SUMMARY

A total of 130 ram lambs were used in a study to determine the effects of sex alteration on serum hormone levels, growth rate and carcass traits. Sex alteration included no treatment (intact rams), scrotal ablation to alter normal testicular secretion (short scrotum rams) and castration to completely remove influences derived from the testes (wethers). Although these data suggest that scrotal ablation at birth did not produce complete azoospermia in Finn-crossbred rams, reduction (P<.01) in testicular weight did produce significant results. Serum testosterone in short scrotum and intact rams was similar, whereas castration resulted in considerably lower concentrations of this steroid (P<.01). On the other hand, serum luteinizing hormone was increased (P<.01) threefold in short scrotum rams and 12-fold in wethers as compared to that of intact rams. Because these results cannot be fully explained by changes in serum testosterone, it is speculated that changes in secretory products of the testis which accompany degeneration of the germinal epithelium are responsible for elevated luteinizing hormone.

Post-weaning average daily gain (P<.01) and feed efficiency were highest in intact and short scrotum rams indicating that testosterone (or testis) may be beneficial. Although dressing percentage and adjusted backfat were highest (P<.01) in wethers, carcass weight and yield grade were advantageous (P<.01) in short scrotum and intact rams. Quality grades were similar; all animals reached average choice. (Key Words: LH, Testosterone, Short scrotum, Lambs, Growth, Carcass.)

INTRODUCTION

Hormones secreted from the testis of domestic species are known to have significant effects on growth rate and efficiency of feed utilization. Furthermore, quality and quantity of the retail product are changed by hormonal status of the animal. With the possible exception of quality, the intact bull, ram and boar have distinct advantages over castrate counterparts for these traits (Wierbicki et al., 1955; Field, 1971).

Ram lambs gain faster than wethers and have less carcass waste (Hunt et al., 1938; Walker, 1950; Mc Claugherty et al., 1959; Turton, 1962; Glimp, 1971); yet castration of male lambs continues, largely because of discriminatory practices. To retain the benefits of feeding intact lambs, studies have been conducted to evaluate growth and carcass data from sexually altered males. Hudson et al. (1968) demonstrated that induced cryptorchidism in male lambs resulted in growth rates similar to those observed in rams and at the same time eliminated the live animal market discrimination. In a subsequent study, Glimp (1971) not only showed growth rates in short scrotum males to equal those in intact rams but also showed carcass grades to be superior to those in intact rams and equivalent to wethers.

The present study was conducted to determine the effects of shortened scrotums and castration on growth rate and carcass characteristics of Finn-crossbred rams. Changes in spermatogenesis as a result of shortened scrotum and the effects of all treatments on serum luteinizing hormone (LH) and testosterone (T) concentrations were evaluated.
EXPERIMENTAL PROCEDURE

A total of 130 ram lambs (% Finnish-Landrace) born in October, 1974 were used in this study. At birth, animals were randomly assigned to one of three sex treatment groups: group 1 lambs remained as intact rams; group 2 lambs were made short scrotum by pushing the testes toward the body cavity and placing a rubber elastrator ring high on the scrotum; and group 3 lambs were castrated by placing an elastrator ring above both testes. This procedure was accomplished between 12 and 48 hr of neonatal life.

Lambs were weaned on the same day at an average age of 42 days and weighed to evaluate pre-weaning growth. For management purposes, lambs were then sorted into their respective treatment groups and penned together for the duration of the study. A pelleted ration consisting of 54% ground shell corn, 20% dehydrated alfalfa, 18% soybean meal, 7.5% molasses and .5% trace mineralized salt was fed ad libitum.

Because of the variation in finishing weights, two slaughter dates were designated so that all animals within a treatment group would have similar body weights. The heavier animals (one-half of each group) were slaughtered at an average age of 175 days, and the remaining animals were held for an additional 28 days feeding. Lambs were left unshorn.

