3-1992

Growth and wool production of Merino wethers after treatment with testosterone

M A. Johns

A Meldrum

J F. Wallace
CSIRO, Floreat (Australia). Division of Mathematics and Statistics

K P. Croker

F E. Watson
Queen Elizabeth II Medical Centre, Nedlands (Australia). Dept. of Clinical Chemistry

Recommended Citation

Johns, M A, Meldrum, A, Wallace, J F, Croker, K P, and Watson, F E. (1992), *Growth and wool production of Merino wethers after treatment with testosterone*. Department of Primary Industries and Regional Development, Western Australia, Perth. Technical Bulletin 85.

ISSN 0083-8675
Agdex 430/67

DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA

Technical Bulletin

Growth and wool production of Merino wethers after treatment with testosterone

No. 85

K.P. Croker, M.A. Johns, A. Meldrum, J.F. Wallace and F.E. Watson

The authors K.P. Croker, M.A. Johns, A. Meldrum and J.F. Wallace; Department of Agriculture, Western Australia

F.E. Watson, The Queen Elizabeth II Medical Centre

Present addresses:

K.P. Croker and M.A. Johns
Sheep and Wool Branch
Division of Animal Production
Department of Agriculture
Baron-Hay Court, South Perth 6151
Western Australia

A. Meldrum
Research Station
Department of Agriculture
Merredin 6415
Western Australia

J.F. Wallace
Division of Mathematics and Statistics
Private Bag
CSIRO
Wembley 6014
Western Australia

F.E. Watson
Department of Clinical Chemistry
The Queen Elizabeth II Medical Centre
Nedlands 6009
Western Australia

National Library of Australia

Cataloguing-in-Publication

Growth and wool production of Merino wethers after treatment with testosterone

Bibliography
Includes index
ISBN 0 7309 4639 8

1. Merino sheep. 2. Testosterone. I. Croker, K.P. (Keith Percival), 1943- . II. Western Australia, Dept. of Agriculture. (Series : Technical Bulletin (Western Australia, Dept. of Agriculture); No. 85).

636.36

Preface

In Western Australia, testosterone preparations are only registered for treatment of ovine posthitis and for the induction of male behaviour in wethers. The potential for the use of testosterone as a growth promoter in wethers was examined from 1982 to 1985, before the European Community banned the importation of carcasses from animals treated with hormones.

The data obtained do not support the use of testosterone for growth promotion in wethers. Therefore, on two counts, the European initiative and the lack of an economic growth and wool response, it is unlikely that testosterone preparations would be registered for more than the current uses (1991) in Australia.

Contents

Abstract

This investigation was done over three years, in the wheatbelt of Western Australia, to measure the performances of weaner and 2-tooth Merino wether sheep treated with different quantities (0, 0.5, 1.0, 2.0 or 4.0 mL) of an injectable testosterone preparation with the equivalent of 260 mmol testosterone/L (Banrot-Coopers Animal Health, Cabarita, N.S.W.*) with different intervals (1, 2, 3, 4, 6 or 12 months) between the injections. The first treatment of the young sheep was given the day they were weaned from the ewes which was in September in year 1, October in year 2 and July in year 3. The weaners were then grazed at low or high stocking rates for the following 12 months with 2-tooth wethers in the first two years. In years 1 and 2, the effect of treating weaners given a production feeding ration of oat grain/lupin seed was also examined.

The results were variable with there being no response to the testosterone treatment of the weaners in year 2 which were weaned onto dry feed. In the other two years, the weaners grazed at the lower stocking rates were heavier and there appeared to be a general increase in the weight of those injected with testosterone. However, the level of response was not consistent and in year 3 there was no response while the sheep grazed green feed for four months or so following weaning. There was a general trend for an increased wool cut and an increase in the fibre diameter from the treated weaners, but the cost of treatment was rarely recouped.

There was no response to treatment with testosterone of weaners given an *ad libitum* ration with 75% oat grain and 25% lupin seed by weight. However, the efficiency of the conversion of feed to liveweight was improved in treated weaners fed 500 g/head.d. The extra wool cut from the supplemented weaners only compensated for a proportion of the cost of the feed at the wool prices prevailing in 1983 and 1984. It is suggested that, in practice, weaners would only be fed to attain target

* Note: Banrot® is no longer produced. However, other similar injectable forms of testosterone are still marketed.

weights and not for prolonged periods as in these experiments. This could have a marked effect on the economics of such strategies.

There were no economic gains arising following the treatment of 2-tooth wethers with 2 mL of Banrot at two or three monthly intervals.

The amounts of testosterone in the peripheral blood a month or more after treatment with testosterone were very low (< 0.2 nmol/L) even where 4.0 mL of Banrot was injected. This suggests that the use of this preparation would not lead to residue problems, especially as it would be unlikely that treatment would be more frequent than every month.

We conclude that growth responses in Merino wether weaners following treatment with testosterone can be obtained under some circumstances. There appears to be no advantage in treatment where there is unlimited feed on offer, but to obtain a response there is a need for good quality feed. Overall, the results indicate that treatment of wethers with Banrot does not produce economic gains.

In addition, it is unlikely that such preparations will be registered for use in Australia because the European Community has banned the importation of meats from animals receiving hormonal treatments.

Introduction

The main reason for treating animals raised for slaughter with hormones is to stimulate growth of muscle and to improve feed conversion ratios (Hoffmann 1982). It appears that an alteration in hormone status or balance, rather than the direct effect of the hormone, determines the change in rate of growth and body composition of animals (Galbraith and Tipps 1981). Although Heitzman (1979) reported that combined preparations of androgenic and oestrogenic compounds gave the greatest increase in the growth rates of wether lambs compared with untreated lambs, most research on sheep growth and production has investigated the response to one hormone only, rather than using combinations of hormones.

As early as 1949, Andrews, Beeson and Harper reported that the subcutaneous treatment of wether lambs with a testosterone pellet increased their growth and market value. A number of subsequent experiments examining the effect of testosterone on growth have been reported from various countries. Some of these have involved the use of testosterone pellets with sheep in feedlots or run under paddock conditions. Other researchers have used either implants or injections of testosterone propionate. However, the effects of testosterone, irrespective of its formulation, on growth rates have not been consistent.

In eastern Australia, Osborne and Widdows (1961), Southcott and Royal (1971) and Southcott and Shorthose (1972) reported that liveweights and carcass weights were increased in Merino wethers grazed under paddock

conditions following treatment with implants containing testosterone propionate. In addition to the growth responses, Osborne and Widdows (1961), Southcott (1962) and Osborne (1966) reported that there was an increase in wool production in wethers treated with testosterone propionate, although Southcott and Royal (1971) reported that wool growth was not usually affected significantly. Southcott (1962) suggested that when there was an increase in wool production it was mainly because of the control of posthitis resulting from the treatment.

The results from earlier investigations in Western Australia on wethers treated with both implants (J.M. Armstrong and A.S. Hadlow, unpublished data) and injections (P.W. Morcombe, unpublished data) of testosterone were not conclusive.

According to unconfirmed reports, some farmers in Western Australia were treating wethers with an injectable testosterone preparation in anticipation that the wethers will be heavier and in better condition before their sale for live export.

The aim of this project was to test the performances of Merino wethers in the wheatbelt of Western Australia, following treatment with different doses of an injectable testosterone preparation with different intervals between treatments, to determine if economic responses in growth rate or wool production could be obtained. Our hypothesis was that increasing the dose rate and frequency of injection with testosterone would likewise increase growth rate and wool production of wethers.

The investigation was conducted on the Department of Agriculture's Research Station at Newdegate, about 300 km south-east of Perth, over three years. Groups of Merino sheep bred on the Research Station were used in the project.

The climate is Mediterranean with a mean annual rainfall of 383 mm (n = 32 years). During the project the rainfalls, with the percentages of the yearly total falling during the period of May to September, were 1982 - 396 mm, 59%; 1983 - 397 mm, 65%; 1984 - 322 mm, 71% and 1985 - 253 mm, 69%.

The pastures grazed were based on subterranean clover (*Trifolium subterranean*) cultivars, Geraldton, Dwalganup, Nungarin, Daliak and Northam A, but other broad-leaved species (e.g. capeweed - *Arctotheca calendula* and erodium - *Erodium* sp.) were also present. The amount of grass, mainly rye (*Lolium rigidum*) and brome grass (*Bromus rigidum*), in the pastures varied between 25 and 50%. Cereal stubbles left after harvest were grazed during the late summer and autumn of each year.

