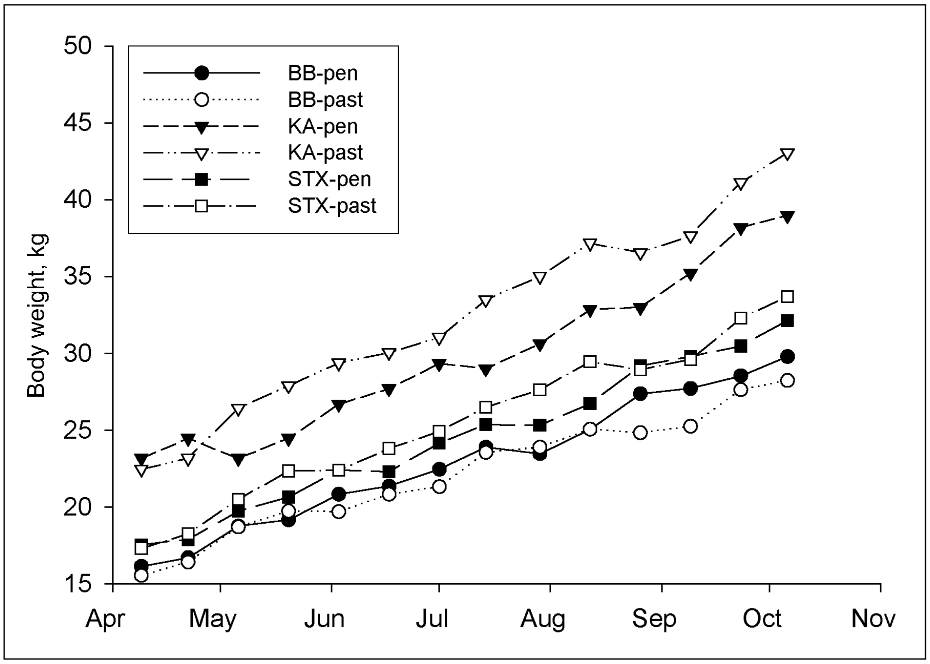


Table 2. Effect of breed, forage base and sex on body weight and daily gain (LSM) in hair sheep lambs fed pasture and hay-based diets, supplemented with corn/soybean meal at 0.75% BW (Experiment 1)

	Starting weight, kg	Final weight, kg	Daily gain, g/d
Breed			
Blackbelly	21.5[a]	31.0[a]	56[a]
Katahdin	31.4[b]	45.5[c]	84[b]
St. Croix	22.5[a]	35.1[b]	75[b]
SE	1.10	1.43	4.0
Forage base			
Pasture	25.8	37.0	67[a]
Alfalfa hay	24.4	37.4	77[b]
SE	0.89	1.17	3.3
Sex			
Ewe	24.7	36.9	72
Wether	25.5	37.5	71
SE	0.90	1.17	3.3

[a,b,c] values in same column with unlike superscripts within same category differ ($P<0.05$)

Figure 2. Body weight change (LSM) in Barbados Blackbelly (BB), Katahdin (KA), and St. Croix (STX) lambs fed grass hay (pen) or pasture (past) with corn/soybean meal supplement at 1.5% BW



lambs to express their increased growth potential compared to St. Croix and Barbados Blackbelly. The same reasoning may account for the higher daily gain of wether compared to ewe lambs in Experiment 1 compared to Experiment 2. In Experiment 2 the higher level of supplement feeding may have masked differences in daily gain in lambs on pasture and hay-based diets.

Lambs in both experiments had lower growth rates than hair sheep lambs fed finishing diets in several other studies. St. Croix lambs fed concentrate diets achieved growth rates of 259 g/d (Foote, 1983), 210 g/d (Bunch et al., 2004), 200 g/d (McClure et al., 1991), and 187 g/d (Philips et al., 1995). Under more stressful, tropical production conditions in the Caribbean, St. Croix lambs fed a complete pelleted ration of 19 percent crude protein at 4 percent of body weight and *ad libitum* coastal bermuda grass hay had an average daily gain 144 g/d (Godfrey and Collins, 1999). These studies suggest that the hair sheep lambs in the present experiment fed a forage-based diet grew below their production potential.

Few studies have directly compared the growth performance of the breed types evaluated here. Horton and Burgher (1992) fed small groups of Barbados Blackbelly, Katahdin and St. Croix lambs (3 to 4 lambs/breed) a commercial pelleted growing ration (16 percent crude protein) and achieved average daily gains of 138, 267 and 203 g/d, respectively. Although the actual growth rates were higher in their study, the relative growth performance of the three was similar to that observed here. In a study using Katahdin and St. Croix among other breeds, Burke et al. (2003) reported an average post weaning daily gain of 181 and 205 g/d in Katahdin and St. Croix lambs, respectively, fed a finishing diet formulated for moderate growth in Arkansas. This ranking in growth performance of the two breeds is in contrast to the results here, and may have been caused by the stress in the Katahdin lambs in Arkansas due to relocation just prior to the experiment. Ockerman et al. (1982) observed a faster daily gain in St. Croix (222 g/d) than Barbados Blackbelly lambs (172 g/d) when fed a high concentrate diet, in agreement with breed differences observed here.

The growth rates of the lambs in both experiments were higher than those reported in Barbados Blackbelly and Barbados Blackbelly x Dorset lambs fed Coastal bermudagrass pellets (50 g/d; Mann et al. 1987), likely as a result of the higher quality forage (both pasture and alfalfa and grass hay) and moderate levels of supplementation employed in the present experiments. Hair sheep lambs fed tropical forages had growth rates that ranged from 34 g/d in St.

Table 3. Effect of breed, forage base, supplement type, and sex on body weight and daily gain in hair sheep lambs fed pasture and hay-based diets, supplemented at 1.5% BW (Experiment 2)

	Starting weight, kg	Final weight, kg	Daily gain, g/d
Breed			
Blackbelly	15.8[a]	29.0[a]	73[a]
Katahdin	22.8[c]	42.5[c]	109[c]
St. Croix	17.4[b]	32.9[b]	86[b]
SE[1]	0.54	0.79	3.7
Forage base			
Pasture	18.4	34.9	92
Grass hay	18.9	34.6	87
SE	0.44	0.64	3.0
Supplement			
Low protein	18.6	34.0	86
High protein	18.8	35.5	93
SE	0.44	0.64	3.0
Sex			
Ewe	18.2	33.2[a]	83[a]
Wether	19.2	36.4[b]	95[b]
SE	0.44	0.64	3.0

[a,b,c] values in same column with unlike superscripts within same category differ (P<0.05)

[1] pooled standard error of means

Croix lambs fed guineagrass (Hammond and Wildeus, 1993) and Blackhead Persian lambs fed rhodesgrass (Sarwatt, 1990) to 44 g/d in Somali lambs fed napiergrass (Barros et al. 1990). Performance of lambs in these trials generally improved with protein, but not energy supplementation. In contrast, no difference in growth rate was observed in lambs fed either the high or low protein supplement in Experiment 2, which could be attributed to the higher crude protein concentration in both pasture and grass hay in the present experiments, compared to those of tropical grasses. Experiment results further suggest that protein was not a limiting factor, either as a component of forage utilization or the ability of lambs to cope with gastrointestinal parasitism.

Conclusion

Growth rates generally reflected the mature size of the three breeds, however, there was no difference in growth between Katahdin and St. Croix lambs when a lower level of concentrate supplement was supplied. This suggests that Katahdin were not able to express their improved growth potential on a high-forage diet. Overall, growth rates in both experiments were moderate and considerably lower than has been achieved for these breeds when fed high concentrate diets. The final weight of lambs at the end of the grazing season made them suitable primarily for the Muslim and Hispanic ethnic market, rather than the traditional lamb market.

Literature Cited

AAOC, 1990. Official methods of analysis. 15th ed. Association of Official Analytical Chemists, Arlington, VA.

Barros, N. N., J. Kawas, W. L. Johnson and J. M. Shelton. 1990. Energy utilization by Somali lambs fed napier grass 'ad libitum' and energy supplement in incremental levels. Pesq. Agropec. Bras. 25: 1283-1291.

Bunch, T. D., R. C. Evans, S. Wang, C. P. Brennand, D. R. Whittier and B.J. Taylor. 2004. Feed efficiency, growth rates, carcass evaluation, cholesterol level and sensory evaluation of lambs of various hair and wool sheep and their crosses. Small Rumin. Res. 52: 239-245.

Burke, J. M., J. K Apple, W. J. Roberts, C. B. Boger and E.B. Kegley. 2003. Effect of breed-type on performance and carcass traits of intensively managed hair sheep. Meat Sci. 63: 309-315.

FASS. 1999. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. 1st rev. ed. Fed. Anim. Sci. Soc., Savoy, IL.

Foote, W. C. 1983. The St. Croix sheep in the United States. In: Fitzhugh, H. A. and G. E. Bradford (Eds), Hair Sheep of Western Africa and the Americas: A Genetic Resource for the Tropics. Westview Press, Boulder, Colorado. pp. 275-287.

Goering, J. K., and P. J. Van Soest. 1970. Forage fiber analysis (apparatus, reagents, procedures, and some applications). Agriculture Handbook 370, USDA-ARS, Washington, DC, 20 pp.

Godfrey, R. W. and J. R. Collins. 1999. Post-weaning growth and carcass traits of hair and wool x hair lambs in the U.S. Virgin Islands. Sheep & Goat Res. J. 15: 100-105.

Hammond, A. C. and S. Wildeus. 1993. Effect of coconut meal or fish meal supplementation on performance, carcass characteristics and diet digestibility in growing St. Croix lambs fed a tropical grass-based diet. Small Rumin. Res. 12: 13-25.

Horton, G. M. J. and C. C. Burgher. 1992. Physiological and carcass characteristics of hair sheep and wool breeds of sheep. Small Rumin. Res. 7: 51-60.

Mann, D. L., L. Goode and K. R. Pond. 1987. Voluntary intake, gain, digestibility, rate of passage, and gastrointestinal tract fill in tropical and temperate breeds of sheep. J. Anim. Sci. 64: 880-886.

McClure, K. E., C. F. Parker and N. A. Parrett. 1991. Feedlot performance and carcass characteristics of hair, wool and hair crossbred lambs fed high energy diets. In: Wildeus S. (Ed.), Proc. Hair Sheep Research. Symposium., University Virgin Islands, St. Croix. pp. 252-256

Moore, J. E. 1970. Procedure for the two-stage in vitro digestion of forages. In: Harris, L. E. (Ed.), Nutrition Research Techniques for Domestic and Wild Animals, vol. I. Utah State University, Logan, pp. 5001.1-5001.3.

Ockerman, H. W., H. Emsen, C. F. Parker and C. J. Pierson. 1982. Influence of type (wooled or hair) and breed on growth and carcass characteristics and sensory properties of lambs. J. Food Sci. 47: 1365-1371.

Phillips, W.A., D. L. Von Tungeln and M. A. Brown. 1995. Feedlot performance of spring born Polypay, Romanov, St. Croix, and Texel crossed lambs finished during the summer. J. Anim. Sci. 73) (Suppl. 1) 252 (Abstr.).

Sarwatt, S. V. 1990. Feed intake, growth rate and digestibility coefficients of growing sheep fed hay supplemented with *Crotalaira ochroleuca*. Anim. Feed Sci. Technol. 28: 51-59.

SAS Institute Inc., 1996. SAS User's Guide: Statistics, 6th ed. SAS, Cary, NC, p. 956.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Br. Grassl. Soc. 18: 34-43.

Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3597.

Wildeus, S., 1997. Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. J. Anim. Sci. 75: 630-640.

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Gastrointestinal Parasitism in Hair Sheep and Meat Goat Breeds Grazing Naturally Infected Pasture[1]

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Summary

Differences in indicators of gastrointestinal parasitism between species, breeds within species, and two grazing systems (goats only) were evaluated in a total of 66 does and 22 ewes (11 animals/breed/management system), representing four goat and two sheep breeds. Animals were either grazed continuously (does and ewes, n=66), or rotationally on 0.4 ha of pre-dominantly fescue pastures (does only, n=22). Fecal and blood samples were collected in 14-day intervals from mid-May until October. Animals were dewormed (ivermectin, sc, 0.3 mg/kg) by breed group when breed composites (five animals/breed) exceeded 1000 eggs/g. Data were analyzed in subsets for species, breed, and grazing management comparisons. Hair sheep had lower mean FEC (376 vs. 669 eggs/g; $P < 0.01$) and higher mean PCV (31.9 percent vs. 26.5 percent; $P < 0.001$) than the goats. Within hair sheep, Katahdin had lower FEC (242 vs. 518 eggs/g; $P < 0.01$) and were dewormed less frequently (2 vs 7) than the Barbados Blackbelly. In goats, Nubian and Spanish (1035 and 865 eggs/g, respectively) had higher ($P < 0.01$) mean FEC than Myotonic and Pygmy (413 and 359 eggs/g, respectively), and were dewormed five, four, three, and three times, respectively, during the experimental period. Fecal egg counts were similar in goats under rotational, compared to continuous grazing. Hair sheep appeared to be more resistant to parasites than goats, however, differences may have been masked by considerable breed variation within species. The anthelmintic treatment protocol may have prevented breeds from expressing their ability to tolerate gastrointestinal parasites.

Key words: Hair Sheep; Meat Goats, Gastrointestinal Parasitism; Fecal Egg Counts; Packed Cell Volume

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Introduction

Gastrointestinal parasitism, especially infection with the barber pole worm (*Haemonchus contortus*), is a major constraint to goat and sheep production in the Southeastern United States, where environmental conditions (warm and humid) are ideal for survival of the parasite. Traditionally, nematode parasites have been controlled with the use of anthelmintics, but these products are losing their effectiveness (Kaplan, 2004; Zajac and Gipson, 2000; Miller and Barras, 1994). Other means of parasite control involve pasture management (reseeding, rest/rotation, haying, mixed species grazing), and a number of experimental approaches, such as feeding condensed tannin feeds (Min et al., 2004), oral dosing with nematode-trapping fungi (Terrill et al., 2004) and copper wire particles (Burke et al. 2004), and liquid-nitrogen fertilization of pastures (Howell et al. 1999). However, these approaches have not shown the same level of efficacy to which producers have been accustomed with anthelmintics. Hence, the inherent ability of sheep and goat breeds to cope with parasitism is becoming increasingly important.

Goats and hair sheep fit well into forage-based production systems in a farm-flock setting in the southeastern and mid-Atlantic region of the United States. The lambs and kids produced are smaller and lighter than wool lambs and are suited for the expanding ethnic niche markets located near urban centers. Product requirements vary with the targeted ethnic market, and dual species production systems may be useful to take full advantage of marketing opportunities. Information is needed on management requirements and performance differences when the two species are comanaged. The current experiment was designed to evaluate differences in parasite resistance in goats and hair sheep comanaged on naturally infected pastures.