At biweekly intervals before slaughter, three blood samples were taken from each lamb for the estimation of serum hormone concentrations. Serum LH concentrations were determined by radioimmunoassay (Niswender et al., 1969) using NIH LH-S18 as reference standard. There was no cross-reactivity of the LH-antisera to 1 /ag of purified ovine FSH (LER-1881-3). The correlation between standard LH added to ram serum and the amount determined in excess of initial serum concentration was .997 for duplicate determinations of seven levels of LH ranging from .12 to 10 ng per assay tube and sensitivity was .06 nanograms. Intraassay coefficients of variation for duplicate determinations as described by Abraham et al. (1971) were always less than 10%. Interassay coefficient of variation was 11.6% across seven assays for a pool of serum containing 10.5 ng/ml. Radioimmunoassay procedures for the determination of serum T have been previously described (Schanbacher, 1976).

At the time of slaughter, testes were taken and weighed and a portion was fixed for histological evaluation. In hematoxylin-eosin stained sections (4 μm), spermatogenesis was qualitatively evaluated and seminiferous tubule diameters measured with a micrometer. This information was used to assess the effects of shortened scrotum on testicular function.

Hot carcass weights were used for calculation of dressing percentage and carcass data collected 24 hr after slaughter were used for calculation of quality grade and yield grade.

The data were analyzed by the program for least-square analysis of data with unequal subclass numbers (Harvey, 1960); the model used adjusted for main effects of sex treatment, slaughter group, type of birth, type of rearing and age of dam. Significant F values are shown in the summary of analyses (table 1). Where significant, group means were tested by least significant differences (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Sex Alteration and Growth. Table 2 contains pre-weaning and post-weaning growth data for sexually altered rams. Pre-weaning growth rates were not affected significantly by castration or short scrotum modification. All post-weaning traits, on the other hand, were affected (P<.01) by treatment. Whereas intact rams and short scrotum rams did not differ, wethers were lighter at the time of slaughter and had reduced average daily gain. Relative growth rate which represents the percentage change in body weight per day of age (Fitzhugh and Taylor, 1971) was also lower in wethers. Feed efficiency data were not collected on individual animals in this experiment; however, group measures were available. The intact ram required the least amount of feed per kilogram weight gain (4.1 kg), whereas, the short scrotum ram and wether required 4.3 and 4.8 kg, respectively. The present results, obtained in the early maturing Finnish-Landrace sheep, are consistent with the observations of others (Field, 1971; Glimp, 1971; Gortsema et al., 1974) relative to the effect of sex alteration on growth in males.

Sex Alteration and Carcass Traits. Carcass weight, like final weight, was lower (P<.01) in wethers than in males with testes. Unlike the results of Glimp (1971) and others (Field, 1971; Glimp, 1971; Gortsema et al., 1974) the short scrotum rams had a lower (P<.01) dressing percentage than wethers. Kidney and pelvic fat were similar in
TABLE 1. SUMMARY OF ANALYSES OF VARIANCE FOR VARIOUS TRAITS OF SEXUALLY ALTERED RAMS

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Final weight (kg)</th>
<th>Avg daily gain (g/day)</th>
<th>Carcass traits</th>
<th>Hormonal traits</th>
<th>Testicular traits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LH (ng/ml)</td>
<td>Testosterone (ng/ml)</td>
</tr>
<tr>
<td>Sex treatment</td>
<td>2</td>
<td>619.01**</td>
<td>21450**</td>
<td>65.05**</td>
<td>3.77**</td>
<td>1.96**</td>
</tr>
<tr>
<td>Slaughter group</td>
<td>1</td>
<td>141.53**</td>
<td>41940**</td>
<td>19.28**</td>
<td>58.62**</td>
<td>.18</td>
</tr>
<tr>
<td>Type of birtha</td>
<td>3</td>
<td>22.52</td>
<td>505</td>
<td>7.63</td>
<td>1.54</td>
<td>.13</td>
</tr>
<tr>
<td>Type of rearingb</td>
<td>3</td>
<td>3.15</td>
<td>210</td>
<td>4.71</td>
<td>1.25</td>
<td>.15</td>
</tr>
<tr>
<td>Age of damc</td>
<td>4</td>
<td>12.24</td>
<td>509</td>
<td>7.48</td>
<td>1.71</td>
<td>.22</td>
</tr>
<tr>
<td>Remainder</td>
<td>116</td>
<td>18.73</td>
<td>600</td>
<td>12.47</td>
<td>1.44</td>
<td>.30</td>
</tr>
</tbody>
</table>

a Lambs born as singles, twins, triplets and quadruplets.

b Lambs reared as singles, twins, triplets or in nursery.

c Lambs from ewes 1 through 5 years of age.