Method

Sheep used and trial design

In years 1 and 2 the wethers were selected from the current and previous year's crop of lambs. In year 3, they were selected only from the current year's lambs. All sheep were allocated to treatment groups on a liveweight basis to give a similar range of weights in the groups and in years 1 and 2, apart from the sheep on the plots, both the young and old wethers were grazed together.

The experiments were started when the lambs were weaned from the ewes at about 2.5 to 3.5 months of age, but this time varied each year as did the duration of each experiment.

Year 1. September 3, 1982 until October 6, 1983 (13 months)

Experiment 1. Paddock grazing

(a) Wethers about three months old at the start. Fed barley from February 2, 1983 to July 4, 1983.

Treatments

Volume of Banrot
0.5, 1.0, 2.0, 4.0 mL
Frequency of treatment
1, 3, 6, 12 month intervals
Stocking rate
Low (5.4-6.5/ha), high (8.3-9.8/ha)
There were 32 groups of eight wethers each = 256 sheep.
Control (not treated)
There were two groups of eight wethers each = 16 sheep.

(b) Wethers about fifteen months old at the start. Fed barley from February 2, 1983 to July 4, 1983.

Treatments

Volume of Banrot
0, 2.0 mL every 3 months
Stocking rate
Low (5.4-6.5/ha), high (8.3-9.8/ha)
There were four groups of eight wethers each = 32 sheep.

Experiment 2. Plot grazing (5.0/ha)

Wethers about three months old at the start fed 'grain' (75% oats:25% lupins by weight) *ad libitum* from October 25, 1982 to June 24, 1983.

Volume of Banrot
2.0 mL
Frequency of treatment
3, 6 month intervals
Replicates
3
There were six groups of five wethers each = 30 sheep.
Control (not treated)
3 replicates
There were three groups of five wethers each = 15 sheep.

Year 2. October 11, 1983 until September 9, 1984 (12 months)

The weaners used in the second year were born, on average, one month later than the previous year. Also, the experiment was of a shorter duration than year 1 because shearing was brought forward to early September 1984 after being in October the previous year.

In year 2, two of the intervals at which Banrot was injected were changed to evaluate injection schedules which were thought to be more practical for farmers. In addition, another two groups given a reduced amount of 'grain' were added to the 'grain' feeding comparison to examine the efficiency of production under these conditions.

Experiment 1. Paddock grazing

(a) Wethers about three months old at the start. Fed barley from April 12, 1984 to June 7, 1984.

Treatments

Volume of Banrot
0.5, 1.0, 2.0, 4.0 mL
Frequency of treatment
1, 2, 4, 12 month intervals
Stocking rate
Low (3.0-5.1/ha), high (4.0-5.8/ha)
There were 32 groups of eight wethers each = 256 sheep.
Control (not treated)
There were two groups of eight wethers each = 16 sheep.

(b) Wethers about sixteen months old at the start. Fed barley from April 12, 1984 to June 7, 1984.

Treatments

Volume of Banrot
0, 2.0 mL
Frequency of treatment
Every 2 months
Stocking rate
Low (3.0-5.1/ha), high (4.0-5.8/ha)
There were four groups of eight wethers each = 32 sheep.

Experiment 2. Plot grazing (5.0/ha)

Wethers about three months old at the start fed 'grain' (75% oats:25% lupins by weight), from December 12, 1983 to June 14, 1984.

Volume of Banrot
2.0 mL
Frequency of treatment
1, 2 month intervals
Rate of feeding
500 g/head.d, *ad libitum*
Replicates - 3
There were 12 groups of five wethers each = 60 sheep.
Control (not treated) *ad libitum* 'grain' - 3 replicates
There were three groups of five wethers each = 15 sheep.

Year 3. July 25, 1984 until July 11, 1985 (13 months)

The weaners used in the third year were born earlier than were those used in year 1 (March-April cf June-July). Because the growing season in 1985 was poor, the experiment was ended in early July which was earlier than planned.

Only young wethers were examined in this year because there appeared to be little response to treatment of the older wethers in the previous two years. The highest volume of Banrot used in years 1 and 2 also was not re-examined, nor was the performance of wethers fed 'grain'.

Paddock grazing

Wethers about three months old at the start. Fed oats from mid March to July, 1985.

Treatments

Volume of Banrot
0.5, 1.0, 2.0 mL
Frequency of treatment
1, 2, 3 month intervals
Stocking rate
Low (4.6-5.0/ha), high (8.0-8.2/ha)
There were 18 groups of nine wethers each = 162 sheep.
Control (not treated)
There were two groups of nine wethers each = 18 sheep.

Procedure

The wethers received two anthelmintic drenches during summer to control internal parasites and the weaners were vaccinated against pulpy kidney and tetanus at marking and weaning.

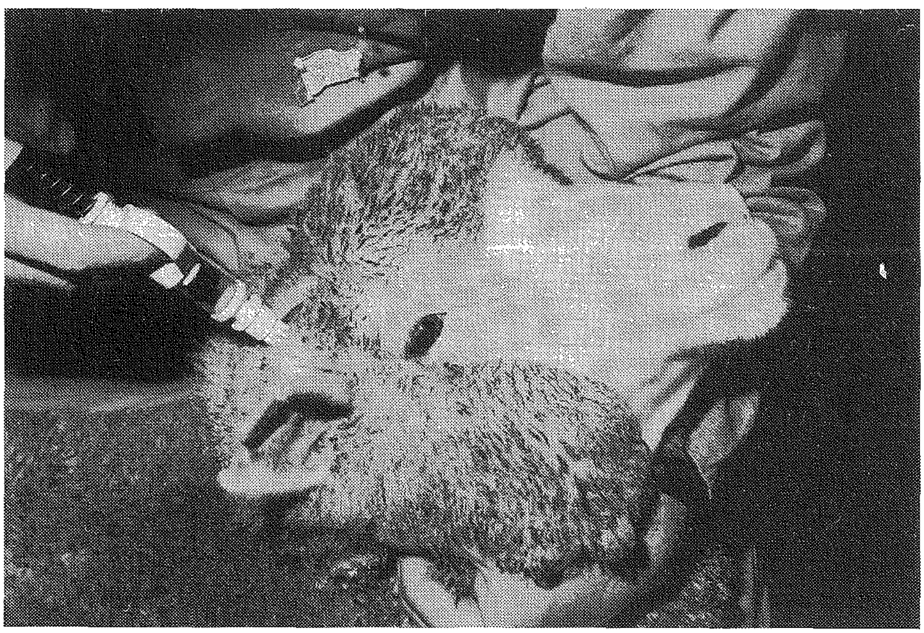
The appropriate dose of a long-acting testosterone ester was injected subcutaneously at the base of the ear on the allocated days from the start of each particular experiment. The product used was Banrot (Coopers Animal Health, Cabarita, N.S.W.) which contained 260 mmol/L testosterone in each mL from testosterone cyclopentyl-propionate. Banrot is no longer manufactured, but similar veterinary preparations are currently registered in Western Australia only for the prevention and treatment of external and internal forms of posthitis (sheath rot) and the induction of male behaviour in sheep.

The old and young wethers grazed together with the stocking rates varying both between years and during each year. In year 1, the low stocking rate was close to what would normally be used on the Research Station while the high stocking rate was expected to provide a lower level of nutrition to the sheep. In year 2 the high stocking rate used was close to the normal carrying capacity whereas the low stocking rate was conservative. Stocking rates in year 3 were selected on a similar basis to those for year 1 because the 1984 season was relatively good.

Grazing details for each year are recorded in Table 1.

In years 1, 2 and 3, the paddock grazed sheep received supplements of barley or oat grain, the grains normally fed out to maintain liveweight. The plot grazed sheep in years 1 and 2 received the 'grain' ration of 75% oat grain and 25% lupin seed by weight. With *ad libitum* availability of this ration, young sheep can achieve close to maximum growth rates (Suiter and Croker 1980).

In years 1 and 3, hand feeding started earlier than in year 2 where the high stocking rate was lower than in the other years. In addition, in year 2, the stubbles were from higher yielding crops and so more material would have been available.