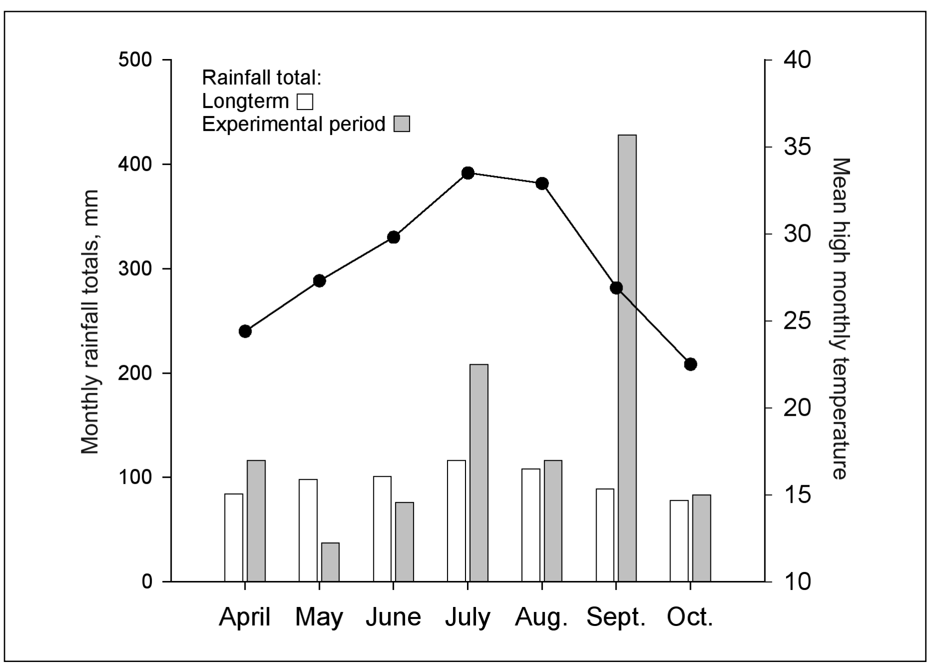
Materials and Methods

The experiment was conducted at the Small Ruminant Program Facilities of Virginia State University and followed accepted guidelines for the care and use of animals in agricultural research and teaching (FASS, 1999). A total of 66 does and 22 ewes (11 animals/breed/grazing management system), confirmed pregnant to a March mating, were randomly selected for the experiment. Hair sheep breeds included Barbados Blackbelly and Katahdin, and goat breeds Myotonic (Fainting), Nubian, Pygmy and Spanish. With the exception of Barbados Blackbelly, breed populations at the Small Ruminant Program were established from a diverse cross-section representing animals from a minimum of five breeders, and are maintained as purebred populations with several sire lines. The breeds should be considered representative of these populations in the southern United States.

Randomly selected does and ewes (n=66) in the main herd continuously grazing naturally parasite-infected (goats had grazed these pastures over the past six years) predominantly fescue pasture, at a stocking rate of 35 breeding females/ha, were sampled. A subset of Myotonic and Spanish goats (n=22) was also sampled in a goat herd rotationally grazing pre-dominantly fescue pasture on 0.4 ha units at the same location at a stocking rate of 30 does/ha. Frequency of pasture rotation in this system was based on forage availability and quality. During late pregnancy and lactation does and ewes were supplemented with corn/soybean meal mix (16 percent CP) at 0.5 percent of body weight. Fecal and blood samples were collected in 14-day intervals throughout the grazing season from mid-May until October. Fecal egg counts (FEC) were determined using the modified McMaster technique (Whitlock, 1948), and blood was processed to determine packed-cell volume (PCV). Breed groups were dewormed (ivermectin, sc, 0.3 mg/kg) when composite FEC exceeded 1000 eggs/g. Composite FEC was employed as the routine parasite-management tool in the Virginia State University herd at the time of the study, and was determined from five randomly selected animals from each breed group within a sex class and management system at two-week intervals. Composite samples were analyzed within 24 h of sampling and breed groups dewormed if they exceeded the pre-determined limit. Animals contributing to the composite samples were selected at random and were not necessarily part of the animals sampled for this experiment.

Fecal egg counts and PCV were analyzed by repeated-measures analysis using the GLM procedure of SAS (SAS, 1996) and are presented as least-squares-mean values for the grazing season. Differences in FEC were statistically analyzed after log transformation, but are presented as arithmetic means. Data were analyzed in subsets to determine effects of species, breed within species

Figure 1. Longterm monthly total rainfall (white bars) and monthly total rainfall (grey bars) and mean daily maximum temperatures (line) during the duration of the experiment.



and grazing management. Models included species, breed, animal within breed, sampling time, days from previous deworming, and production stage (pregnant, lactating) as main effects.

Results and Discussion

Monthly rainfall totals and mean monthly maximum temperatures for the duration of the experiment and the long-term average monthly rainfall totals are presented in Figure 1. Rainfall totals during the experiment exceeded the long-term average for this location and provided a favorable environment for nematode larval development, and represented conditions typically experienced by goats and sheep in southeastern Virginia. In this study observations on seasonal changes in parasite burden were confounded with stage of production, and no attempt was made to determine effects of season and stage of production on FEC.

Fecal egg count was higher, and PCV was lower in four breeds of does than in two breeds of ewes continuously grazed (P < 0.001; Table 1). These findings correspond to other observations at our location that suggest that meat goat breeds are less resistant to nematode parasites than hair sheep breeds (Wildeus, unpublished data). There is limited published information comparing indicators of gastrointestinal parasitism in goats and sheep in co-grazed herds. Papadopoulos et al. (2003) reported that parasite burdens were significantly higher in Greek dairy sheep than dairy goats in commercial herds in the same geographic regions, but managed separately. This difference between the studies may be related to the considerable difference between breeds within species. Several studies have shown hair sheep breeds to be more parasite resistant than most wool breeds, with lambs requiring anthelmintic treatment less frequently during natural infection (Amarante et al., 2004), and maintaining lower FEC in response to experimental infections (Gruner at al. 2003; Notter et al., 2003). Therefore differences observed between the two species are likely specific to hair sheep, and should not be extrapolated to wool sheep.

Katahdin ewes had lower mean FEC (Table 1; P < 0.01) compared to Barbados Blackbelly ewes, and were dewormed less frequently during the experimental period (2 vs. 7; Figure 2). Fecal egg counts in Katahdin ewes increased in July, coinciding with seasonal rainfall and onset of lambing, but remained negligible for the remainder of the grazing period, while Barbados Blackbelly ewes were also elevated in late spring and early summer and declined only in late

Table 1. Effect of species, breed within species, and grazing management on mean fecal egg count (FEC) and packed blood cell volume (PCV) during the annual grazing season (May to October) in Virginia.

	n	FEC	PCV
Species†			
Goats	44	669	26.5
Sheep	22	376	31.9
P-value		.001	.001
Hair sheep†			
Barbados Blackbelly	11	518	31.8
Katahdin	11	242	32.0
P-value		.001	.621
Meat goats†			
Myotonic	11	421[b]	26.4[b]
Nubian	11	1035[a]	28.4[a]
Pygmy	11	359[b]	25.5[c]
Spanish	11	865[a]	25.8b[c]
Grazing management‡			
Continuous	22	657	26.1
Rotational	22	824	26.8
P-value		.554	.011

† animals managed under a continuous grazing system
‡ data on grazing management determined for Myotonic and Spanish goats only
[abc] values for meat goats in same column with unlike superscripts differ significantly (P < 0.05)

Figure 2. Variation in fecal egg counts (FEC) in two hair sheep breeds continuously grazed during the experiment; arrows indicate the time of deworming of the breeds listed.

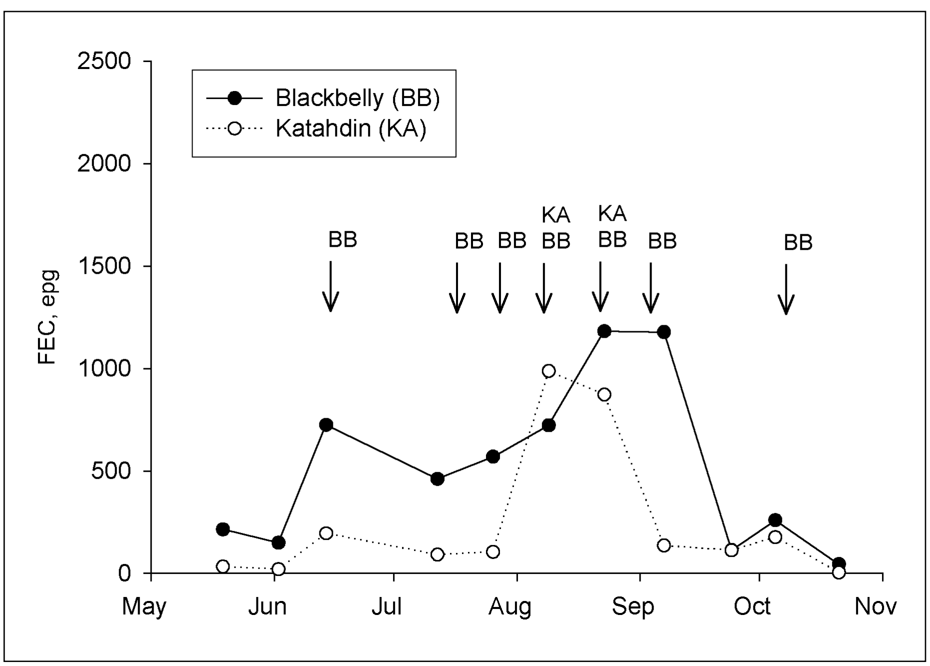
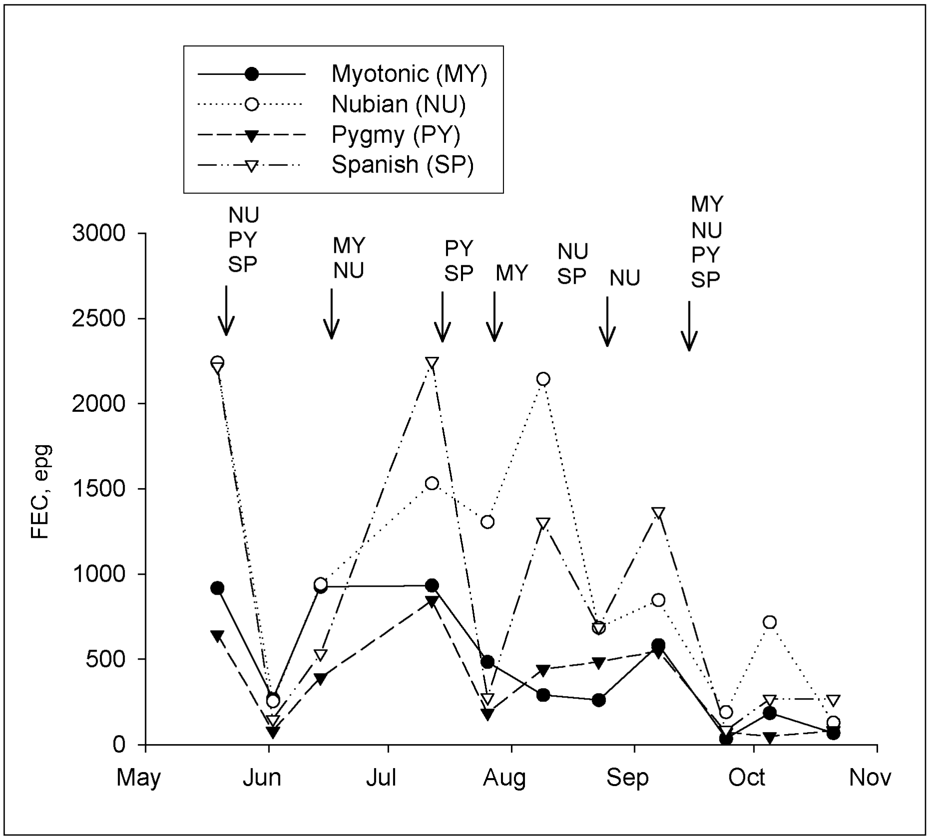


Figure 3. Variation in fecal egg counts (FEC) in four goat breeds continuously grazed during the experiment; arrows indicate the time of deworming of the breeds listed.



September (Figure 2). Barbados Blackbelly in the Caribbean were reported to be parasite resistant (Gruner et al., 2003). In the United States Barbados Blackbelly have not shown the same degree of parasite resistance as St. Croix sheep, but were more resistant than most wool breeds (Courtney et al., 1985). The reduced parasite resistance in Barbados Blackbelly may be unique to the population on the U.S. mainland, which was crossbred since being imported in 1904. Barbados Blackbelly recently imported from Barbados into Indonesia showed a high degree of parasite resistance (Romjali et al., 1997). Katahdin lambs in the Southeastern United States tended to be more parasite resistant than wool (Suffolk) and Dorper hair sheep, but were not as resistant as St. Croix under more severe parasite challenges (Burke and Miller, 2004). Katahdin ewes, however, had a similar level of parasite resistance as St. Croix ewes, and both breeds were more resistant than a wool breed (Hampshire) in another study (Burke and Miller, 2002).

Mean FEC were higher ($P < 0.05$) in Nubian and Spanish than in Myotonic and Pymgy goats, and these differences were reflected in more deworming treatments during the experimental period (5, 4, 3, and 3, respectively; Figure 3). Mean PCV also differed ($P < 0.05$) between goat breeds, but did not correspond to the differences in FEC, and likely reflected physiological differences between breeds not related to parasite infection. This is supported by the fact that all values for PCV were well within the normal range (22 percent to 38 percent; Jain; 1993). Breed differences in parasite resistance have been reported for goats in Africa (Baker et al., 1998) and Asia (Chauhan et al., 2003), but not for goat breeds in the United States. The Nubian breed, traditionally a dual-purpose breed, has developed primarily into a dairy breed in the United States, and requires considerable management inputs to achieve optimum performance. The increased susceptibility to nematode parasitism observed in the breed here may be the result of the forage-based, low-input production conditions employed. Infusion of Anglo-Nubian germplasm into native goats in Thailand resulted in a decline in parasite resistance as the percentage of Nubian in crossbred animals increased (Pralomkarn et al., 1997).

Spanish goats are a breed developed in a semi-arid, range environment and are accustomed to perform under forage-based (browse) production conditions. This native environment is not supportive of gastrointestinal nematodes, and relocation in a more humid environment, with naturally parasite-infected pastures, as was the case here may have challenged the immune system of these goats. In contrast, Myotonic and Pygmy goats originate from hot, humid environments (southeastern United States and Western Africa, respectively) and are better adapted to the environmental conditions, and parasite burden, encountered by the animals in the experiment.