*p<.05, **p<.01.

TABLE 2. PRE-WEANING AND POST-WEANING TRAITS OF SEXUALLY ALTERED RAMS

<table>
<thead>
<tr>
<th>Sex</th>
<th>No.</th>
<th>Weaning weight (kg)</th>
<th>Avg daily weight gain (g/day)</th>
<th>Relative growth rate (% wt/day)</th>
<th>Final weight (kg)</th>
<th>Avg daily gain (g/day)</th>
<th>Relative growth rate (% wt/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ram</td>
<td>45</td>
<td>7.4 ± .6d</td>
<td>140 ± 14d</td>
<td>.033 ± .002d</td>
<td>50.9 ± 1.6d</td>
<td>259 ± 10d</td>
<td>.012 ± .0004d</td>
</tr>
<tr>
<td>Short scrotum</td>
<td>46</td>
<td>7.7 ± .6d</td>
<td>138 ± 13d</td>
<td>.031 ± .002d</td>
<td>49.1 ± 1.7d</td>
<td>249 ± 10d</td>
<td>.011 ± .0004d</td>
</tr>
<tr>
<td>Wether</td>
<td>39</td>
<td>7.6 ± .6d</td>
<td>141 ± 14d</td>
<td>.032 ± .002d</td>
<td>42.9 ± 1.7e</td>
<td>213 ± 10e</td>
<td>.010 ± .0004e</td>
</tr>
</tbody>
</table>

a Means not followed by the same superscript are different (P<.01).
rams with testes but were increased (P<.01) in castrate lambs. Adjusted backfat showed trends comparable to dressing percentage with short scrotum ram carcasses having less backfat than wether carcasses. Other investigators have pointed out the increased dressing percentage (Field, 1971) and backfat (Hudson et al., 1968; Field, 1971) derived from castrate lambs.

As indicated in table 1, quality grades were not affected by sex treatment. Although quality grades were slightly higher in wethers, all three treatment groups graded average choice (table 3). On the other hand, a distinct advantage (P<.01) was noted for yield grade of intact males; short scrotum rams were favored. The conclusion, therefore, is that intact males and particularly short scrotum rams may have certain advantages over wethers in regard to carcass merit. Although a distinct advantage in carcass grade was noted in short scrotum rams and wethers by Glimp (1971), the lack of differences in quality grade in the present study may be due to the early maturing characteristics of the Finn-crossbred male.

**Sex Alteration and Hormone Levels.** Endocrine function changed considerably in sexually altered rams (table 4). Luteinizing hormone, which is largely responsible for maintenance of Leydig cell function in several species (Neaves, 1975), was significantly affected by the presence of germinal epithelial tissue. Shortening the scrotum of ram lambs and elevating testicular temperature resulted in elevated serum LH when compared to normal intact rams (3.54 vs 1.21 ng/ml; P<.01), and complete removal of the testes resulted in even higher LH concentrations (14.29 ng/ml). Although removal of the testes is known to elevate serum LH (Crim and Geschwind, 1972), only a short communication has reported a similar response in cryptorchid rams (Hillard and Bindon, 1975). These investigators observed increased LH in both artificially induced and natural cryptorchid rams.

Mean serum T concentrations for sexually altered rams are presented in table 4. Although no differences (P>.05) in serum T levels were noted between normal intact rams (1.94 ng/ml) and short scrotum rams (2.12 ng/ml), these values were significantly higher than those determined for wethers (.01 ng/ml). Similar results in sexually altered bulls have been reported by Gortsema et al. (1974). Using crossbred calves, these investigators showed that plasma levels of T in short scrotum bulls were not significantly