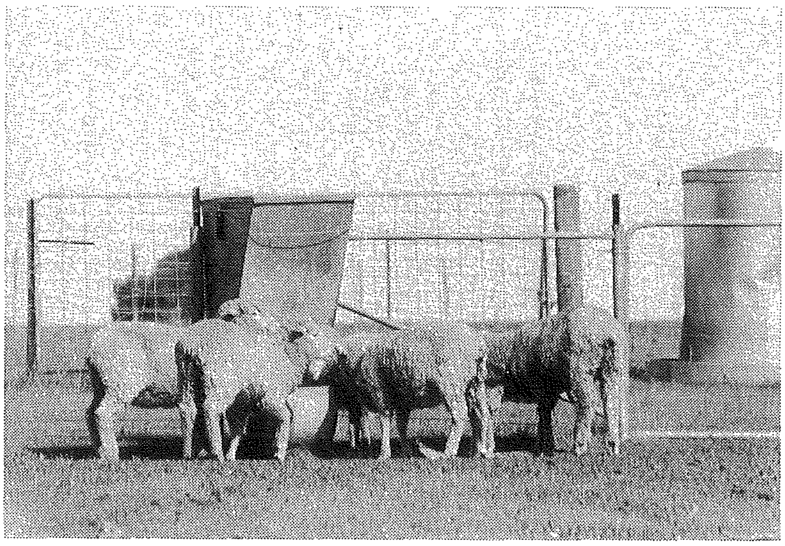


Injecting Banrot into the base of the ear.

Table 1. Details of grazing and supplementation of the paddock grazed wethers

	Age at start (mths)	Month	Feed	Stocking rate (sheep/ha)	
Year 1	3 and 15	September 1982	pasture	high - 9.8 low - 6.1	
		January 1983	stubble	high - 8.3 low - 5.4	(wheat crop yielded 0.8 t/ha) (barley crop yielded 0.8 t/ha)
		July 1983	pasture	high - 9.7 low - 6.5	
Supplementation -	February 2 to July 4, 1983 - barley grain. Two week introduction, then 300 g/head.d until March 3, 350 g/head.d until April 8, 300 g/head.d until July 4.				
Year 2	3 and 16	October 1983	pasture	high - 4.0 low - 3.0	
		January 1984	stubble	high - 5.3 low - 3.4	(barley crop yielded 2.2 t/ha) (barley crop yielded 2.5 t/ha)
		May 1984	pasture	high - 5.8 low - 5.1	
Supplementation -	April 12 to June 7, 1984 - barley grain. Two week introduction, then 350 g/head.d until May 3, 500 g/head.d until June 7.				
Year 3	3	July 1984	pasture	high - 8.0 low - 5.0	
		January 1985	stubble	high - 8.2 low - 5.0	(oat crop yielded 1.7 t/ha) (wheat, barley, oat crops yielded 1.5 t/ha)
		June 1985	pasture	high - 8.2 low - 4.6	
Supplementation -	mid-March to July, 1985 - oat grain. Two week introduction, then 500 g/head.d.				

The groups of 'grain' fed wethers were randomly allocated to plots which were grazed at a stocking rate of 5.0 sheep/ha. In year 1 the 'grain' was introduced from October 25, 1982 just before it was expected that the pastures would be completely dry. These wethers subsequently received an *ad libitum* ration from November 10 until June 24, 1983. In year 2, a similar 'grain' ration was introduced from December 12, 1983 and the equivalent of 500 g/head.d was fed from January 5, 1984 with the *ad libitum* ration being supplied from January 19. The last 'grain' was fed on June 14, 1984.



Merino wether weaners fed an oat grain: lupin seed mix *ad libitum*.

Measurements

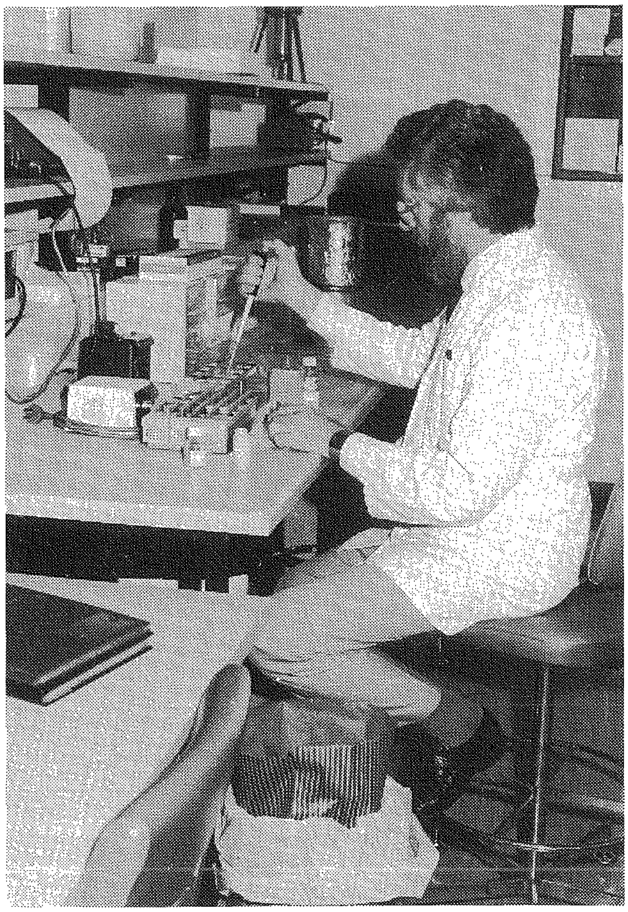
The sheep were weighed at about monthly intervals.

Blood samples were collected from four sheep in each of a number of the treatment groups in years 1 and 2 before the start of grazing. The same wethers were re-sampled at the weighing when the group averages reached 34 kg, or more, and again when the experiments were finished. The older wethers were only re-sampled at the finish.

Serum was separated after the blood had been stored overnight at 4°C. The sera were then frozen at -20°C until analysed for testosterone by radioimmunoassay (RIA-mat Testosterone; Mallinckrodt Diagnostica, Germany).

Each year, the fleeces shorn from the weaners near the start of the experiment were weighed and then at the next shearing, which was after 11, 11 and 9 months in years 1, 2 and 3 respectively, the fleeces also were weighed. The greasy fleece weights of the older wethers in years 1 and 2 were only weighed at the end of each experiment after 11 months growth.

Before the final shearing, the right mid side was marked on all sheep. Following shearing, the fleeces (bellies included) were weighed and then samples of wool were removed from the marked areas. These samples were forwarded to the Western Australian Department of Agriculture's Fleece Measurement Laboratory where the yield and fibre diameter were measured. An experienced wool classer also gave each sample an Australian Wool Corporation type, which allowed a valuation to be placed on each fleece using the Australian Wool Corporation's reserve price schedule for the year in which the sheep were shorn.



F.E. Watson analysing blood sera samples for testosterone contents.

Statistical analyses

Effects of treatments on the liveweights and greasy fleece weights were assessed by analysis of variance. Where appropriate, the initial measurement was used as a covariate.

Economic comparisons

The average values of the fleeces were based on AWC reserve prices for the different categories of wool harvested – these were assessed from mid-side samples of wool. The costs of the treatments were calculated from the retail price of Banrot and the contract price for treating sheep which then allowed the determination of simple net returns. There was no consideration of any indirect effects of the treatments, e.g. on intake and so stocking rate.

Results

Treatments did not have consistent marked effects on the wethers. Therefore, the detailed results of the lengths of time taken for the wethers to attain certain weights and the average production of wool from each year of the investigation are only recorded in the appendices.

Year 1

Liveweights

The young wethers grazed at the high stocking rate were significantly ($P < 0.001$) lighter at every weighing after the first one (see Figure 1 for the wethers treated with 1 mL Banrot). However, the interaction between stocking rate and treatment was also significant ($P < 0.05$ to $P < 0.001$) on the same occasions. There was very little difference between the treated and untreated wethers at the high stocking rate, but at the low stocking rate the wethers treated with Banrot were significantly heavier and this is illustrated in Figure 1.