Grazing management had no significant effect on FEC or PCV (Table 1). Grazing management has only a limited ability to control nematode parasites infection in small ruminants (Eysker et al., 2005), and any differences here were likely associated with improved nutrition, rather than a direct effect of reduced worm burden in the rotationally-grazed pastures.

The results from this experiment confirmed the observational data on species and breed differences previously collected in this mixed-species flock. However, the anthelmintic treatment schedule employed for herd management (based on breed group composite FEC exceeding 1000 eggs/g) likely masked some of the differences that may have been apparent if does and ewes had been treated in less frequent intervals. This is also apparent from the PCV values that were always well within the normal range for both species. Our findings point to management constraints in applying uniform anthelmintic treatment schedules to mixed species, and/or multi-breed herds with different levels of parasite resistance.

Conclusion

Hair sheep appeared to be more resistant to parasites than goats, however, there was considerable breed variation within species. Differences observed between Barbados Blackbelly and Katahdin hair sheep may have been associated with an increased ability to cope with the effects of parasitism (resilience) rather than resistance in the Barbados Blackbelly. Nubian and Spanish goats were more susceptible to gastrointestinal parasitism than Myotonic and Pygmy goats, and these differences need to be taken in consideration when designing effective parasite control management systems for these breeds.

Literature Cited

Amarante, A.F.T., P.A. Bricarello, R.A. Rocha and S.M. Gennari. 2004. Resistance of Santa Ines, Suffolk, and Ile de France sheep to naturally acquired gastrointestinal nematode infections. Vet. Parasitol. 120:91-106.

Baker, R.L., D.M Mwamachi, J.O. Audho, E.O. Aduda and W. Thorpe. 1998. Resistance of Galla and Small East African goats in the sub-humid tropics to gastrointestinal nematode infections and the peri-parturient rise in faecal egg counts. Vet. Parasitol. 79:53-64.

Burke, J.M. and J.E. Miller. 2002. Relative resistance of Dorper crossbred ewes to gastrointestinal nematode infection compared with St. Croix and Katahdin ewes in the southeastern United States. Vet. Parasitol. 109:265-275.

Burke, J.M. and J.E. Miller. 2004. Relative resistance to gastrointestinal nematode parasites in Dorper, Katahdin, and St. Croix lambs under conditions encountered in the southeastern region of the United States. Small Rumin. Res. 54:43-51.

Burke, J.M., J.E. Miller, D.D. Olcott, B.M. Olcott and T.H. Terrill. 2004. Effect of copper oxide wire particles dosage and feed supplement level on *Haemonchus contortus* infection in lambs. Vet. Parasitol. 123:235-243.

Chauhan, K.K., P.K. Rout, P.K. Singh, A. Mandal, H.N. Singh, R. Roy and S.K. Singh. 2003. Susceptibility to natural gastro-intestinal nematode infection in different physiological stages in Jamunapari and Barbari goats in the semi-arid tropics. Small Rumin. Res. 50:219-223.

Courtney, C.H, C.F. Parker, K.E. McClure and R.P. Herd. 1985. Resistance of exotic and domestic lambs to experimental infection with *Haemonchus contortus*. Int. J. Parasit. 15:101-109.

Eysker, M., N. Bakker, F.N.J. Kooyman and H.W. Ploegger. 2005. The possibilities and limitations of evasive grazing as a control measure for parasitic gastroenteritis in small ruminants in temperate climates. Vet. Parasitol. 1329:95-104.

FASS. 1999. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. 1st rev. ed. Fed. Anim. Sci. Soc., Savoy, IL.

Gruner, L., G. Aumont, T. Getachew, J.C. Brunel, C. Pery, Y. Cognie and Y. Guerin. 2003. Experimental infection of Black Belly and INRA 401 straight and crossbred sheep with trichostrongyle nematode parasites. Vet. Parasitol. 116:239-249.

Howell, J.M, J.-M. Luginbuhl, M.J. Grice, K.L. Anderson, P. Arasu and J.R. Flowers. 1999. Control of gastrointestinal parasite larvae of ruminant using nitrogen fertilizer, limestone and sodium hypochlorite solutions. Small Rumin. Res. 32:197-204.

Jain, N.C. 1993. Comparative hematology of common domestic animals. In: Essentials of Veterinary Heamtology, Jain, N.C., Ed., Lea & Febiger, Philadelphia, p. 19-53.

Kaplan, R.M. 2004. Drug resistance in nematodes of veterinary importance: a status report. Trends Parasitol. 20:477-481.

Miller, J. E. and S.R. Barras. 1994. Ivermectin resistant *Haemonchus contortus* in Louisiana lambs. Vet. Parasitol. 55:343-346.

Min, B.R., W.E. Pomroy, S.P. Hart and T. Sahlu. 2004. The effect of short–term consumption of a forage containing condensed tannins on gastrointestinal nematode parasite infections in grazing wethers. Small Rumin. Res. 51:279-283.

Notter, D.R., S.A. Andrews and A.M. Zajac. 2003. Responses of hair and wool sheep to single fixed dose of infective larvae of *Haemonchus contortus*. Small Rumin. Res. 47:221-225.

Papadopoulos, E., G. Arsenos, S. Sotiraki, C. Deligiannis, T. Lainas, and D. Zygoyiannis. 2003. The epizootiology of gastrointestinal nematode parasites in Greek dairy breeds of sheep and goats. Small Rumin. Res. 47:193-202.

Pralomkarn, W., V.S. Pandey, N. Ngampongsai, S. Cholumrongkul, S. Saitanoo, L. Rattaanachon and A. Verhulst. 1997. Genetic resistance of three genotypes of goats to experimental infection with *Haemonchus contortus*. Vet. Parasitol. 68:79-90.

Romjali, E. V.S. Pandey, R.M. Gatenby, M. Doloksaribu and H. Sakul, A. Wilson, A. Verhulst. 1997. Genetic resistance of different genotypes of sheep to natural infections with gastrointestinal nematodes. Anim. Sci. 64:97-104.

SAS Institute Inc., 1996. SAS User's Guide: Statistics, 6th ed. SAS, Cary, NC, p. 956.

Terrill, T.H., M. Larsen, O. Samples, S. Husted, J.E. Miller, R.M. Kaplan and S. Gelaye. 2004. Capability of the nematode-trapping fungus *Duddingtonia flagrans* to reduce infective larvae of gastrointestinal nematodes in goat feces in the southeastern United States: dose titration and dose time intervals studies. Vet. Parasitol. 120:285-296.

Whitlock, H.V. 1948. Some modifications of the McMaster helminth egg-counting technique apparatus. J. Coun. Sci. Ind. Res. 21:177-180.

Zajac, A.M. and T.A. Gipson. 2000. Multiple anthelmintic resistance in a goat herd. Vet. Parasitol. 87:163-172.

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Carcass and Growth Characteristics of Wethers Sired by Percentage White Dorper or Hampshire Rams[1]

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Summary

To evaluate the use of percentage Dorper rams as terminal sires in the Upper Midwest, 72 Finn-Dorset-Targhee (FDT) ewes were mated to one of two 3/4 White Dorper-1/8 East Fresian-1/8 Corriedale (WD) rams and 77 FDT ewes were mated to one of two Hampshire rams in single-sire mating groups. Thirty-seven WD-sired and 55 Hampshire-sired wethers were utilized for the study. All male lambs were castrated by elastration at 1 day of age. Wethers were maintained as a group until slaughtered at a commercial packing plant. Carcass data were collected at slaughter. Hampshire-sired wethers tended to have greater birth weights (4.8 ± 0.14 kg vs. 4.4 ± 0.15 kg; P = 0.06) and had greater adjusted weaning weights (33.4 ± 0.85 kg vs. 30.4 ± 1.01 kg; P = 0.03) than WD-sired wethers. Hampshire-sired wethers had greater post-weaning average daily gain (0.36 ± 0.02 kg/day vs. 0.28 ± 0.01 kg/day, respectively; P = 0.0002), greater finished weights (57.8 ± 0.7 kg vs. 51.7 ± 0.8 kg, respectively; P = 0.0001), greater hot-carcass weights (29.1 ± 0.4 kg vs. 26.6 ± 0.5 kg, respectively; P = 0.0001), less fat over the ribeye (0.46 ± 0.02 cm vs. 0.55 ± 0.03 cm, respectively; P = 0.03) and thinner body walls (2.2 ± 0.06 cm vs. 2.5 ± 0.1 cm, respectively; P = 0.001) than WD-sired wethers. Hampshire-sired wethers grew faster and produced leaner carcasses than wethers sired by percentage WD rams.

Key words: Dorper, Hampshire, Growth, Carcass

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Introduction

Dorper sheep, a hair breed, have been reported to have high survival of lambs to weaning, the ability to breed out of season, and superior rates of gain and carcass characteristics relative to wool breeds in South Africa (Cloete et al., 2000; Elias et al., 1985; Schoeman, 2000). Schoeman (Schoeman, 2000) reported that growth rate of Dorper sheep was generally superior to that of wool and indigenous breeds and compared favorably with specialized mutton breeds. These reports have led to a great deal of interest in using Dorper and percentage Dorper animals in breeding programs in the Upper Midwest. However, most studies of Dorper performance have been conducted under animal management systems and climatic conditions differing greatly from the Upper Midwest.

Dorper lambs have a projected slaughter weight of 40 kg to 47 kg based on an adult ewe weight of 60 kg to 70 kg (Notter, 2000). Lambs in the Upper Midwest typically are slaughtered at weights between 50 kg and 68 kg. Optimum-slaughter weight and other traits of economic importance, including growth rate, mothering ability, and reproductive efficiency, have not been evaluated for Dorper sheep in the Upper Midwest. Therefore, we assessed the live performance and carcass characteristics of crossbred Dorper wethers in the farm flock program at the SDSU sheep unit in Brookings.

Materials and Methods

In the fall of 2001, 72 Finn-Dorset-Targhee (FDT) ewes were mated to one of two 3/4 White Dorper-1/8 East Fresian-1/8 Corriedale (WD) rams and 77 FDT ewes were mated to one of two Hampshire rams in single-sire mating groups A total of 55 Hampshire-sired and 37 WD-sired wethers were produced and evaluated in this study. All male offspring were weighed and castrated by elastrator at processing within 24 hours of birth. All lambs were raised as either singles or twins and had a pelleted, commercial, creep feed available *ad libitum*. Lambs were weaned at an average of 78 ± 1.6 days of age and weights were recorded. Wethers were maintained as one group on *ad libitum* feed until finished. Diets for the lambs consisted of a pelleted feed (20 percent protein; Big Gain lamb creep, Big Gain, Inc., Mankato, Minn.) available as creep feed until approximately two weeks before weaning, at which time the feed was switched to a grower ration that consisted of 62.5 percent cracked corn, 25 percent commercially available, pelleted-feed supplement formulated for growing lambs (pellets containing 16 percent protein, vitamins, and minerals; Big Gain lamb grower), and 12.5 percent oats. When lambs weighed approximately 45 kg, the diet was changed to a finisher diet that consisted of 72.5 percent cracked corn, 15 percent commercially available, pelleted feed formulated for finisher lambs (pellets containing 13 percent crude protein, vitamins, and mineral; Big Gain lamb finisher), and 12.5 percent oats. Weaning weights were adjusted for type of birth and rearing, age of dam, and sex of lamb, using generic breed adjustment factors to 78 days of age (*SID Sheep Production Handbook, 2002*). Weaning weights were adjusted to compensate for the low frequency of some group types (e.g. triplets). Lambs were slaughtered in two separate slaughter groups at a commercial processing plant (Iowa Lamb Corporation, Haywarden, Iowa). The first group (n= 26 Hampshire-sired and 15 WD-sired) was slaughtered (7/18/2002) and consisted of all lambs estimated visually and by palpation to have a minimum of 0.5 cm of fat cover (12 th- 13 th rib). The remaining lambs (n= 29 Hampshire-sired and 22 WD-sired) were slaughtered (8/22/2002) when 75 percent of them were assessed to have at least 0.5 cm of fat cover. Carcass traits (fat thickness over the ribeye, ribeye area, body-wall thickness, and USDA- yield and -quality grades) were recorded the day following slaughter. Percentage of boneless, closely trimmed, retail cuts was estimated from hot-carcass weight, fat depth, body-wall thickness, and ribeye area using the formula of Savell and Smith (1998). Data were tested for the effect of sire breed on lamb birth weight, adjusted-weaning weight, slaughter weight, post-weaning average daily gain, and hot-carcass weight by ANOVA using GLM procedures for SAS (1999). Effect of breed on carcass traits was tested by analysis of covariance with hot-carcass weight as the covariant, using GLM procedures for SAS. Effects of breed on USDA-quality grade was tested by chi-square analysis.

Results and Discussion

In the current study, WD-sired wethers tended to be lighter at birth than Hampshire-sired wethers (Table 1; P = 0.06). Notter et al. (2004) observed a tendency for Dorper-sired lambs to have lighter birth weights than Dorset-sired lambs; however, Snowder and Duckett (2003) reported no difference in birth weight between Dorper-, Columbia-, and Suffolk-sired lambs. Records from the South African Sheep Performance Testing Scheme indicated Dorper lambs had greater birth weights than Hampshire lambs; however, although these records contain a large number of observations (more than 117,000), the results could be biased by differences in production environments and management levels which were not accounted for (Schoeman, 2000). Furthermore, differences likely exist in the available WD genetics in the United States and South Africa.

Table 1. Effect of sire breed on lamb growth traits.

	Sire Breed		
Growth Trait	Hampshire	White Dorper	P-value
Number of head	55	37	------
Birth weight (kg)	4.8 ± 0.14	4.4 ± 0.15	0.06
Actual weaning weight (kg)	29.2 ± 0.85	27.1 ± 1.06	0.12
Adjusted weaning weight (kg)	33.4 ± 0.85	30.4 ± 1.01	0.03
Age at slaughter (days)	159.4 ± 2.2	165.3 ± 2.8	0.10
ADG (kg/day)	0.36 ± 0.02	0.28 ± 0.01	0.0002
Finished weight (kg)	57.8 ± 0.7	51.7 ± 0.8	0.0001

Hampshire-sired wethers had a greater adjusted-weaning weight than WD-sired wethers (Table 1; P = 0.03). Notter et al. (2004) reported greater weaning weights for Dorper-sired lambs than Dorset-sired lambs in one out of three years of their study. Snowder and Ducket (2003) observed greater 77 day weights in Columbia- and Suffolk-sired lambs than for Dorper-sired lambs but breed differences at weaning at 118 days of age were not significant. Schoenman (2000) reported that South African Sheep Performance Testing Scheme records indicated Hampshire lambs had heavier 42- and 100-day weights than Dorpers.

