A series of three trials was conducted to investigate the nutritional requirements for optimal testicular growth in rams. Measurements were made of liveweight, wool growth and scrotal circumference in rams given a range of dietary treatments (n = 5 per treatment, in individual pens). In all experiments there was a control group fed 1 kg pelleted diet (approx. 70 cereal grain : 30 straw) to maintain liveweight, and a group supplemented with 750 g lupin/d. The remaining treatments provided supplements of varying ME and protein content. There was an asymptotic relationship between liveweight gain and testicular growth with maximum change in testicular volume (3.4 ml/d) achieved at growth rates of approximately 200 g/d. There was no relationship between wool production (protein status) and testicular growth.

INTRODUCTION

Although it has been demonstrated that undernutrition of rams results in decreased testicle volume and sperm production (Parker and Thwaites 1972, Alkass et al. 1982), the specific nutritional requirements when feeding above maintenance in order to increase testicle size are not clearly defined. The data of Braden et al. (1974) indicate that high levels of dietary protein are not required to increase daily sperm production. On the other hand Oldham et al. (1978) suggested that more than half of the variation in testicle growth could be accounted for by the protein status of the animal as measured by nitrogen balance.

The objective of the studies reported here was to investigate the role of protein and energy, provided as supplements to a basal maintenance diet, on the rate of testicle growth. Changes in liveweight were measured to confirm the efficiency of supplementary metabolisable energy (ME) utilization for growth and wool production was monitored as an index of protein status.

MATERIALS AND METHODS

A series of three experiments was conducted. The first trial started in June and terminated in August 1982 (49d). The second and third trials were carried out from October to December 1982 and from March to May 1983 respectively (both 42d).

Animals and feeding Eighteen Merino rams (six years of age) were selected from the Wongan Hills Research Station culls on the basis of having sound mouths and no detectable abnormalities of the testes. All animals were dehorned and fitted with indwelling abomasal cannulae six weeks before the first experiment. During the post-operative recovery period animals were introduced to a pelleted diet containing (g/kg): oats, 230; barley, 230; wheat, 200; oat hay, 300; and minerals and vitamins, 40. For three weeks before each experiment the animals were housed individually and fed a ration of 1 kg pellets/d.
In all experiments animals were allocated to treatments on the same basis. Five replicate groups, each of three rams, were formed on the basis of similar scrotal circumference and liveweight. Within each group animals were assigned to experimental treatments at random. Mean initial liveweight ranged from 55 to 60 kg for all experiments.

In Experiment 1 the animals were held in metabolism cages. In Experiments 2 and 3 they were held in individual pens on a slatted floor. Drinking water was freely available.

Dietary treatments. A basal maintenance ration of 1 kg pellets/d was fed to each animal on all experimental treatments. Two treatments were common to the three experiments: the maintenance, control diet and supplementation of this maintenance ration with 750 g lupin grain/d. These served as negative and positive controls to evaluate the responses due to the third treatment and to account for any seasonal differences in testicular growth. The "test" treatments studied in the three experiments are summarized below.

Experiment 1. The equivalent amount of protein to that consumed in 750 g lupins (236 g/d) was infused directly into the abomasum as a solution of casein. Glucose (112 g/d) was included in the infusate.

Experiment 2. The equivalent amount of ME and protein contained in 750 g lupins was given in purified forms. ME was provided as (g/d): glucose (112), vegetable oil (60), sodium acetate (127), and sodium propionate (64). Casein (236 g/d) providing both protein and ME was infused into the abomasum with the glucose. The other sources of ME were mixed in the diet.

Experiment 3. Barley grain was fed (800 g/d) to provide approximately the same ME intake and about 30 per cent of the additional protein.

Testicular volume. In all experiments the scrotal circumference was measured at the point of greatest diameter at weekly intervals. In Experiment 1, estimations were also made using the comparative palpation technique described by Oldham et al. (1978). At the termination of Experiment 3 the animals were slaughtered and the volumes of each testis and epididymis measured separately by water displacement.

Liveweight. Animals were weighed at weekly intervals. The relationship between liveweight change and testicular growth obtained in these experiments was compared with the data of Lindsay et al. (1976) and Oldham et al. (1978).

Wool growth. This was estimated from the amount of clean wool produced from a 100 cm patch on each side of the animals.