The interaction between stocking rate and the volume of Banrot injected was significant ($P < 0.05$ to $P < 0.001$) at weighings 3, 4, 5, 6, 7 and 11 months showing that there were different responses to the volumes of Banrot at the two stocking rates (see Figures 1 and 2). In addition, the interaction between treatment with Banrot and the frequency of treatment for the last four weighings ($P < 0.05$ to $P < 0.001$) indicates that the frequency of treatment had an effect independent of the volume of Banrot injected.

There were only small differences between groups at the two stocking rates in the time taken to reach a range of weights. However, there is a suggestion that the young wethers grazed at the low stocking rate, which received monthly injections of Banrot, did reach the identified weights earlier (Table 2).

The liveweights of the older wethers are shown in Figure 3 (a, b). Those grazed at the high stocking rate had significantly ($P < 0.05$

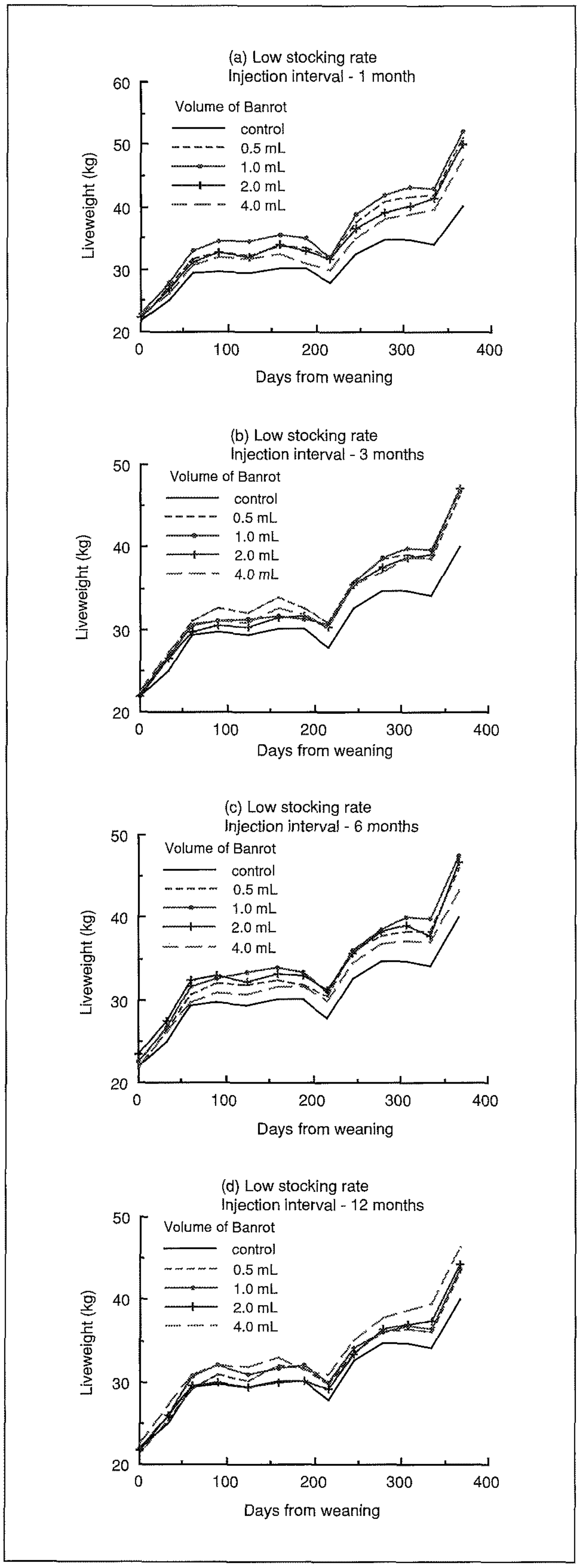


Figure 1. Experiment 1a; Year 1. The average liveweights of young Merino wethers, which were injected with a range of doses of Banrot with different intervals between injections, while grazing at the low stocking rate, between September, 1982 to October, 1983.

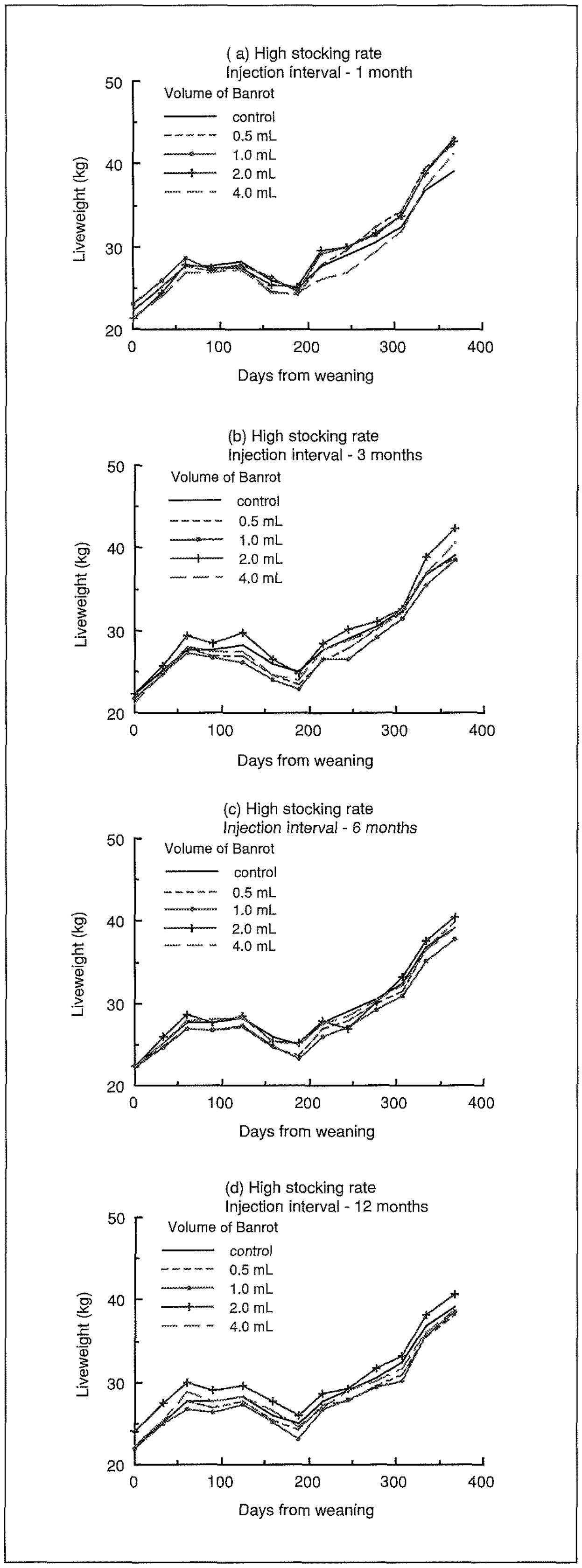


Figure 2. Experiment 1a; Year 1. The average liveweights of young Merino wethers which were injected with a range of doses of Banrot, with different intervals between injections, while grazing at the high stocking rate, between September, 1982 to October, 1983.

Table 2. The length of time taken for young, untreated wethers and those treated with 1 mL Banrot at different intervals while grazing at low or high stocking rates to reach identified liveweights in years 1 and 3

Treatment Stocking rate	Injection interval (mths)	Starting weight (kg)	Months to reach average weight greater than 30 kg	34 kg	40 kg	50 kg
Year 1						
low						
	not treated	21.9	5	9	12	-
	1	22.9	2	3	9	12
	3	22.0	2	8	12	-
	6	22.5	2	8	10	-
	12	21.9	2	8	12	-
high						
	not treated	22.2	2	9	11	-
	1	23.0	1	9	11	12
	3	21.7	2	10	11	-
	6	22.2	2	10	11	-
	12	21.9	2	10	11	-
Year 3						
low						
	not treated	19.9	2	3	10	-
	1	20.3	2	2	5	-
	2	20.1	2	3	4	-
	3	20.1	2	3	5	-
high						
	not treated	20.3	1	2	3	-
	1	20.2	1	2	3	10
	2	20.1	1	2	3	10
	3	20.1	1	2	3	10

to $P < 0.001$) lower weights at all weighings compared with the low stocking rate. The wethers treated with Banrot had significantly heavier weights than the untreated wethers at weighings 2 ($P < 0.001$), 4 ($P < 0.01$), 6 ($P < 0.05$) and 13 ($P < 0.01$) months.