Hampshire-sired wethers had more than a 20 percent advantage in post-weaning, average-daily gain, which resulted in a heavier finished weight (Table 1; P < 0.0002). Snowder and Ducket (2003) observed higher finished weights in Dorper-sired lambs than Columbia- and Suffolk-sired lambs. However, Notter et al. (2004) did not observe a significant difference in post-weaning growth between Dorper- and Dorset-sired lambs. Dorper-sired lambs have been reported to have greater average-daily gain than western white-face lambs on a forage diet (Means et al., 1999). Staab et al. (1999) reported an advantage in average daily gain for Dorper-sired wethers over western white-face wethers initially, but Suffolk-sired wethers had superior overall average daily gain with no difference in overall average daily gain between Dorper-sired and western white-face wethers.

Hampshire-sired lambs had greater hot-carcass weights than WD-sired wethers (Table 2; P = 0.0001). Staab et al. (1999) did not observe a difference in hot-carcass weights between Suffolk-, Dorper-, or western white-face-sired wethers. Means et al. (1999) reported that Dorper-sired ewe lambs tended to have heavier carcasses than western white-face-sired ewe lambs. Snowder and Duckett (2003) observed greater hot-carcass weights in Dorper-sired lambs than Columbia or Suffolk-sired lambs.

In the current study, Hampshire-sired wethers had less fat than WD-sired wethers, as indicated by reduced fat depth over the ribeye and reduced body-wall thickness adjusted for hot-carcass weight (Table 2; P = 0.03). The

Table 2. Effect of sire breed on lamb carcass traits.

Growth Trait	Sire Breed Hampshire	 White Dorper	P-value
Number of head	55	37	------
HCW (kg)	29.1 ± 0.4	26.6 ± 0.5	0.0001
Fat (cm)*	0.46 ± 0.02	0.55 ± 0.03	0.03
Body Wall Thickness (cm)*	2.2 ± 0.06	2.5 ± 0.08	0.001
Dressing Percentage*	49.9 ± 0.2	52.0 ± 0.3	0.0001
REA (cm2)*	16.2 ± 0.2	16.2 ± 0.3	0.98
USDA Yield Grade*	2.2 ± 0.1	2.5 ± 0.1	0.04
% USDA Choice	92	88	0.54
% USDA Prime	8	12	0.54
Percent boneless, closely trimmed retail cuts*	46.9 ± 0.2	46.3 ± .2	0.04

*Values are means adjusted for the covariate (HCW) ± SE

WD-sired wethers also had higher USDA-yield grades assigned by the plant grader than Hampshire-sired wethers (Table 2; P = 0.04). Snowder and Duckett observed that Dorper-sired lambs had greater fat depth between the 12th and 13th rib than Suffolk-sired lambs and greater fat depth at the tail head than Columbia-sired lambs (2003). There was no difference in ribeye area adjusted for hot carcass weight between Hamshire-sired and WD-sired wethers (Table 2; P = 0.98). Notter et al. (2004) did not observe any differences in ultrasound estimates of longissimus muscle, cross-sectional area between Dorper-sired and Dorset-sired lambs. The lack of a difference in ribeye area between Hampshire- and WD-sired wethers indicates that Hampshire-sired wethers were very similar to WD-sired wethers in their degree of muscling. However, the differences in hot-carcass weight, fat depth, and body-wall thickness resulted in estimated higher percent boneless, closely trimmed retail cuts in Hampshire-sired wethers than WD-sired wethers (Table 2; P = 0.04). Staab et al. (1999) reported that Suffolk and Dorper-sired wethers had a greater estimated percentage of boneless closely trimmed retail cuts than western-white faced wethers.

All of the lambs in the current study graded USDA choice or prime (Table 2). There was no genotype difference in the percentage of lambs that graded USDA prime (P = 0.54; Table 2). Notter et al. (2004) observed higher-quality grades in Dorper-sired lambs than Dorset-sired lambs. Staab et al. (1999) found Suffolk-sired wethers had a higher-mean-quality grade than Dorper-sired wethers. But Snowder and Duckett (2003) did not find a difference in quality grade between Dorper-sired and Columbia-sired or Suffolk-sired lambs.

Conclusion:

Although the percentage WD-sired lambs did produce acceptable carcasses at a finished weight within the range at which lambs are typically marketed in the Upper Midwest, the Hampshire-sired lambs had higher growth performance in the finishing phase and produced carcasses with less fat. This work suggests that Hampshire rams are superior to percentage WD rams as terminal sires.

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Literature Cited:

Cloete, S. W., M. A. Snyman, and M. J. Herselman. 2000. Productive performance of Dorper sheep. Small Rumin. Res. 36: 119-135.

Elias, E., D. Cohen, and P. Dayenoff. 1985. Characteristics and indices of reproduction in Dorper sheep. J. S. Afr. Vet. Assoc. 56: 127-130.

Means, W. J., K. A. Staab, R. A. Field, B. W. Hess, J. E. Nel, and F. S. Hruby. 1999. Carcass characteristics of forage-fed Dorper, Suffolk, and western white-faced sired lambs. J. Anim. Sci. 77: 109.

Notter, D. R. 2000. Potential for hair sheep in the United States. Proc. Amer. Soc. Anim. Sci.

Notter, D. R., S. P. Greiner, and M. L. Wahlberg. 2004. Growth and carcass characteristics of lambs sired by Dorper and Dorset rams. J. Anim. Sci. 82: 1323-1328.

SAS. 1999. Proprietary Software Version 8. SAS Institute, Cary, NC.

Savell, J. W. and G. C. Smith. 1998. Laboratory Manual for Meat Science 6th Ed. American Press, Boston, MA. p 143-144.

Schoeman, S. J. 2000. A comparative assessment of Dorper sheep in different production environments and systems. Small Rumin. Res. 36: 137-146.

Snowder, G. D., and S. K. Duckett. 2003. Evaluation of the South African Dorper as a terminal sire breed for growth, carcass, and palatability characteristics. J. Anim. Sci. 81: 368-375.

Staab, K. A., B. W. Hess, W. J. Means, J. E. Nel, and J. T. Cecil. 1999. Feedlot performance and carcass differences among Dorper, Suffolk, and western white face sired wethers. J. Anim. Sci. 77: 105-106.

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Lamb Production of Dorper, Katahdin, and St. Croix Bred in Summer, Winter, or Spring in the Southeastern United States

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[1] *Mention of trade names or commercial products in this manuscript is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.*
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Summary

Ewe production traits and ability to breed out of season were compared for the Dorper (DO), Katahdin (KA), and St. Croix (SC) breeds between 2000 and 2005. Sheep were managed on grass pasture and were supplemented with corn/soybean meal and free-choice, trace-mineral mix. Ewes were exposed to rams of their respective breeds in late summer (August/September), winter (December), or spring (April/May) for 30-day breeding periods. Lambs were weighed at birth and 60 days of age. Pregnancy and lambing rates and litter birth weight were greater for all breeds bred in winter and lowest in spring. Pregnancy losses were greater and birth weights reduced for DO and KA ewes less than two years of age bred in the spring compared with other seasons. Birth weights of lambs were not affected by season, but weaning weights were greatest for all breeds when ewes were bred in summer. Relative efficiency at weaning (kg of lamb produced/kg ewe weight) was greatest for summer-bred ewes and greatest for KA compared with DO and SC ewes. In summary, DO, KA, and SC ewes are capable of out-of-season breeding in Arkansas. However, relative efficiency and weaning weights were lowest for spring-bred ewes and fertility of yearling ewes of all breeds was reduced during spring breeding.

Key words: Dorper, Katahdin, Pregnancy, Production, St. Croix

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Introduction

Numbers of hair sheep in the United States have increased in the past few years because of their ease of management. These sheep shed their hair, thus require no shearing, and are resistant to parasites (Courtney et al., 1985; Zajac et al., 1990; Gamble and Zajac, 1992; Burke and Miller, 2002), a trait of growing importance, especially in the southeastern United States. Because of resistance of gastrointestinal nematodes to chemical dewormers, resistant breeds of sheep represent an important control measure for these parasites. U.S. hair or shedding breeds include American and Barbados Blackbelly, Dorper, Katahdin and St. Croix, which are described (ASI, 2002) and reviewed by Wildeus (1997).

Out-of-season breeding is an important characteristic of sheep in the eastern and southeastern United States. Marketing potential increases with year-round supply of lamb, which can occur when multiple breeding seasons are included in reproductive management. Because sheep are short-day breeders, traditionally ewes are bred in the fall to lamb in the spring. Length of the breeding season is dependent largely on breed and latitude. Brown and Jackson. (1995) determined that St. Croix ewes were capable of breeding in the spring in Arkansas, but at a reduced rate compared with other times of the year. Dorper ewes were capable of year round breeding in South Africa (Schoeman and Burger, 1992).

Prolificacy is another important trait of sheep in the southeastern and eastern US. Lambing rate of St. Croix and Katahdin ewes was 140 percent to 212 percent, and 168 percent, respectively (Wildeus, 1997). Lambing rate of Dorper ewes in South Africa was 141percent (Shoeman and Burger, 1992) and has not been reported in the United States. These lambing rates compare favorably with some of the moderately prolific wool breeds in the United States.

The objectives of this study were to examine ewe production traits and the ability to breed out of season among Dorper (DO), Katahdin (KA), and St. Croix (SC) ewes.

Materials and Methods

Animals and Their Management

The research site was located in west-central Arkansas at latitude of 35°N. The climate is characterized by hot, humid summers with little to moderate rainfall and mild winters with moderate rainfall. Annual precipitation is 112 cm.

The DO sheep used for these studies were derived from five purebred black-headed or white DO rams bred to either SC or Romanov ewes from this ARS station or to Romanov ewes from a private farm. These ewes were subsequently exposed to one of these rams (none bred to sires) or an additional two white DO rams. The percentage DO for each of the seasons is indicated in Table 1. The KA ewes originated from two farms (at least three genetic lines from one farm and commercial ewes from a second farm) and the rams from an additional two farms and within the flock for a total of four rams. The SC flock has been at the Booneville site since 1987, and replacement rams originated from within the flock and three additional farms. There were a total of nine SC rams used. Replacement ewe lambs were produced from within the flock.

Sheep grazed tall fescue (*Festuca arundinacea*), a cool season grass, or bermudagrass (*Cynodon dactylon*), a warm season grass, overseeded with annual ryegrass (*Lolium multiflorum*) for winter forage production. They were supplemented with corn/soybean meal (16 percent CP with added lasolocid; up to 500 g/d for growing lambs and up to 1 kg/d 30 d before and after lambing) and free choice trace mineral mix. Bermudagrass hay was provided during winter when forage was limited. Pastures were fertilized with N, P, and K as recommended based on soil tests.

Ewes were exposed to rams of their breed type in late summer (August/September), winter (December), or spring (April/May) for 30 days. All rams passed a breeding soundness exam within 7 days before initial exposure to ewes. Rams were exposed to not more than 30 ewes during the breeding season. One ram was used per breeding season for SC and KA ewes between 2000 and 2002, and two rams per season in a single-sire mating was used in 2003 through 2005. Up to four DO rams per season were used in 2000 and 2001. In 2002 one ram per season was used for DO ewes, and in 2003 two rams were used for each season. Number of ewes for each breed type that were exposed in each season is indicated in Table 1. Ewes were exposed to rams at a minimum of six months of age. Ewes that lambed were re-exposed at eight-month intervals. Ewes that did not conceive were given a second chance at the subsequent mating cycle. Ewes failing to conceive after two consecutive opportunities were culled. Pregnancy was determined by transrectal ultrasonagraphy (Aloka SSD 500 V ultrasound scanner equipped with a 7.5 MHz linear array prostate transducer; Aloka Co. Ltd, Japan) at the time of ram removal and 30 days later. Ewes were vaccinated against *Clostridium chauvoei*, *C. septicum*, *C. novyi* Type B, *C. haemolyticum*, *C. tetani*, and *C. perfringens* Types C and D (Covexin 8®) 30 days before the first ewe was due to lamb.

Ewes were transported to a lambing facility approximately 7 to 14 d before lambing. They were maintained outdoors on bermudagrass hay and grain supplement until lambing. When ewes lambed they were moved to individual pens with their lambs for approximately 24 h during which lambs were weighed, ear tagged, and had their navels dipped in iodine. The smallest lamb was removed from triplets after 24 h. Lambs were creep fed with the corn/soybean

Table 1. Numbers of Dorper (DO), Katahdin (KA), and St. Croix (SC) ewes exposed in summer, winter, or spring.

	DO[a]	3/4 DO	1/2 DO	KA	SC
Summer	5	42	64	106	83
Winter	9	39	2	102	85
Spring	16	60	81	93	112

[a] Greater than 3/4 DO.

meal supplement starting at 30 days of age, and were weighed at 60 days of age.

All experimental procedures were reviewed and approved by the Agricultural Research Service Animal Care and Use Committee in accordance with the *NIH Guide for the Care and Use of Laboratory Animals*. Pain and stress to animals were minimized throughout the experimental period.