RESULTS

The feed intake and measurements of production for the three experiments are summarized in Table 1. In Experiment 1 there were significant (P < 0.05) increases in liveweight gain, scrotal circumference and wool growth as a result of supplementation of the basal diet with lupin seed. In response to an intra-abomasal infusion of casein and glucose there was a significant (P < 0.05) increase only in wool production. Testicular growth was not changed by the additional protein and glucose given via the abomasum.
TABLE 1  Feed intake, daily liveweight change, testicular growth and wool production measured in three experiments using 15 rams

<table>
<thead>
<tr>
<th>Dietary treatment</th>
<th>Total feed given (g/d)</th>
<th>Liveweight change (g/d)</th>
<th>Change in scrotal circumf. (mm/d)</th>
<th>Wool growth (mg/cm²/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DM</td>
<td>CF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basal</td>
<td>890</td>
<td>85</td>
<td>-7</td>
<td>-0.15</td>
</tr>
<tr>
<td>+ Lupin</td>
<td>1570</td>
<td>300</td>
<td>222**</td>
<td>0.71*</td>
</tr>
<tr>
<td>+ Casein + glucose</td>
<td>1189</td>
<td>260</td>
<td>82</td>
<td>-0.14</td>
</tr>
<tr>
<td>+ Energy and Protein</td>
<td>1382</td>
<td>279</td>
<td>349**</td>
<td>0.71</td>
</tr>
<tr>
<td>LSD</td>
<td>9/</td>
<td>NS</td>
<td></td>
<td>(P = 0.08)</td>
</tr>
</tbody>
</table>

Experiment 2

| Basal             | 815 | 73 | 52                   | 0.42                               | 0.82                  |
| + Lupin           | 1530 | 290 | 355**                | 0.91                               | 1.29                  |
| + Energy and Protein | 1382 | 279 | 349**                | 0.71                                | 1.37                  |
| LSD               | 9/ | NS |                      | (P = 0.08)                          |                       |

Experiment 3

| Basal             | 900 | 81 | 31                   | 0.17                               | 0.93                  |
| + Lupin           | 1557 | 295 | 189***               | 0.80                               | 1.60**                |
| + Barley          | 1468 | 133 | 254***               | 0.77                               | 0.82                  |
| LSD               | 54 | (P = 0.06) |                  | 0.30                  |

\[ \text{LSD} \text{ Least significant difference (7 < 0.05)} \]
\[ \text{Casein and glucose (abomasal infusion), oil and UFA in diet} \]
\[ * , ** , *** \text{ values significantly (P < 0.05, 0.01, 0.001 respectively) different from animals on basal diets} \]

In Experiment 2 there were highly significant (P < 0.001) increases in liveweight gain in response to supplementation with lupins and also to the intra-abomasal infusion of mixed energy substrates and casein. Although wool production and testicular volume were increased as a result of these treatments the differences were not statistically significant (P = 0.08 and 0.16, respectively).

In Experiment 3 there was a significant (P < 0.001) increase in liveweight gain in response to supplementation with lupins or barley. There were similar increases (P = 0.06) in scrotal circumference in animals on these supplements but wool production was increased only in animals given lupin seed.
There was a close relationship between testicular volume \( Y \), ml, measured at slaughter and the scrotal circumference \( X \), cm, given by the equation:

\[
Y = 42.2 \times X - 993 \quad R^2 = 0.89.
\]

The relationship between daily liveweight gain and change in testicular volume was asymptotic with maximum testicular growth achieved (3.4 ml/d) in rams gaining around 200 g/d. These data were compared with those reported by Lindsay et al. (1976), and Oldham et al. (1978) and are summarised in Fig. 1. No relationship was observed between wool production and testicular growth. In all trials there was a close relationship between the estimated amount of ME consumed and the rate of liveweight gain.

**DISCUSSION**

It appears from the data presented here that testicular growth may be closely related to the rate of liveweight change (and therefore ME intake) rather than to the protein status of the animal as monitored by wool production. This observation is consistent with the conclusions of Braden et al. (1974) who found that sperm production could be increased by additional digestible organic matter in the diet but did not in response to protein supplementation. The data of Lindsay et al. (1976) and Oldham et al. (1978) provide additional evidence for the relationship between the rates of change of liveweight and testicular volume over a wide range of liveweight change (-300 to 350 g/d). The earlier suggestion, that the high rate of testicular growth in rams given lupins, was related to the nitrogen status of these animals could have resulted from the supplement providing both protein and ME (producing significant growth responses).

Grazing sheep given supplements of lupin grain appear to grow faster than animals given cereal grain. The question of whether this is due to a more balanced supply of crude protein and ME or because of the different carbohydrate composition of the two grains is currently under investigation.

**REFERENCES**