There were no significant differences in growth between the Banrot-treated and untreated groups given access to the oat/lupin 'grain' mix *ad libitum*. These wethers increased weight during the experiment at rates between 99 and 104 g/head.d. (Figure 4).

During the time of *ad libitum* 'grain' feeding, the wethers ate an average of 223 kg/head of the 'grain' at a rate of 983 g/head.d. The amounts of 'grain' consumed for each kilogram increase in weight were 8.92, 8.61 and 8.88 kg for the untreated wethers and for those injected with 2.0 mL of Banrot every third or sixth month, respectively.

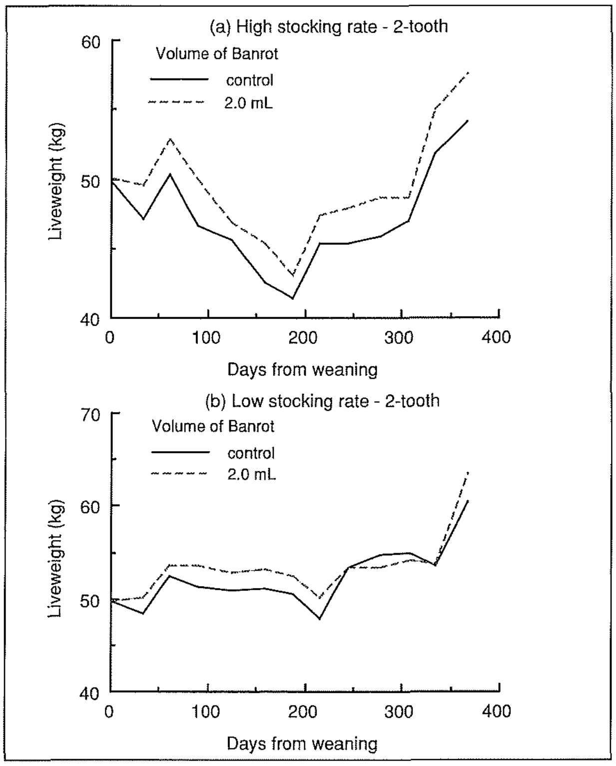


Figure 3. Experiment 1b; Year 1. The effect of 2 mL Banrot, injected every three months, on the average liveweights of 2-tooth Merino wethers grazed at high and low stocking rates between September, 1982 and October, 1983.

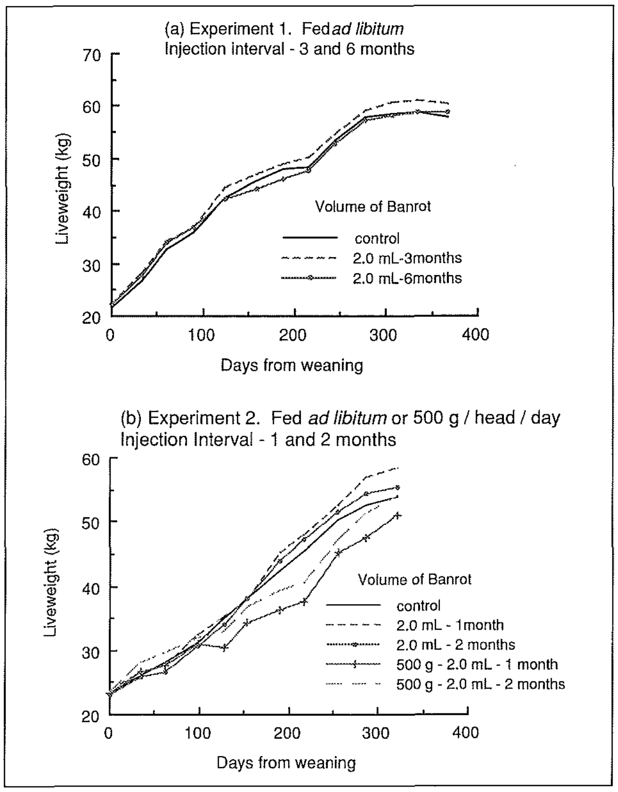


Figure 4. The average liveweights of young Merino wethers, set stocked at 5/ha on a subterranean clover based pasture, when fed grain while being injected with Banrot at different intervals.

Fleece weights

The average weights of the fleeces at the first shearing of the young wethers were 0.90, 0.89 and 0.89 kg for those grazed at the low and high stocking rates and those on the plots, respectively. The average greasy and clean fleece weights with the fibre diameters and average values for the fleeces obtained at the next shearing of the untreated wethers and those injected with 1 mL Banrot are shown in Table 3.

Stocking rate and frequency of dose had significant effects on wool production of young wethers whereas the effects of volume of Banrot and the interactions were not significant. At the lower stocking rate more greasy wool was produced ($P < 0.001$; 4.5 *cf.* 3.7 kg) while treatment with Banrot every month produced the heaviest fleeces ($P < 0.05$, 4.0, 4.3, 4.1, 4.1 and 4.0 kg for the untreated, monthly, three, six and twelve monthly treated groups, respectively, 5% LSD = 0.18). There were similar relationships between treatments for clean fleece weight and fibre diameter. At the low stocking rate, wethers treated with Banrot had higher wool values than did the untreated sheep.

There were no significant differences in production of greasy wool between the groups which received 'grain' *ad libitum*. However, these wethers produced an average of 7.3 kg of greasy wool with a fibre diameter of 22.3 μ compared with 4.2 kg with a diameter of 18.9 μ` from the untreated wethers grazed at the low stocking rate which resulted in a difference in fleece value of $11.05. As noted, these wethers consumed 223 kg/head of the oat/lupin 'grain' mix, whereas the other wethers were fed a total of 40 kg barley/head to ensure the maintenance of weight.

The wool production of the older wethers showed a significant stocking rate effect ($P < 0.001$) with a mean fleece production of 5.6 kg at the low stocking rate and 5.0 kg at the high stocking rate. The amount of clean wool produced at the low stocking rate was 3.8 kg with a fibre diameter of 22.2 μ compared with 3.3 kg with a diameter of 21.0 μ at the high stocking rate. Treatment with Banrot did not affect wool growth in these sheep.

Table 3. The average production of wool by young, untreated wethers and those treated with 1 mL Banrot at different intervals while grazing at low or high stocking rates

Treatment: Stocking rate	Treatment: Injection interval (mths)	Greasy fleece weight (kg)	Clean fleece weight (kg)	Fibre diameter (μ)	Value: Av./hd ($)	Value: Treated - not treated ($)
Year 1						
low						
	not treated	4.2	2.6	18.9	15.85	-
	1	5.0	3.2	20.1	18.01	+ 2.16
	3	4.4	2.9	19.6	17.35	+ 1.50
	6	4.7	3.0	19.2	17.74	+ 1.89
	12	4.5	3.1	19.0	19.80	+ 3.95
high						
	not treated	3.7	2.4	18.4	13.42	-
	1	3.9	2.5	19.2	14.41	+ 0.99
	3	3.6	2.3	18.1	13.60	+ 0.18
	6	3.8	2.3	18.0	12.53	- 0.89
	12	3.6	2.2	18.4	12.66	- 0.76
Year 3						
low						
	not treated	4.0	2.4	20.2	16.13	-
	1	3.8	2.5	21.9	14.94	- 1.19
	2	4.0	2.5	20.0	17.48	+ 1.35
	3	4.0	2.6	21.3	15.82	- 0.31
high						
	not treated	3.8	2.1	19.0	15.67	-
	1	4.0	2.6	21.4	15.82	+ 0.15
	2	3.7	2.4	20.3	16.46	+ 0.79
	3	3.8	2.4	19.9	17.37	+ 1.70

Testosterone levels

There was virtually no testosterone in the peripheral blood serum of the young wethers

Table 4. The average concentrations of testosterone in the peripheral blood sera samples of wethers at three times during year 1 (n = 4) (± standard deviations)

Age at start (mths)	Treatment: Volume of Banrot (mL)	Treatment: Injection interval (mths)	Concentration (nmol/L): At start	Concentration (nmol/L): At about 34 kg liveweight	Concentration (nmol/L): At finish
3	not treated		< 0.1	< 0.1	< 0.1
	1	1	< 0.1	39.1 ±36.21[1]	< 0.1
	2	1	< 0.1	30.0 ± 17.7[1]	< 0.1
	4	1	< 0.1	41.3 ±12.61[1]	< 0.1
	1	3	< 0.1	< 0.1[2]	< 0.1[3]
	2	3	< 0.1	< 0.1[2]	< 0.1[3]
	4	3	< 0.1	< 0.1[2]	< 0.1[3]
15	not treated		3.9 ± 6.1	-	< 0.1
	2	3	22.0 ± 23.4	-	< 0.1[3]

1 The wethers were injected with Banrot one to two hours before the plasma samples were taken.

2 The last injection was two months before the plasma samples were taken.

3 The last injection was three months before the plasma samples were taken.

at the start of the experiment, but relatively high levels were recorded in the older wethers (Table 4). At the end of the experiment, very low concentrations were recorded in all the wethers (< 0.1 nmol/L).