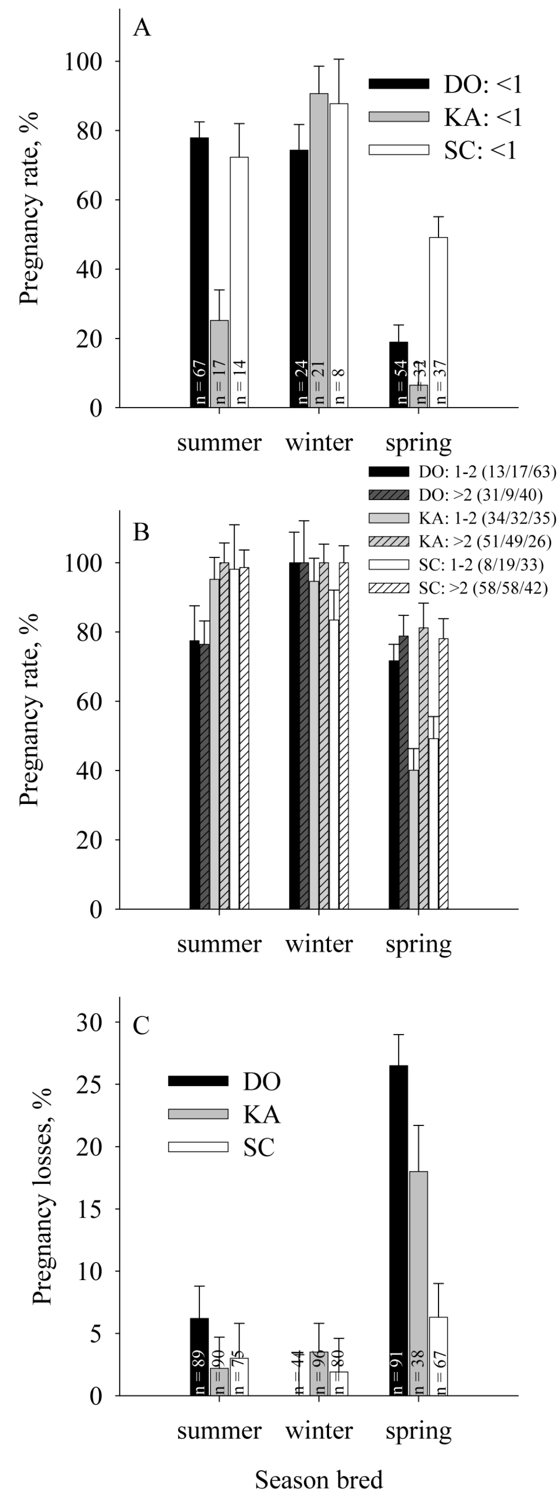
Statistical Analysis

Data were analyzed using the GLM procedures of SAS (1996) and means were compared using the PDIFF option. Variables analyzed included body weight determined at breeding and weaning, pregnancy and lambing rate, individual weights of lambs, and relative efficiency of lamb production. For ewe production traits, the model included the random effects of breed, age of ewe at breeding (yearling or less than one year of age, one to less than two years of age, or ≥ two years of age), season, and the interactions (two- and three-way), and year as a covariate. For lamb weights independent variables were breed, season, litter type, sex and any possible interaction. Birth order and year were included as continuous variables. If year was not significant, it was deleted from the model and observations among years pooled. Year was significant for pregnancy and lambing rates, litter birth weight of all ewes exposed, and individual weaning weights. Pregnancy rate was the proportion of ewes exposed to a ram that were pregnant at 30 days to 60 days of gestation. Percentage lambing was the proportion of ewes exposed that produced live or dead lambs. Percentage of lost pregnancies was the proportion of exposed ewes that were determined to be pregnant after ram removal that did not lamb. Percentage of lambs lost at birth was the proportion of lambs born that were dead or died within 24 hours of birth. Litter birth and weaning weights per ewe were the sum of weights within a litter. Relative efficiency was the weight (kg) of lambs produced per unit ewe weight determined at breeding multiplied by 100.

Results and Discussion

Pregnancy rate was greatest during winter breeding for all breeds and lowest in yearling ewes bred in spring (breed x age x season, $P < 0.001$; Figures 1A and

Figure 1. Least squares means and standard errors of pregnancy rate determined 30 days post-breeding in ewes that were < 1 (A), 1 – 2, or ≥ 2 years of age at breeding (B; breed x age x season, *P* < 0.001) or pregnancy losses between 30 days post-breeding and lambing (C; breed x season, *P* < 0.001) for Dorper (DO; black or dark gray bars), Katahdin (KA; light gray bars), and St. Croix (SC; white bars) ewes bred in summer, winter, or spring. Numbers of ewes are indicated within bars or next to legends in parenthesis for summer, winter, and spring breeding season, respectively.



B). For ewes exposed at <1 year of age, DO and SC ewes were more fertile than KA ewes bred in summer. Pregnancy losses were greatest in DO and KA ewes bred in spring (breed x season, $P < 0.001$; Figure 1C) and ewes bred in spring at < 1 year of age (age x season, $P < 0.001$; data not shown). Lambs born per ewe exposed (breed x age x season, $P < 0.001$; Figures 2A and B), proportion of exposed ewes that lambed (breed x age x season, $P < 0.001$; Figures 2C and D), and litter birth weights (breed x age x season, $P < 0.002$; Figure 3A and B) were greatest in ewes that were two years or older and lowest in spring-bred ewes. Litter birth weights were greatest for KA and lightest for SC (DO, 5.4 kg; KA, 5.8 kg; SC, 5.1 ± 0.14 kg; $P < 0.002$) without any seasonal effects (Figure 3C). Litter birth weights increased with age (< 1 year, 4.4 kg; 1 to 2-year old, 5.2 kg; ≥ 2 years of age, 6.6 ± 0.14 kg; $P < 0.001$), partly because there were more single than multiple births from ewes < 1 year of age at exposure. In all breeds, ewes that were 2 years or older at breeding were more capable of out-of-season breeding than younger ewes. There were more DO (DO, 15.7 percent; KA, 3.1 percent; SC, 6.3 ± 2.6 percent; $P < 0.003$) and spring-bred (summer, 4.7 percent; winter, 5.4 percent; spring, 15.0 ± 2.5 percent; $P < 0.02$) ewes that lost lambs during the first 24 hours of birth than other breeds or seasons.

There was some degree of seasonality in all breeds, as pregnancy rate was reduced during spring breeding. Out-of-season breeding for hair and shedding sheep has been reported by others. Brown and Jackson (1995) reported decreased pregnancy and lambing percentages in SC ewes bred in spring at the current location. The DO breed has been observed to breed out-of-season in South Africa in February/March and June/July with 51 percent and 56 percent, respectively, of exposed ewes lambing compared to October/November with 68 percent lambing (Shoeman and

Figure 2. Least squares means and standard errors for lambs born per ewe exposed (lambing rate; A and B) and proportion of ewes exposed to ram that lambed (C and D) for ewes that were < 1 (A and C), 1 – 2, or ≥ 2 years of age (B and D; breed x age x season, $P < 0.001$). Breeds were Dorper (DO; black or dark gray bars), Katahdin (KA; light gray bars), and St. Croix (SC; white bars) bred in summer, winter, or spring. Numbers of ewes are indicated within bars or next to legends in parenthesis for summer, winter, and spring breeding season, respectively.

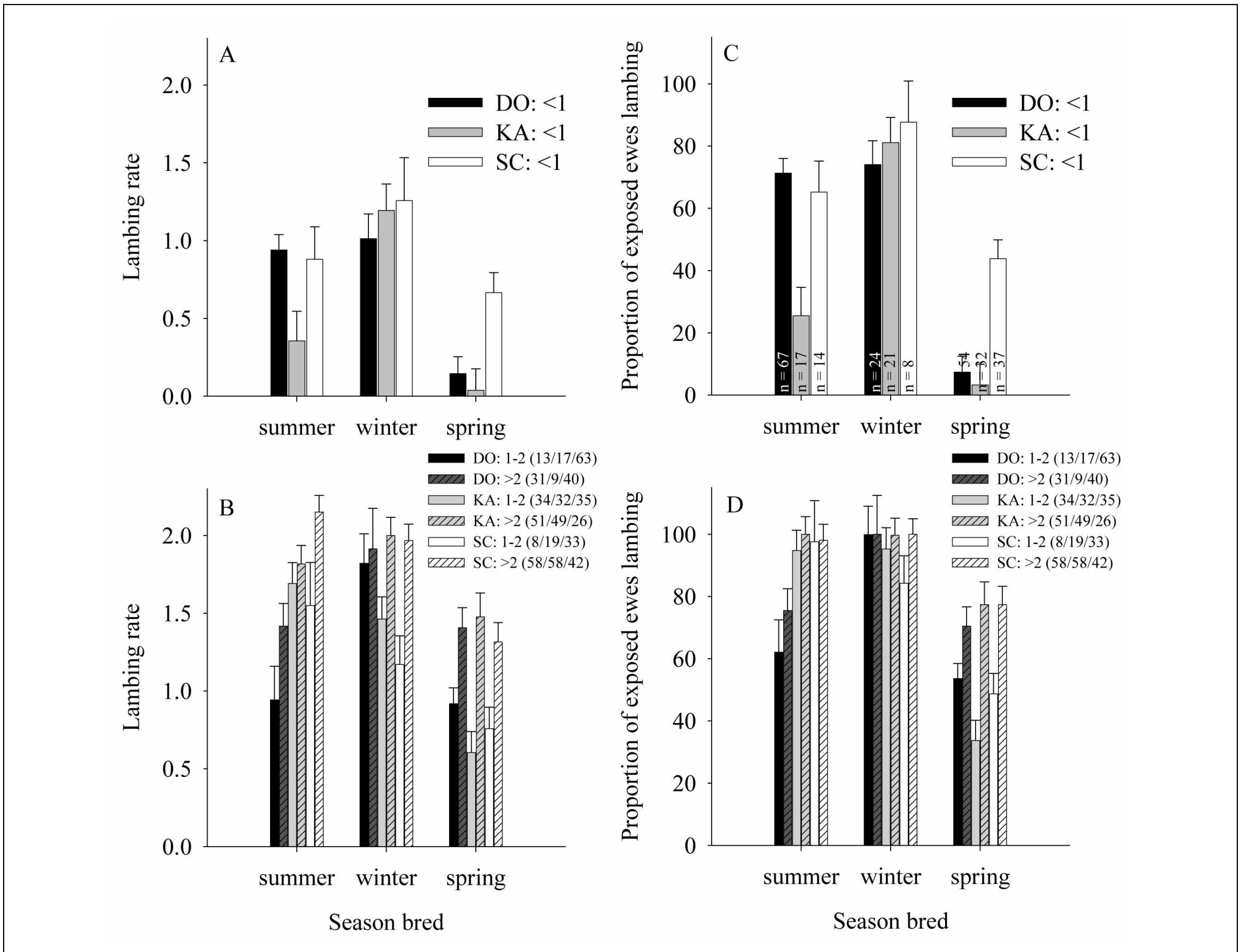
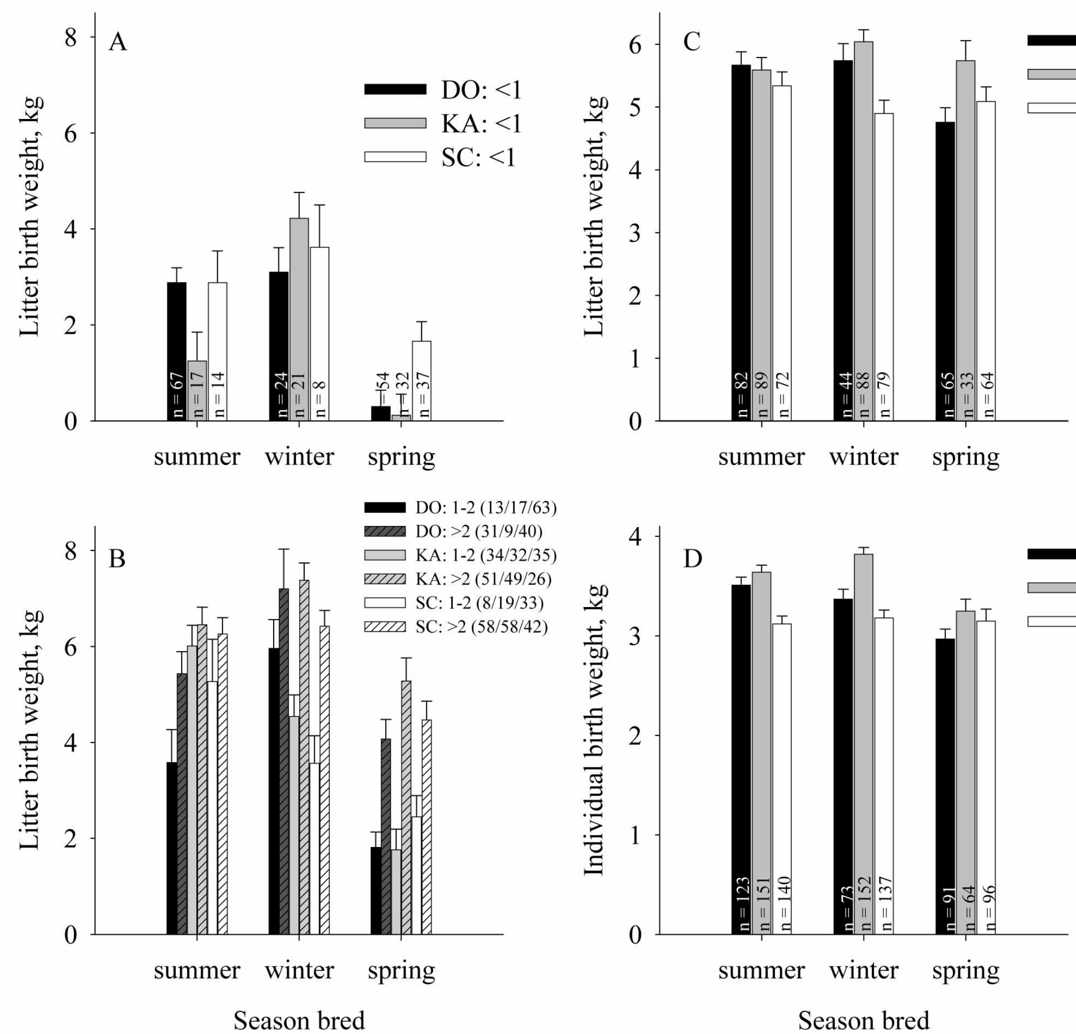


Figure 3. Least squares means and standard errors of litter birth weights for all ewes exposed at < 1 year of age (A), 1 – 2, or ≥ 2 years of age (B) (breed x age x season, $P < 0.002$), litter birth weight of ewes lambing (C; breed, $P < 0.002$), and individual birth weights of lambs (D; breed x season, $P < 0.02$). Breeds were Dorper (DO; black or dark gray bars), Katahdin (KA; light gray bars), and St. Croix (SC; white bars) and ewes were bred in summer, winter, or spring. Numbers of animals are indicated within bars or next to legends in parenthesis for summer, winter, and spring breeding season, respectively.