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**Table 3. Carcass Traits of Sexually Altered Rams**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Carcass weight (kg)</th>
<th>Dressing weight (kg)</th>
<th>Yield grade</th>
<th>Quality grade</th>
<th>Adjusted backfat (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ram</td>
<td>2.2 ± 1.1d</td>
<td>51.6 ± 1.4d</td>
<td>3.1 ± 2d</td>
<td>11.4 ± 5d</td>
<td>3.0 ± 2d</td>
</tr>
<tr>
<td>Short scrotum</td>
<td>2.1 ± 1.0d</td>
<td>57.7 ± 1.4d</td>
<td>3.4 ± 2d</td>
<td>11.2 ± 5d</td>
<td>3.4 ± 2d</td>
</tr>
<tr>
<td>Wether</td>
<td>2.3 ± 1.0d</td>
<td>55.3 ± 1.4d</td>
<td>3.5 ± 2d</td>
<td>11.8 ± 5d</td>
<td>3.6 ± 2c</td>
</tr>
</tbody>
</table>

*Means not followed by the same superscript are different (P<.01).
Quality grade: 10 = low choice; 12 = high choice.
Yield grade: 5 = low curability; 1 = high curability.
TABLE 4. HORMONE CONCENTRATIONS AND TESTICULAR TRAITS OF SEXUALLY ALTERED RAMS

<table>
<thead>
<tr>
<th>Sex</th>
<th>No.</th>
<th>LH (ng/ml)</th>
<th>Testosterone (ng/ml)</th>
<th>Avg testis weight (g)</th>
<th>Seminiferous tubule diameter (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ram</td>
<td>45</td>
<td>1.21±1.43d</td>
<td>1.94±.30d</td>
<td>121.7±10.0d</td>
<td>56.4±7.4d</td>
</tr>
<tr>
<td>Short scrotum</td>
<td>46</td>
<td>3.54±1.35e</td>
<td>2.12±.28d</td>
<td>55.2±9.2c</td>
<td>105.2±6.7c</td>
</tr>
<tr>
<td>Wether</td>
<td>39</td>
<td>14.29±1.38f</td>
<td>.01±.29c</td>
<td>. . .</td>
<td>. . .</td>
</tr>
</tbody>
</table>

a Means not followed by the same superscript are different (P<.01).

Different from those of normal bulls and approached undetectable levels in steer plasma. Although intact and short scrotum rams have measurable quantities of serum T, simple correlations between mean hormone levels and growth or carcass traits for these rams were extremely low (r = -.05 to .02). Therefore, growth and carcass differences between rams and wethers indicate that only a threshold level of T is required to alter protein and lipid metabolism. It is speculated that testicular hormones in addition to T are likely to influence the quality and quantity of meat produced by a given animal.

Data in table 4 indicates a marked effect of sex alteration on average testis weight and seminiferous tubule diameter. Considerable variation was seen between short scrotum individuals with regard to testicular development. Although average testis weight for short scrotum rams was less (P<.01) than that obtained for normal rams, weight range (20 to 190 g) was considerable. Histological sections of these testes showed that short scrotum ram testes contained seminiferous tubules with varying numbers of spermatogenic cells. A high correlation (r = .87) existed between testis weight and the number of fully differentiated spermatozoa. Bauman et al. (1975) have attributed disrupted spermatogenesis in short scrotum rams to increased testicular temperature.

Brief mention is made of the significant effects of slaughter group on reproductive traits. Animals in group 1 had faster growth rates and heavier testes weights than animals in group 2; thus, it appears that testes growth rates were greater in ram lambs which gained faster. A plausible explanation for the effect of slaughter group on LH concentrations is not presented, but it should be noted that the magnitude of difference in mean LH between group 1 (5.7 ng/ml) and group 2 (7.0 ng/ml) was small when compared to differences due to sex treatment (ram, 1.2 ng/ml; short scrotum, 3.5 ng/ml; wether, 14.3 ng/ml).

Despite the fact that the short scrotum technique was not as successful as expected, certain conclusions can be drawn. Shortening scrotums of ¾ Finn-crosbred rams at birth was a less-than-adequate method of regulating testicular descent and development. Perhaps uniform results could be obtained if the optimum age or weight for sexual alteration was determined for a given breed of ram.

Other reports have suggested the probability that increased growth rates and superior carcass cutability in males with testes are due to higher levels of circulating T. Although our data support this contention, a better understanding of testicular physiology, its secretory products and their influence on body chemistry and metabolism may enable animal scientists to better utilize available animal resources.

LITERATURE CITED