Higher concentrations of testosterone were found in the young wethers treated with Banrot each month when they were sampled after reaching 34 kg liveweight. However, these samples were obtained shortly after the wethers had been injected. These observations show the rapidity with which the testosterone from Banrot enters the blood stream. The wethers which were sampled about two months after their last injection (those treated at three month intervals) had very low concentrations (< 0.1 nmol/L) of testosterone at 34 kg.

Year 2

Liveweights

The young wethers grazed at the high stocking rate were significantly ($P < 0.001$) heavier than those grazed at the low stocking rate for weighings at 2, 3, 4, 5, 9 and 10 months. Only on two occasions (weighings 7 - $P < 0.001$, and 11 - $P < 0.01$) were those at the low stocking rate significantly heavier. The interaction between stocking rate and the volume of Banrot injected was significant for weighings at 5, 6, 7 and 8 months. However, there was no consistent pattern with these interactions. For the last three weighings (9, 10 and 11) the wethers which were injected with Banrot every month were heavier than those treated less frequently ($P < 0.001$) (Figures 5 and 6).

The liveweights of the older wethers grazed at the lower stocking rate were heavier than those at the higher stocking rate from just before halfway through the experiment. In addition, at the end of the experiment, the wethers treated with 2.0 mL of Banrot were heavier than the untreated wethers. The levels of significance for the differences at weighings 9, 10 and 11 were $P < 0.05$, $P < 0.01$ and $P < 0.05$, respectively (Figure 7 (a, b)).

The changes in weight recorded for the young wethers fed 'grain' are shown in Figure 4b. By two months after feeding started, those receiving 'grain' ad libitum were significantly heavier ($P < 0.001$) than those given 500 g/ head.d and a similar difference was measured on each occasion thereafter. The wethers given 'grain' *ad libitum* increased weight during the experiment at a rate ranging between 95 and

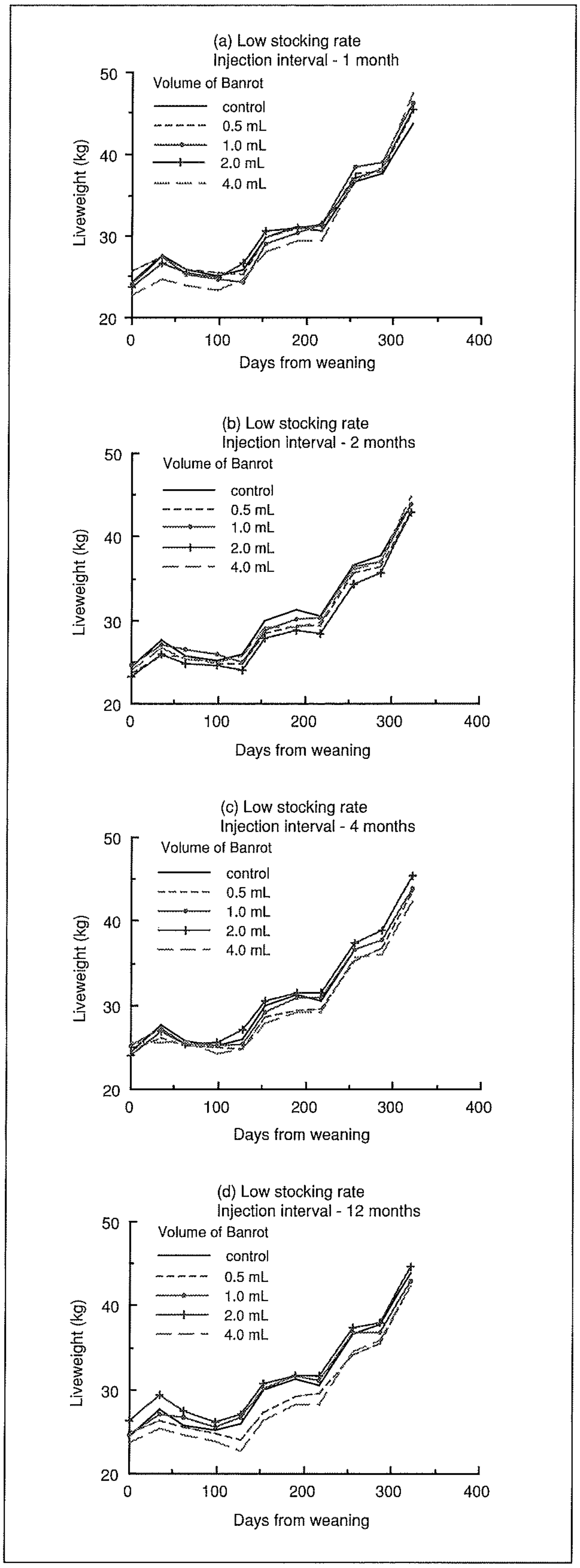


Figure 5. Experiment 1a; Year 2. The average liveweights of young Merino wethers which were injected with a range of doses of Banrot, with different intervals between injections, while grazing at the low stocking rate, between October, 1983 and September, 1984.

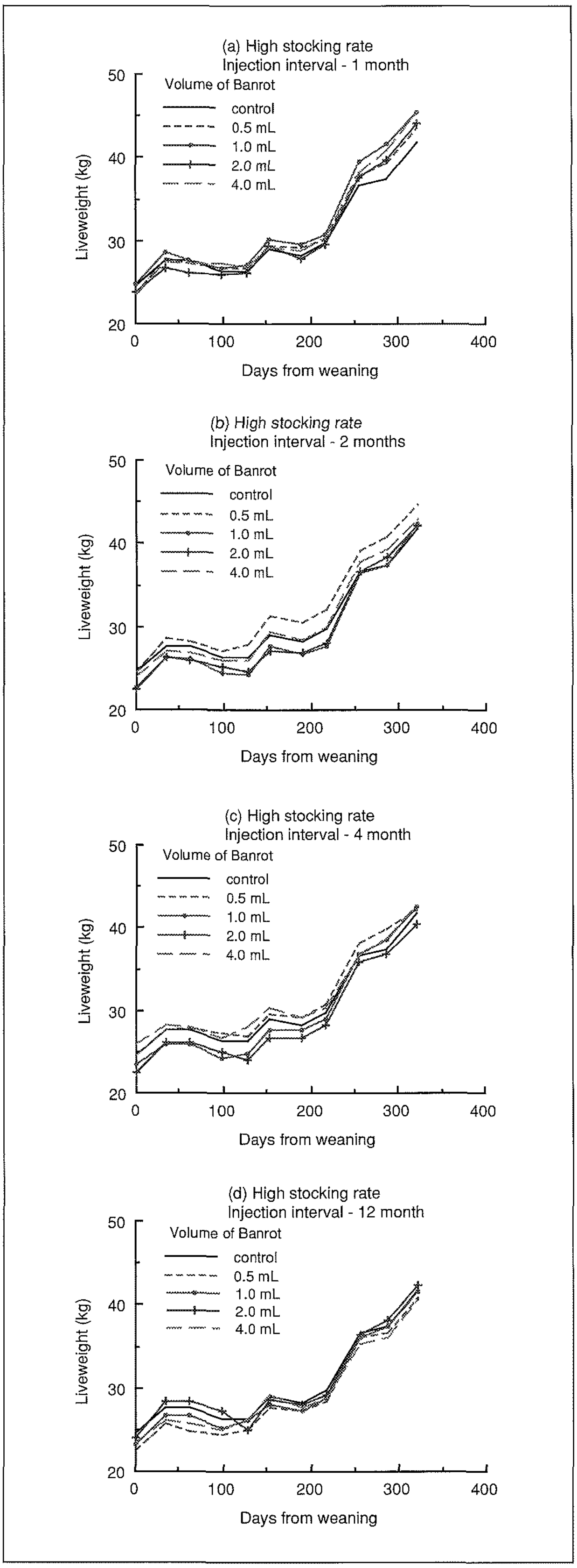


Figure 6. Experiment 1a; Year 2. The average liveweights of young Merino wethers, which were injected with a range of doses of Banrot, with different intervals between injections, while grazing at the high stocking rate, between October, 1983 and September, 1984.