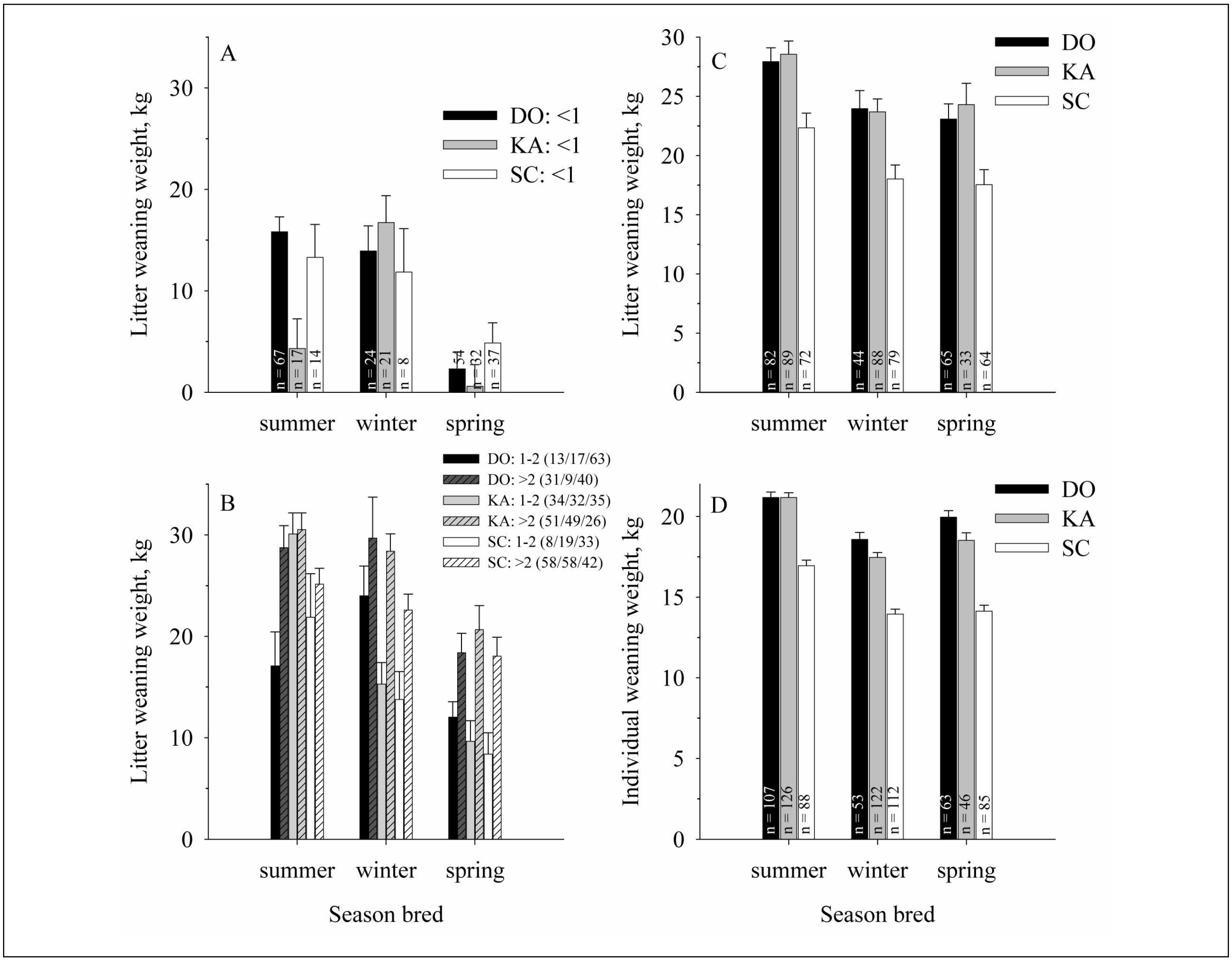


Burger, 1992). Pregnancy rates in KA ewes have been greater than 80 percent when bred in July or March compared to 98 percent when bred in November, but number of lambs born per ewe was lower (less than 1.6) than for those ewes bred in November (1.9; Wildeus, 2005).

It was noted that body condition was good during spring and summer. Therefore, factors other than nutrition, such as summer heat stress, may have contributed to lower fertility during spring or summer breeding in DO and KA ewes. There may have been an initial heat stress leading to increased early embryonic mortality or delayed resumption of cyclicity. It has long been known that chronic heat stress of pregnant ewes is associated with embryonic mortality and small lambs with poor survival rates (Moule, 1954; Yeates, 1956; Shelton, 1964a, b; Alexander and Williams, 1971). This suggests that DO ewes may be somewhat more susceptible to heat stress than SC ewes that had fewer lamb losses among seasons.

Survival of single and twin-born lambs to weaning was similar among seasons for KA and SC lambs (89 to 95%), but decreased in DO lambs from ewes bred in winter and spring compared with summer (82% vs. 98%; breed x season, $P < 0.003$). Weaning rate or the number of lambs weaned per ewe that lambed was similar among breeds and seasons, but increased with age of ewe (< 1 year of age, 123%; 1 - 2-year old, 140%; ≥ 2 years of age, 162 ± 5%; $P < 0.001$). Weaning weights of litters for all ewes exposed to a ram were greatest in winter-bred and older ewes and lowest in ewes < 1 year of age bred in spring (breed x age x season, $P < 0.001$; Figure 4A and B). For those ewes that lambed, litter weights were greatest for DO and KA ewes compared with SC ewes (DO, 24.9 kg; KA, 25.4 kg; SC, 19.3 ± 0.7 kg; $P < 0.001$), increased with age (< 1 year of age, 18.3 kg; 1 - 2-year old, 23.2 kg; ≥ 2 years of age, 28.1 ± 0.6 kg; $P < 0.001$), and were greatest for summer-bred ewes

Figure 4. Least squares means and standard errors of litter weaning weights for all ewes exposed at < 1 (A), 1 – 2, or ≥ 2 years of age (B) (breed x age x season, $P < 0.002$), litter weaning weights of ewes lambing (C; breed, $P < 0.002$), and individual weaning weights of lambs (D; breed, $P < 0.001$, season, $P < 0.001$). Breeds were Dorper (DO; black or dark gray bars), Katahdin (KA; light gray bars), and St. Croix (SC; white bars) and ewes were bred in summer, winter, or spring. Numbers of animals are indicated within bars or next to legends in parenthesis for summer, winter, and spring breeding season, respectively.



(summer, 26.3 kg; winter, 21.8 kg; spring, 21.5 ± 0.7 kg; $P < 0.001$; $P < 0.001$; Figure 4C). Similarly, individual weaning weights of DO and KA were greater than SC lambs ($P < 0.001$) and greatest in lambs from ewes bred in summer ($P < 0.001$; Figure 4D). Not surprisingly, individual weaning weights were greater in single-compared with multiple-born lambs ($P < 0.001$) and greater in KA and SC male compared with female lambs but similar between sexes for DO lambs (breed x sex; $P < 0.001$). Forage quality and quantity are often greater during late winter and early spring in Arkansas, because of growth of cool season grasses such as tall fescue and winter annuals, which contribute to greater weaning weights. Brown and Jackson (1995) also determined that weaning weights of SC lambs were lighter during fall lambing than spring.

The forage base for this flock included endophyte-infected tall fescue, which has been shown to reduce pregnancy and calving rates in beef heifers (Brown et al., 1992; Gay et al., 1988) and increase body temperature of cattle (Porter and Thompson, 1992). Previously, we reported lower pregnancy rates in yearling, but not mature ewes, grazing tall fescue compared with bermudagrass (Burke et al., 2002). In addition to reduced ability for out-of-season breeding, lower pregnancy rates during spring breeding in the current study could have been attributed to fescue toxins. Tropically-adapted breeds of cattle were less sensitive to fescue toxins than English breeds, likely because of greater heat tolerance (Brown et al., 1992, 2000; Browning et al., 1998). This could be true of the tropically-adapted SC, which experienced fewer pregnancy losses, compared with DO and KA ewes. Greater heat tolerance of SC is evident by lower rectal temperatures compared to that of Targhee, a wool breed, observed at elevated ambient temperatures (Horton et al., 1991).

Body weights of SC were less than

Figure 5. Least squares means and standard errors of relative efficiency of lamb production (kg lamb produced/kg ewe weight at breeding x 100) at birth (breed x age x season, $P < 0.04$; A, B; season, $P < 0.001$; C) or weaning (breed x age x season, $P < 0.005$; D, E; season, $P < 0.001$; F) for all ewes exposed at < 1 (A and D), 1 – 2, or ≥ 2 years of age (B and E) (breed x age x season, $P < 0.002$), or for all ewes lambing (C and F). Breeds were Dorper (DO; black or dark gray bars), Katahdin (KA; light gray bars), and St. Croix (SC; white bars) and ewes were bred in summer, winter, or spring. Numbers of animals are indicated within bars or next to legends in parenthesis for summer, winter, and spring breeding season, respectively.

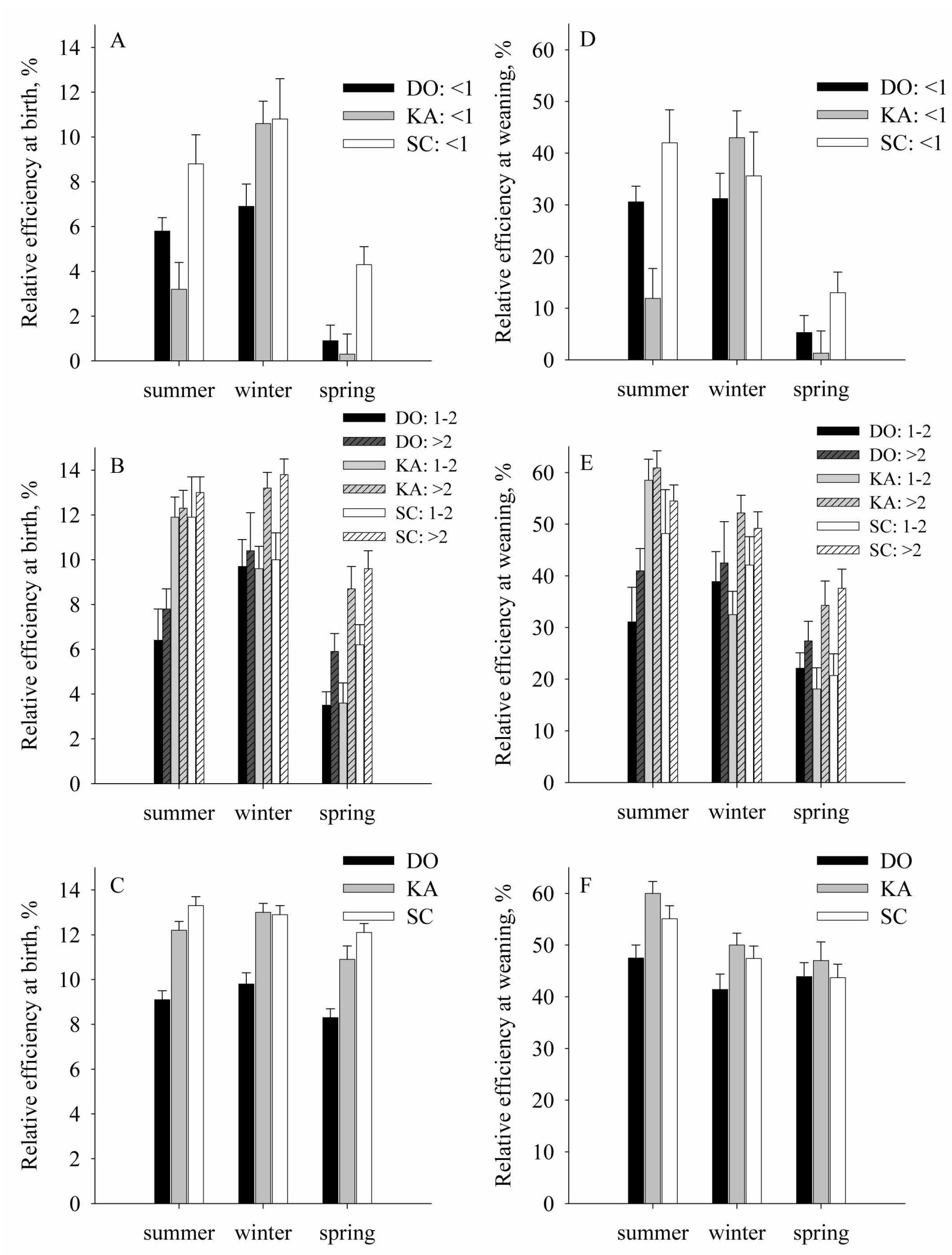


Table 2. Least squares means of body weight (kg) of Dorper (DO), Katahdin (KA), and St. Croix (SC) ewes < 2 or ≥ 2 years of age at ram introduction (breed x age, $P < 0.001$).

	DO		KA		SC	
	< 2 yr	≥ 2 yr	< 2 yr	≥ 2 yr	< 2 yr	≥ 2 yr
Breeding	50.4 ± 0.6	70.2 ± 1.0	43.7 ± 0.7	60.4 ± 1.1	35.6 ± 0.8	47.9 ± 0.8
Weaning	58.1 ± 0.7	72.1 ± 1.0	54.6 ± 0.9	59.4 ± 1.2	41.5 ± 1.1	50.4 ± 0.9

KA which were less than DO ewes at breeding and weaning ($P < 0.001$; Table 2). Body weights of older ewes were similar or slightly heavier at weaning than breeding. Body weight of mature DO, KA, and SC ewes ranged between 45 to 92 kg, 43 to 76 kg, and 33 to 60 kg, respectively. The range of body weights of DO and SC ewes was lighter than that cited by ASI (DO, 77 to 91 kg; KA, 54 to 72 kg; SC, 57 to 68kg; ASI, 2002).

The relative efficiency of lamb production at birth (breed x age x season, $P < 0.04$; Figures 5A and B) and weaning (breed x age x season, $P < 0.005$; Figures 5D and E) for all ewes exposed to a ram was greatest in older ewes and at birth for ewes bred in winter and at weaning for ewes bred in summer or winter compared with spring. For ewes that lambed, relative efficiency at birth was greatest for SC ewes (DO, 9.1%; KA, 12.0%; SC, 12.8 ± 0.3%; $P < 0.001$) and lowest for spring bred ewes (season, $P < 0.001$; Figure 5C). By weaning, relative efficiency of production for ewes that lambed was greatest for KA ewes (DO, 44.4%; KA, 52.5%; SC, 48.6 ± 1.5%; $P < 0.003$) and ewes bred in summer (season, $P < 0.001$; Figure 5F).

Conclusion

Hair and shedding breeds are most challenged with spring breeding compared with summer and winter breeding, but can provide lambs for market from breeding at this time if desired. All breeds that were two years or older were capable of out-of-season breeding, although early pregnancy rates were highest during winter breeding. Selection for fall born lambs may improve the genetic potential for out-of-season breeding in these breeds. Despite lower pregnancy rates and higher pregnancy losses for DO and KA ewes bred at < 1 year of age in the spring compared with late summer or winter, relative efficiency at weaning for DO ewes that lambed in spring was similar to other seasons and relative efficiency at weaning was greatest for KA ewes. In this warm, humid environment, KA ewes have the greatest production potential compared with SC and DO ewes.

Literature Cited

Alexander, G., D. and Williams. 1971. Heat stress and development of the conceptus in domestic sheep. J. Agric. Sci. 76:53-72.

American Sheep Industry. 2002. Sheep Production Handbook, C & M Press, Denver, CO, pp. 921-923.

Brown, M.A., and W.G. Jackson, 1995. Ewe productivity and subsequent preweaning lamb performance in St. Croix sheep bred at different times during the year. J. Anim. Sci. 73:1258-1263.

Brown, M.A., L.M. Tharel, A.H. Brown Jr, J.R. Miesner, and W.G. Jackson. 1992. Reproductive performance of Angus and Brahman cows grazing common bermudagrass or endophyte-infected tall fescue. Prof. Anim. Sci. 8:58-65.