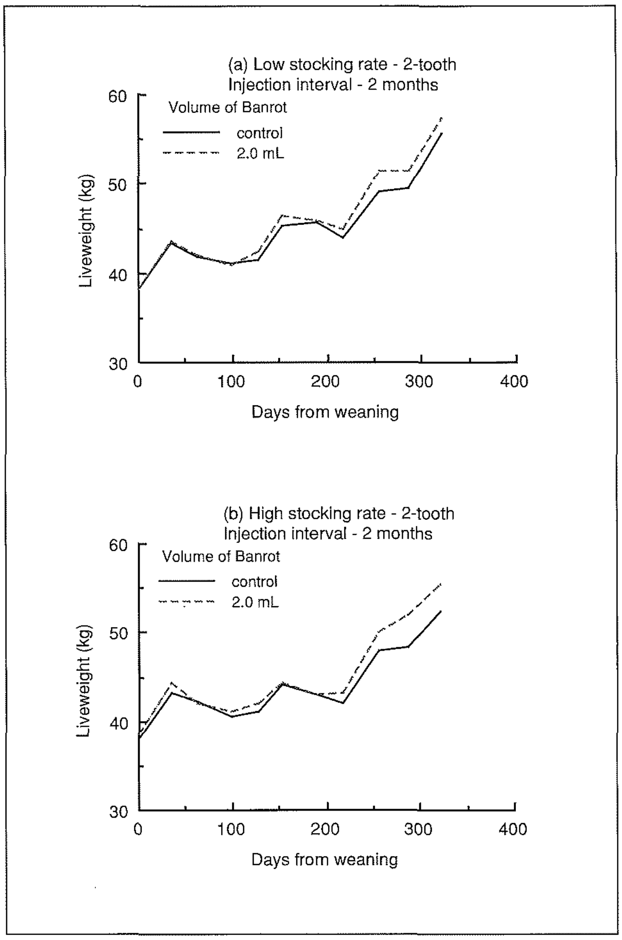


Figure 7. Experiment 1b; Year 2. The effect of 2 mL Banrot injected every two months, on the average liveweights of two-tooth Merino wethers grazed at the low and high stocking rates, between October, 1983 and September, 1984.

108 g/head.d, while those with restricted access to the 'grain' gained weight between 86 and 95 g/head.d. Hence, slightly longer periods were required for these weaners to reach the same average weights as those given 'grain' *ad libitum.*

During the period of *ad libitum* feeding, the wethers ate an average of 152 kg/head of the 'grain' at a rate equivalent to 1,027 g/head.d. The amounts of 'grain' consumed for each kilogram increase in liveweight during this period were 8.04, 7.52 and 7.24 kg for the untreated wethers and those injected with 2.0 mL of Banrot every month or second month, respectively. In comparison, the amounts of 'grain' consumed for each kilogram increase in weight during the same period for the wethers fed the equivalent of 500 g/head.d were 5.17 and 4.84 kg for those injected with 2.0 mL of Banrot every month or second month, respectively.

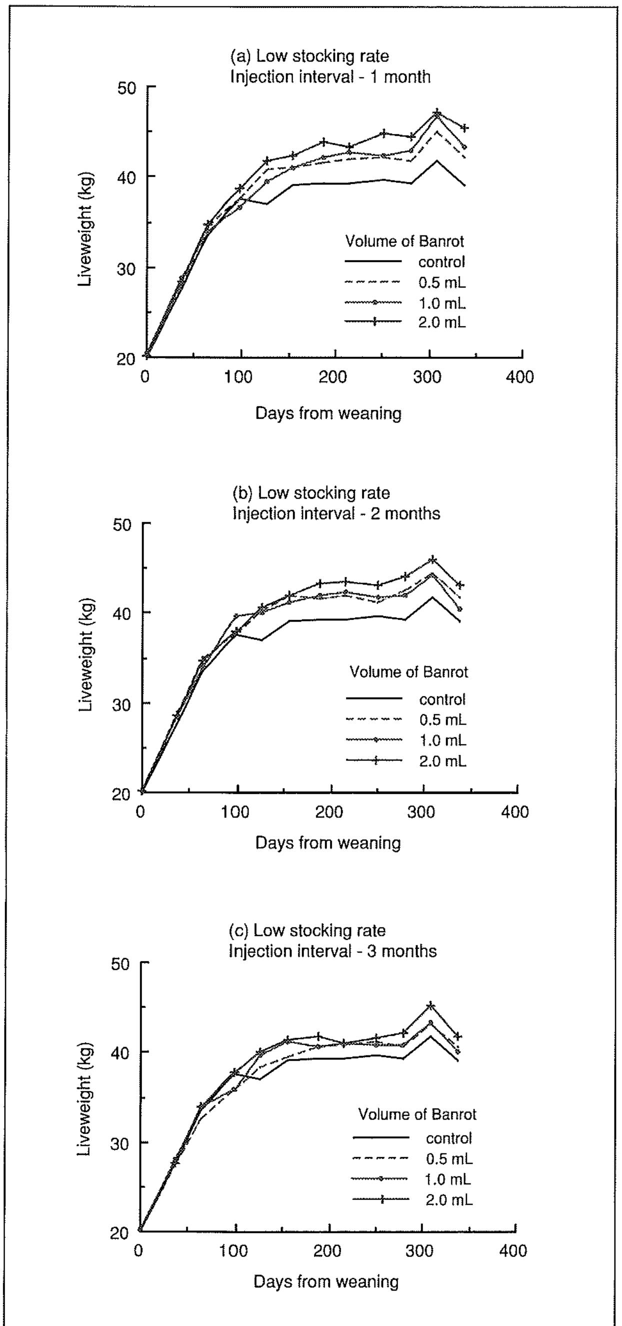


Figure 8. Year 3. The average liveweights of young Merino wethers, which were injected with a range of doses of Banrot, with different intervals between injections, while grazing at the low stocking rate, between July, 1984 and July 1985.

Fleece weights

The average weight for the fleeces obtained when the young wethers were shorn at weaning was 0.91 kg. None of the main effects were significant for the unsupplemented young wethers. However, the interaction between frequency of treatment and volume of Banrot was significant ($P < 0.001$) although this interaction cannot be interpreted readily because of the variations in the group fleece weights.

As expected, the older wethers produced more wool ($P < 0.001$). In addition, the older wethers treated with Banrot produced more wool than did the untreated wethers (5.9 *cf.* 5.4 kg, $P < 0.05$) with a slightly thicker diameter (21.5 *cf.* 21.2 μ).

Amongst the sheep fed the oat/lupin 'grain' mix, those given the supplement *ad libitum* produced more wool (6.0 *cf.* 5.2 kg, $P < 0.05$) of a thicker fibre diameter (21.6 *cf.* 20.6 μ) than did those given 500 g/head.d.

Testosterone levels

Apart from one abnormally high value in a wether injected with 4 mL of Banrot monthly, which resulted in a high average value, the concentrations of testosterone measured in the peripheral blood sera were relatively low.

Year 3

Liveweights

The wethers grazed at the high stocking rate were significantly ($P < 0.001$) lighter at every weighing after the first one apart from the last weighing when these sheep were heavier ($P < 0.001$). The only interaction which was significant ($P < 0.05$) was that between stocking rates and the volume of Banrot injected at the fifth and seventh weighings, i.e. days from weaning, 126 and 188.

At the fifth weighing, and from the seventh until the experiment was ended, the wethers treated with Banrot were significantly heavier ($P < 0.05$ to $P < 0.001$) than the untreated wethers. In addition, the effect of frequency of Banrot treatment was significant ($P < 0.05$) at later weighings with the monthly treated group the heaviest at the last three weighings 10, 11 and 12.