Brown, M.A., A.H. Brown Jr, W.G. Jackson, and J.R. Miesner. 2000. Genotype x environment interactions in Angus, Brahman, and reciprocal cross cows and their calves grazing common bermudagrass and endophyte-infected tall fescue pastures, or both forages. J. Anim. Sci. 78:546-551.

Browning, R. Jr., F.N. Schrick, F.N. Thompson, and T. Wakefield Jr. 1998. Reproductive hormonal responses to ergotamine and ergonovine in cows during the luteal phase of the estrous cycle. J. Anim. Sci. 76:1448-1454.

Burke, J.M., W.G. Jackson, and G.A. Robson. 2002. Seasonal changes in body weight and condition and pregnancy and lambing rates of sheep on endophyte-infected tall fescue in the South-eastern United States. Sm. Rum. Res. 44:141-151.

Burke, J.M. and Miller, J.E. 2002. Relative resistance of Dorper crossbred ewes to gastrointestinal nematode infection compared with St. Croix and Katahdin ewes in the southeastern United States. Vet. Parasitol. 109:265-275.

Courtney, C.H., C.F. Parker, K.E. McClure, and R.P. Herd. 1985. Resistance of exotic and domestic lambs to experimental infections with *Haemonchus contortus*. Int. J. Parasitol. 15:101-109.

Gamble, H.R. and A.M. Zajac. 1992. Resistance of St. Croix lambs to *Haemonchus contortus* in experimentally and naturally acquired infections. Vet. Parasitol. 41:211-225.

Gay, N., J.A. Boling, R. Dew, and D.E. Miksch. 1988. Effects of endophyte-infected tall fescue on beef cow-calf performance. Appl. Agric. Res. 3:182-186.

Horton, G.M.J., S.M. Emanuele, M.B. Solomon, C.C. Burgher, and K.E. McClure. 1991. Physiological responses of hair and wool sheep to changes in ambient temperature and feed allowance. p. 331. In: S. Wildeus (ed.) Proceedings of the Hair Sheep Research Symposium. University of Virgin Islands, St. Croix.

Moule, G.R. 1954. Observations on mortality amongst lambs in Queensland. Aust. Vet. J. 30:153-171.

Porter, J.K. and F.N. Thompson Jr. 1992. Effects of fescue toxicosis on reproduction in livestock. J. Anim. Sci. 70:1594-1603.

SAS, 1996. STAT® Software: Changes and Enhancements through Release 6.11. SAS Inst, Inc, Cary, NC.

Shelton, M. 1964a. Relation of environmental temperature during gestation to birth weight and mortality in lambs. J. Anim. Sci. 23:360-364.

Shelton, M. 1964b. Relation of birth weight to death losses and to certain productive characters of fall-born lambs. J. Anim. Sci. 23:355-359.

Shoeman, S.J. and R. Burger. 1992. Performance of Dorper sheep under an accelerated lambing system. Sm. Rum. Res. 9:265-281.

Wildeus, S., 1997. Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. J. Anim. Sci. 75:630-640.

Wildeus, S. 2005. Accelerated and out-of-season breeding with hair sheep. Proceedings of Hair Sheep Workshop at Virginia State University, Petersburg, VA.

Yeates, N.T.M. 1956. The effect of high air temperature on pregnancy and birth weight in Merino sheep. Austr. J. Agric. Res. 7:435-439.

Zajac, A.M., S. Krakowka, R.P. Herd, and K.E. McClure. 1990. Experimental *Haemonchus contortus* infection in three breeds of sheep. Vet. Parasitol. 36:221-235.

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[1]Postweaning Performance of Hair and Wool Sheep and Reciprocal-crosses on Pasture and in Feedlot

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[1] Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.
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Summary

Lambs from three diallel-mating plans (Dorset-St. Croix, n=140; Rambouillet-Gulf Coast, n=80; Katahdin-Suffolk, n=78) and a terminal-cross mating plan (Suffolk rams mated to Dorset, St. Croix and reciprocal-cross ewes, n=100) were used to evaluate postweaning grazing performance of traditional meat breeds and tropically adapted breeds of sheep.

Tropically adapted breeds generally had lower postweaning performance than wool breeds in both grazing and feedlot management with the exception that purebred Katahdin and Suffolk were comparable in gain on bermudagrass. Tropically adapted x wool breed lambs were generally intermediate between the parental purebreds except in the Katahdin x Suffolk diallel where there was an indication of heterosis for feedlot ADG and possibly pasture ADG. In general, all lambs performed poorly on forages compared to performance on mixed diets in feedlot. These results indicated a consistent advantage in direct breed effects for wool breeds over tropically adapted breeds in feedlot management systems. The results also suggest that there is little expression of genetic effects in sheep managed on forages, although direct effects for heat adaptation in tropically adapted breeds may compensate for the superior direct breed effects for growth in the wool breeds under summer grazing.

Key words: Postweaning, Tropically-adapted, Wheat Pasture, Grazing, Sheep

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Introduction

Forages are unique, renewable resources that utilize sunlight, water and soil nutrients to manufacture and store protein, energy and other nutrients. Ruminant animals have been historically used to convert plant nutrients to nutrients available for human consumption. In the southern United States large ruminants, particularly tropically adapted beef cattle, predominate because of the poor adaptation of sheep to heat, humidity and parasites. However, a significant amount of forage resources in the southern United States are not appropriate for cattle because of small land areas available for grazing, as well as the lack of facilities to manage cattle on these small acreages. In areas where cattle predominate, there exist opportunities for additional productivity by incorporation of small ruminants into sustainable grazing systems. In the Southern Great Plains, both warm-season and cool-season forages are available for grazing ruminant animals. The primary cool-season forage for forage-based animal production in the Southern Great Plains is wheat pasture. Wheat forage is of high quality with crude protein concentration varying from 21 percent to 38 percent of the DM, and NDF concentration often less than 50 percent with ADF concentration of less than 30 percent of total DM (Gallavan et al., 1989; Vogel et al., 1989; Phillips and VonTungeln, 1995).

Hair sheep are a recent addition to ruminant animals available in the United States for utilization of forages. They are tolerant of the heat and associated humidity (Bunge et al., 1993a,b; Wildeus, 1997), and parasites (Wildeus, 1997; Vanimisetti et al., 2004) in the Southern United States and have the potential to fill an important niche in meat animal production. In addition, some of the southern landrace breeds, such as the Gulf Coast sheep, have similar traits that would allow them to be productive in the heat, humidity and parasite-laden environments in the southern United States. There is considerable interest in the potential of hair sheep for lamb production in the southern United States. However, there is limited objective information on the growth of these breeds, and there is a need to evaluate the performance of hair and other tropically adapted breeds in grazing-production systems in comparison with conventional wool breeds and their crosses with hair breeds. Consequently, the objectives of this research were: 1) Evaluate the performance of tropically adapted breeds and their crosses with wool breeds as pasture lambs and feedlot lambs; 2) determine the relationship of heterotic expression and maternal- and direct-breed effects to postweaning management.

Materials and Methods

Dorset and St. Croix ewes (n=59; n=61) were spring-bred in 1999, 2000, and 2001 in a diallel-mating scheme to Dorset and St. Croix rams (n=10; n=8) to produce Dorset (n=30), St. Croix (n=37), Dorset x St. Croix (n=39), and St. Croix x Dorset lambs (n=34) for postweaning trials. Similarly, Rambouillet and Gulf Coast ewes (n=27; n=27) were spring-bred in 1999, 2000, and 2001 in a diallel-mating scheme to Rambouillet and Gulf Coast rams (n=6 ; n=4) to produce Rambouillet (n=17), Gulf Coast (n=22), Rambouillet x Gulf Coast (n=19) and Gulf Coast x Rambouillet (n=22) lambs. With the exception on one year of the experiment, after breeding, ewes from the St. Croix x Dorset and Rambouillet x Gulf Coast were managed similarly, lambed at the same time in the fall, their lambs were weaned at the same time, and lambs from each diallel were assigned and managed in postweaning treatments concurrently. Thus, feedlot pens contained Dorset, St. Croix, Rambouillet, Gulf Coast, Dorset x St. Croix, St. Croix x Dorset, Rambouillet x Gulf Coast, and Gulf Coast x Rambouillet lambs. Similarly, lambs on wheat pasture consisted of all breed groups, with the exception of one year, where lambs from the Gulf Coast x Rambouillet diallel were started later due to drought and lack of wheat pasture for all lambs. Ewe lambs from the Dorset-St. Croix diallel were retained and bred to Suffolk rams (n=4) in the spring of 2003 and 2004 to produce two- and three-breed cross lambs (n=100). Dorset, Rambouillet, and Suffolk rams were purchased from producer flocks, either private treaty or at sheep auction sales. Pedigree records for wool rams used in the study that were purchased prior to 1999 were not available, but for rams purchased after 1998, full-sibs or half-sibs were not used. St. Croix, Gulf Coast, and Katahdin rams were obtained from experimental flocks or purchased private treaty as needed and half-sib or full-sib rams were not used in the experiment.

Ewes were flushed prior to breeding using 0.45 kg/d corn and bred in single-sire pastures in 45-day breeding seasons. Ewes were managed on bermudagrass pastures in the summer and fall and managed in large outside lambing pens prior to lambing in the fall. Ewes and lambs were put into sheltered lambing pens for three days after lambing and moved to mixing pens prior to placement on bermudagrass pastures. All lambs were weighed at birth and ram lambs were castrated at birth; lambs did not receive creep feed during the preweaning period. Lambs were weaned and weighed in December of each year at an average age of 80 d. Neither ewes nor lambs were exposed to wheat pasture or cool-season forages during the preweaning period.

After weaning lambs were moved to feeding pens and started on a weaning ration (Table 1). When wheat pasture became available for grazing, lambs were stratified by breed group and sex and assigned to either a feedlot or wheat pasture treatment. Feedlot lambs were fed a high-fiber grower ration that approximated TDN levels normally observed in wheat pasture and had sufficient dietary protein to meet crude protein requirements of the lambs (Table 1). Wheat pasture lambs were allowed to graze for eight hours during the day and lotted at night with fresh water available. Because of differences in wheat pasture availability, the first postweaning trial was initiated in January, 2000; but the second and third could not be initiated until March 2001, and March 2002, respectively. Full weights were taken the morning of trial initiation each year and at least twice a week for six weeks. Data reported includes postweaning ADG of lambs in feedlot from weaning until removed from the feedlot, and it includes postweaning ADG of lambs placed on wheat pasture until the end of the trial with the intent of maximizing the time on a postweaning management regimen for purposes of evaluation of gain on that regimen. Consequently, any inference of comparison of the two postweaning management systems will necessarily reflect those time differ-

Table 1. Diet composition and protein and energy estimates for mixed rations and forages, % DM.

Ingredient	Weaning Ration, %	Growing Ration, %	Wheat Pasture, %	Bermudagrass Pasture, %
Molasses	5	5		
Cottonseed Meal	8	13		
$CaCO_3$	0.5	0.5		
Ca_2CO_3	0.5	0.5		
Chopped Corn	35.5	40.5		
Alfalfa Hay	50.5	40.5		
Crude Protein[a]	15.9	16.9	28.6	7.9
TDN[a]	70.1	72.8	75.0	64.7

[a] Weaning and growing rations based on average NRC values for diet ingredients; wheat pasture and bermudagrass pasture based on laboratory NIRS analyses for pasture samples.

ences, if they are, in fact, influential. However, reanalysis of the data constraining times for both postweaning management systems to be equal and congruent (first six weeks after initiation of grazing wheat pasture in the wheat-pasture lambs) did not result in practically significant changes in ADG for the feedlot lambs, but did bias the wheat-pasture lambs downward because of the 21 d adaptation period common in wheat-pasture stockers (cattle and sheep), where animals do not gain or actually lose weight. The most accurate estimate of performance of lambs on wheat pasture is for the period analyzed and reported (eight-weeks average, rather than six) and is representative of the spring-grazing period from initiation of wheat pasture availability through grazeout in the late spring.

Suffolk and Katahdin ewes (n=28 ; n=18) were fall-bred in 2003 in a diallel-mating scheme to Suffolk (n=2) and Katahdin (n=2) rams to produce Suffolk (n=28), Katahdin (n=15), Suffolk x Katahdin (n=14), and Katahdin x Suffolk (n=21) lambs. Management of ewes and lambs was similar to other studies reported. Lambs were weaned at an average age of 80 d and moved to bermudagrass pastures in early June, 2004. Growth as pasture lambs on bermudagrass was evaluated through mid-August and lambs were moved to feedlot for finishing (90 d).

Linear models used in analyses of postweaning growth included fixed effects of year, sire breed, sire in sire breed (random), dam breed, sex of lamb, parity, postweaning management (pasture vs feedlot) and any appropriate interactions among fixed effects ($P < 0.25$). Direct heterosis was estimated as the contrast between the average of the reciprocal-cross lambs and average of the purebred lambs. Maternal-breed effects were estimated as the contrast between the reciprocal-cross lambs. Direct-breed effects were estimated as twice-the-breed-of-sire main effect contrast. Test of hypotheses were done using t-tests appropriate to the contrast. Sample sizes for lambs in the study are given in Table 2.

Results and Discussion

Least squares means, heterosis, maternal breed, and direct-breed effects for pasture and feedlot postweaning ADG for St. Croix, Dorset, and reciprocal-cross lambs are given in Table 3. Purebred St. Croix gained slower than purebred Dorset on wheat pasture and in feedlot ($P < 0.10$ and $P < 0.01$, respectively; data not shown). There was little evidence of direct heterosis or maternal breed effects but direct-breed effects in favor of Dorset were evident in feedlot lambs ($P < 0.05$). Gains on wheat pasture were 75 percent of gains on feed for St. Croix and numerically less for other breed groups. Results are similar to those of Bunch et al. (2004), who reported lower daily gains in St. Croix than wool breeds.

Least squares means, heterosis, maternal-breed, and direct-breed effects for pasture and feedlot postweaning ADG for Gulf Coast, Rambouillet, and reciprocal-cross lambs are given in Table 4. There was little evidence of breed-group differences on wheat pasture, although Gulf Coast were numerically less than other breed groups. In feedlot, Gulf Coast had lower gains than Gulf Coast x Rambouillet, Rambouillet x Gulf Coast and Suffolk ($P < 0.06$, $P < 0.05$, $P < 0.06$, respectively; data not shown), which were similar in their

Table 2. Sample size for sire breed x dam breed x postweaning management subclasses.

Lamb Breed	Katahdin	K x S[a]	S x K[a]	Suffolk
Pasture	15	21	14	28
Feedlot	15	21	14	28
Lamb Breed	**St. Croix**	**S x D[a]**	**D x S[a]**	**Dorset**
Pasture	20	19	23	15
Feedlot	17	15	16	15
Lamb Breed	**Gulf Coast**	**G x R[a]**	**R x G[a]**	**Rambouillet**
Pasture	11	11	8	10
Feedlot	11	11	11	7
Ewe Breed	**St. Croix**	**S x D[a]**	**D x S[a]**	**Dorset**
Pasture	14	13	13	11
Feedlot	16	14	10	9

[a] K x S = Katahdin x Suffolk, S x K = Suffolk x Katahdin, D x S = Dorset x St. Croix, S x D = St. Croix x Dorset, G x R = Gulf Coast x Rambouillet, R x G = Rambouillet x Gulf Coast (sire breed listed first).

Table 3. Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for St. Croix, Dorset, and reciprocal-cross lambs, kg/d.

Lamb Breed	St. Croix	S x D[a]	D x S[a]	Dorset	Heterosis[b]	Maternal[b]	Direct[b]	No. Years/ No. Lambs
Pasture, 56d	0.12±0.01	0.13±0.01	0.14±0.01	0.16±0.02	0.00±0.01	-0.00±0.02	0.04±0.03	3/77
Feedlot, 98d	0.16±0.02	0.22±0.02	0.22±0.02	0.28±0.03	-0.00±0.02	0.00±0.02	0.12±0.05*	3/63
P/F[c], %	75	59	64	57				

† P < 0.10, * P < 0.05, ** P < 0.01

[a] D x S = Dorset x St. Croix, S x D = St. Croix x Dorset (sire breed listed first).

[b] Heterosis = direct heterosis [(S x D + D x S)/2 – (St. Croix + Dorset)/2], Maternal = maternal breed effects [S x D – D x S], Direct = direct breed effects [(Dorset + D x S) – (St. Croix + S x D)].

[c] Pasture ADG/Feedlot ADG x 100 for each breed group

Table 4. Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for Gulf Coast, Rambouillet, and reciprocal-cross lambs, kg/d.

Lamb Breed	Gulf Coast	G x R[a]	R x G[a]	Rambouillet	Heterosis[b]	Maternal[b]	Direct[b]	No. Years/ No. Lambs
Pasture, 54d	0.11±0.01	0.13±0.01	0.14±0.01	0.14±0.01	0.01±0.01	-0.01±0.02	0.03±0.02	3/40
Feedlot, 119d	0.22±0.01	0.25±0.01	0.27±0.01	0.27±0.02	0.02±0.01	-0.01±0.01	0.06±0.02*	3/38
P/F[c], %	50	52	52	52				

† P < 0.10, * P < 0.05, ** P < 0.01

[a] G x R = Gulf Coast x Rambouillet, R x G = Rambouillet x Gulf Coast (sire breed listed first).

[b] Heterosis = direct heterosis [(G x R + R x G)/2 – (Gulf Coast + Rambouillet)/2], Maternal = maternal breed effects [G x R – R x G], Direct = direct breed effects [(Rambouillet + R x G) – (Gulf Coast + G x R)].

[c] Pasture ADG/Feedlot ADG x 100 for each breed group

ADG. Effects for direct heterosis and maternal-breed effects were not evident on either postweaning treatment, but there were direct-breed effects in favor of Rambouillet in the feedlot lambs (P < 0.05). Gains on wheat pasture as a proportion of gains in feedlot were similar among the breed groups and ranged from 50 percent to 52 percent.

Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for Katahdin, Suffolk and reciprocal-cross lambs are given in Table 5. Breed group means for lambs grazing bermudagrass were similar, and there was little evidence of heterosis, maternal-breed effects, or direct-breed effects in lambs grazing bermudagrass. However, there was a nonsignificant trend for heterosis in the pasture lambs on bermudagrass with a 17 percent advantage of crossbred lambs over purebred lambs. This was partly a function of the low gains in the purebred Suffolk lambs on bermudagrass, which may have been suppressed by high temperatures during the summer. In the feedlot lambs, purebred Katahdin lambs had lower ADG than the other breed groups (P < 0.05,

Table 5. Least squares means, heterosis, maternal breed, and direct breed effects for pasture and feedlot postweaning ADG for Katahdin, Suffolk, and reciprocal-cross lambs, kg/d.

Lamb Breed	Katahdin	K x S[a]	S x K[a]	Suffolk	Heterosis[b]	Maternal[b]	Direct[b]	No. Years/ No. Lambs
Pasture, 70d	0.12±0.01	0.15±0.02	0.13±0.02	0.12±0.02	0.02±0.01	0.01±0.03	-0.02±0.03	1/74
Feedlot, 97d	0.15±0.01	0.21±0.02	0.22±0.02	0.22±0.02	0.03±0.02†	-0.01±0.03	0.08±0.03*	1/75
P/F[c], %	80	71	59	55				

† P < 0.10, * P < 0.05, ** P < 0.01

[a] K x S = Katahdin x Suffolk, S x K = Suffolk x Katahdin (sire breed listed first).

[b] Heterosis = direct heterosis [(K x S + S x K)/2 – (Katahdin + Suffolk)/2], Maternal = maternal breed effects [K x S – S x K], Direct = direct breed effects [(Suffolk + S x K) – (Katahdin + K x S)].

[c] Pasture ADG/Feedlot ADG x 100 for each breed group

Table 6. Least squares means, maternal heterosis, and grandmaternal breed effects for pasture and feedlot postweaning ADG for Suffolk-sired lambs from St. Croix, Dorset, and reciprocal-cross ewes, kg/d.

Ewe Breed	St. Croix	S x D[a]	D x S[a]	Dorset	Maternal Heterosis	Grand-Maternal[b]	No. Years/ No. Lambs
Pasture, 77d	0.16±0.02	0.14±0.02	0.18±0.02	0.17±0.02	-0.00±0.02	-0.04±0.02†	1/51
Feedlot, 77d	0.24±0.02	0.22±0.02	0.22±0.02	0.20±0.03	-0.00±0.02	-0.01±0.03	1/49
P/F[c], %	67	64	82	85			

† P < 0.11, * P < 0.05, ** P < 0.01
[a] D x S = Dorset x St. Croix, S x D = St. Croix x Dorset (grandsire breed listed first).
[b] Maternal heterosis [(S x D + D x S)/2 – (St. Croix + Dorset)/2]; Grandmaternal = grandmaternal breed effects [(S x D) – (D x S)
[c] Pasture ADG/Feedlot ADG x 100 for each breed group

data not shown), there was some evidence of heterosis (P< 0.10) and there was evidence of a direct-breed effect in favor of Suffolk (P < 0.05). There was no evidence of maternal-breed effects in the feedlot treatment group. Pasture performance of Katahdin and Katahdin x Suffolk lambs was 80 percent and 71 percent of contemporaries in feedlot, whereas performance of Suffok x Katahdin and Suffolk lambs on bermudagrass was 59 percent and 55 percent of contemporaries on feed, respectively. Bunch et al. (2004) reported feedlot gains lowest in purebred St. Croix, intermediate in St. Croix x wool crosses but not significantly different from St. Croix, and highest in purebred wool lambs.

Least squares means, maternal heterosis, and grandmaternal-breed effects for wheat pasture and feedlot postweaning ADG for Suffolk-sired lambs from St. Croix, Dorset, and reciprocal-cross ewes are given in Table 6. There was some evidence of a grandmaternal effect in the wheat-pasture lambs with lambs from Dorset x St. Croix ewes gaining better than lambs from St. Croix x Dorset ewes (P < 0.11). There was no evidence of maternal heterosis in either postweaning treatment group nor was there evidence of grandmaternal effects for feedlot lambs. Wheat-pasture gains of lambs from Dorset and Dorset x St. Croix ewes was 85 percent and 82 percent of contemporaries on feed while performance of lambs from St. Croix and St. Croix x Dorset ewes was 67 percent and 64 percent of contemporaries in feedlot.

Rastogi et al. (1975) reported individual heterosis in postweaning ADG for crosses among Columbia, Suffolk, and Targhee but it was only around 2 percent above the purebred mean. Bourfia and Touchberry (1993) reported that individual heterosis for carcass weight per day of age was not important in crosses among Moroccan breeds of sheep. Bidner et al. (1978) reported little evidence of sire breed x dam breed interactions in postweaning ADG for crosses of breed groups involving Suffolk, Rambouillet, and Gulf Coast Native breeds. Mavrogenis (1996) reported positive but small estimates of direct heterosis for postweaning ADG in crosses of Chios and Awassi breeds. Consequently, it is reasonable to conclude that direct breed effects may have more influence on postweaning lamb performance than individual heterosis, with the possible exception of superior summer performance from crosses among Suffolk and Katahdin breeds.

Table 7. Wheat pasture and feedlot performance of Hereford-sired calves from Brahman, Angus, and reciprocal-cross cows, kg/d

Breed of dam	Wheat Pasture	Feedlot	WP/FL[b], %
Brahman	0.78	1.30	60
B x A[a]	0.73	1.37	53
A x B[a]	0.66	1.37	48
Angus	0.66	1.44	46

[a] B x A = Brahman x Angus, A x B = Angus x Brahman (sire breed listed first)
[b] Wheat Pasture/Feedlot x 100

Tropically adapted breeds generally had lower postweaning performance than wool breeds in both grazing and feedlot management. Tropically adapted x wool breed lambs were generally intermediate between the parental purebreds. Exceptions occurred in the summer grazing trial with the Katahdin x Suffolk diallel, where purebred Katahdins and Suffolks were comparable in gain on bermudagrass, and there was an indication of heterosis for feedlot ADG and possibly pasture ADG. These exceptions may relate to expression of heat tolerance in the Katahdin and Katahdin crossbred lambs. Further, even with the low performance of St. Croix on wheat pasture in the winter and spring, the purebred St. Croix gained 75 percent of their contemporaries on grain diets, whereas the gains of purebred Dorsets on wheat pasture were only 57 percent of contemporaries on feed. This trend was not noted in the Gulf Coast in the winter, although Gulf Coast crosses performed comparable to Rambouillet purebreds on wheat pasture. Thus, hair sheep and crosses not only may provide advantages in summer grazing, but also may be best suited for forage gains, where costs of gain are lower. If the growth potential of hair sheep were to be improved genetically and other attributes retained, even greater advantage might be possible. Certainly, there is a need to evaluate the

Gulf Coast under summer grazing conditions, where their heat tolerance might be manifest.

In more general terms, sheep seemed to perform poorly on forages compared to performance on mixed diets in feedlot. Results from this location of a three-year trial comparing wheat-pasture gain to feedlot with different breed groups of cattle (Phillips, et al., 2001) are given in Table 7. Cattle gains on wheat pasture averaged 52 percent of gains in the feedlot compared to an average of 64 percent for sheep in the experiments reported in this paper. While the forage gains as a percentage of gains in feedlot would probably be lower for sheep with higher energy density rations, it is reasonable to conclude that the relative performance of sheep on forages is at least as good as cattle. Moreover, the average weight on trial of the cattle on wheat pasture was 312 kg with an average ADG of 0.71 kg. By comparison, the average weight of sheep on wheat pasture in these trials was 37.4 kg. Therefore, 312 kg of lambs grazing forages (8.33 lambs) yielded an average ADG of 1.17 kg. The comparison is not definitive because of differences in the years in which the experiments were conducted. It does raise the question of relative efficiencies of forage utilization of different ruminant genera and species.

Conclusion

Results from this research suggested that lambs grazing pasture did not attain their genetic potential for postweaning growth and genetic effects such as direct breed effects were not expressed under pasture grazing, particularly in cool-season forages. However, these results also suggested that hair sheep expressed a greater percentage of their genetic potential for postweaning growth on pasture than did wool sheep. Under feedlot conditions, where genetic potential for postweaning growth can be more easily expressed, direct genetic effects favored wool breeds but there was some evidence that the heat tolerance in hair sheep may offset some of the direct, genetic-breed effects of the wool breeds under summer-grazing conditions. It is clearly evident from these results that further work is warranted in evaluation of efficiency of forage utilization by tropically adapted sheep breeds.

Literature Cited

Bidner, T.D., P. E. Humes, R.Boulware, and P. E. Schilling. 1978. Characterization of ram and ewe breeds. II. Growth and carcass traits. J. Anim. Sci. 47:114-123.

Bourfia, M. and R. W. Touchberry. 1993. Diallel cross of three Moroccan breeds of sheep: I. Lamb growth and carcass traits. J. Anim. Sci. 71:870-881.

Bunch, T. D., R. C. Evans, S. Wang, C. P. Brennand, D. R. Whittier, and B. J. Taylor. 2004. Feed efficiency, growth rates, carcass evaluation, cholesterol level and sensory evaluations of various hair and wool sheep and their crosses. Small Ruminant Research 52:239-245.

Bunge, R., D. L. Thomas, and T. G. Nash. 1993a. Performance of hair breeds and prolific wool breeds of sheep in southern Illinois: Lamb production of F1 ewe lambs. J. Anim. Sci. 71:2012-2017.

Bunge, R., D. L. Thomas, T. G. Nash, and R. L. Fernando. 1993b. Performance of hair breeds and prolific wool breeds of sheep in Southern Illinois: Effect of breed of service sire on lamb production of Suffolk and Targhee ewes. J. Anim. Sci. 71:321-325.

Fogarty, N. M., G. E. Dickerson and L. D. Young. 1984. Lamb production and its components in pure breeds and composite lines. II. Breed effects and heterosis. J. Anim. Sci. 58:301-311.

Gallavan, R. H., Jr., W. A. Phillips and D. L. VonTungeln. 1989. Forage intake and performance of yearling lambs fed harvested wheat forage. Nutrition Reports International 39:643-648.

Mavrogenis, A. P. 1996. Environmental and genetic factors influencing milk and growth traits of Awassi sheep in Cyprus. Heterosis and maternal effects. Small Ruminant Research 20:59-65.

Phillips, W. A. and D. L. VonTungeln. 1995. Dry matter intake of freshly harvested wheat forage and supplemental dry matter. Sheep and Goat J. 11:150-155.

Phillips, W. A., M. A. Brown, A. H. Brown, Jr., and S. W. Coleman. 2001. Genotype x environment interactions for postweaning performance in calves grazing winter wheat pasture or dormant native prairie. J. Anim. Sci. 79:1370-1377.

Rastogi, R., W. J. Boylan, W. E. Rempel, and H. F. Windels. 1975. Lamb performance and combining ability of Columbia, Suffolk and Targhee breeds of sheep. J. Anim. Sci. 41:10-15.

Vanimisetti, H. B., S. P. Greiner, A. M. Zajac, and D. R. Notter. 2004. Performance of hair sheep composite breeds: resistance of lambs to Haemonchus contortus. J. Anim. Sci. 82: 595-604.

Vogel, G. J., W. A. Phillips, G. W. Horn, M. J. Ford and R. W. McNew. 1989. Effects of supplemental silage on forage intake and utilization by steers grazing wheat pasture or bermudagrass. J. Anim. Sci. 67:232-240.

Wildeus, S. 1997. Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. J. Anim. Sci. 75:630-640.