At the low stocking rate, the treated wethers reached 40 kg sooner than the untreated sheep, but at the high stocking rate there was no difference between the growth of treated and untreated wethers which was similar to the untreated sheep at the low stocking rate (Table 2). However, in contrast with the wethers at the low stocking rate, those grazed at the high stocking rate gained more weight during the last two months and they were significantly heavier at the last weighings. (Figure 8 and 9).

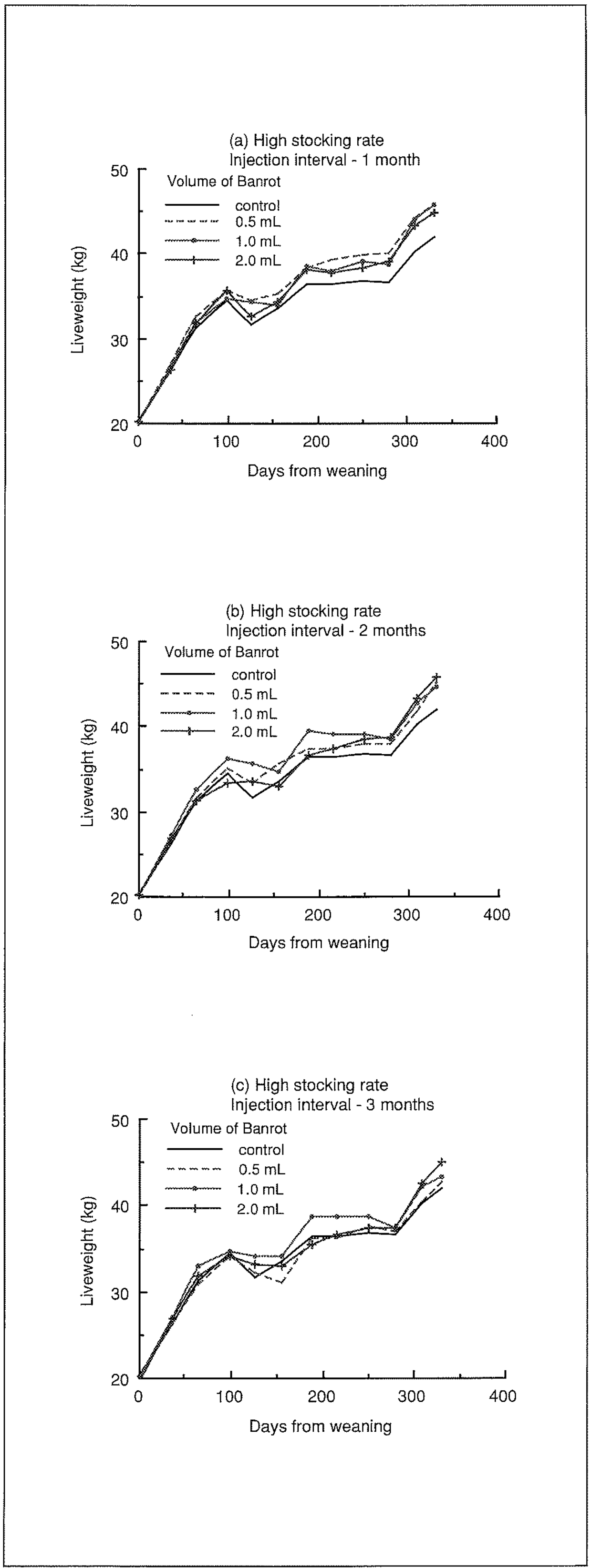


Figure 9. The average liveweights of young Merino wethers, which were injected with a range of doses of Banrot, with different intervals between injections, while grazing at the high stocking rate, between July, 1984 and July, 1985.

Fleece weights

The average weight of the fleeces at the first shearing was 1.61 kg and treatments had not affected wool growth. The average greasy and clean fleece weights with the fibre diameters and average values for the fleeces obtained from the untreated wethers and those treated with 1 mL Banrot when the experiment finished are recorded in Table 3. The wethers grazed at the low stocking rate produced more greasy wool ($P < 0.001$) with a thicker fibre while those treated with Banrot also produced heavier fleeces than the untreated animals ($P < 0.05$). The interpretation of these differences is made difficult by the significance ($P < 0.05$) of the interaction between stocking rate, volume of Banrot and the frequency of treatment.

Economics of treatment

While liveweights and fleece weights of treated sheep increased significantly at the lower stocking rates compared with the higher stocking rates, in all experiments the profitabilities of treated sheep compared with untreated sheep were variable and inconsistent. Furthermore, when there is a surplus of green feed during winter and spring, injections with Banrot do not increase growth rate (year 3). *Ad libitum* 'grain' feeding in years 1 and 2 also masked any effect which treatment with testosterone might have had.

Table 5. The average differences in net return from wool, considering the cost of treatment with Banrot, between treated and untreated young wethers grazed on paddocks at standard stocking rates for Newdegate Research Station. All experiments

Treatment intervals (mths)	Year+	Volume of Banrot (mL) 0.5 $	1.0 $	2.0 $	4.0 $
1	1,2,3	-0.41	-4.66	-4.78	-11.12
2	2,3	1.66	2.30	-5.11	-1.15
3	1,3	-0.75	-1.40	-7.15	-3.53
4	2	4.25	-3.22	-1.11	4.23
6	1	-4.07	3.23	1.74	-0.48
12	1,2	-0.18	11.37	6.80	-1.14

\+ The year results from which the averages were calculated.

Note: The wool prices used for the calculations were the 1988/89 Australian Wool Corporation reserve prices. The treatment costs were based on the 1988 price of Banrot and contract application rates.

Table 6. The average differences in net return from wool, considering the cost of treatment with Banrot, between treated and untreated young wethers grazed on paddocks at the relatively high stocking rates in Table 1. Years 1 and 3

Treatment intervals (mths)	Year+	Volume of Banrot (mL) 0.5 $	1.0 $	2.0 $	4.0 $
1	1,3	-2.60	-2.96	-5.24	-16.32
2	3	1.10	-0.60	-4.59	-
3	1,3	0.40	1.12	-4.99	-4.66
6	1	-4.81	-3.54	-4.60	-1.54
12	1	-4.95	0.45	0.27	-10.48

\+ The year results from which the averages were calculated.

Note: The wool price used for the calculations were the 1988/89 Australian Wool Corporation reserve prices. The treatment costs were based on the 1988 price of Banrot and contract application rates.

Tables 5 and 6 show the variability in net returns in wool income, based on 1988/89 reserve prices, after all associated treatment costs have been deducted. In both cases, wool income from the untreated controls is taken as the base level and total income is not given in the tables.

Discussion

Our work showed that, under some circumstances, the injection of wethers with testosterone can result in heavier sheep and increased wool production. It supports previously reported (e.g. Osborne and Widdows 1961; Southcott and Royal 1971) and unreported (e.g. J.M.Armstrong and A.S. Hadlow unpublished data) observations in Australia. However, the levels of responses following the treatments in this study were variable.

Liveweights, growth rates

Apart from year 2 when there were no significant differences between the stocking rate groups, in both other years as expected the sheep grazed at the higher stocking rates were lighter. However, the sheep treated with testosterone were heavier than the untreated sheep, especially following monthly injections.

It appears that the quantity and quality of feed available to sheep may influence their response to treatment with testosterone. There was no response to treatment in year 2 where the wethers were grazed on dry feed from shortly before the start of treatment (mid-Spring) until after the pastures germinated in the following year. However, in year 1, treatment was started before the pastures had started to mature (early spring) and the weaners were still able to continue growing and so respond to treatment. But in contrast, in year 3, when

treatment was started while there was a plentiful supply of green feed and the young sheep were growing close to their maximum potential (mid-winter), there was no opportunity for treatments to affect performance until after the feed supply became limited.

Similarly, there was a lack of response to treating young wethers with testosterone when they were given an *ad libitum* supply of a near optimum 'grain' ration in years 1 and 2, which produced high rates of growth.

It would appear that, in the wheatbelt, treatment with testosterone will not produce a response in late born wether weaners unless they have access to feed which ensues continued limited growth.

Where treatments were given to the wethers at times and at stocking rates which could produce growth responses in years 1 and 3, there were differences in growth. At the low stocking rate in year 1, the weaners injected with 1 mL Banrot each month reached 34 kg (an acceptable weight of Merino lambs for the Western Australian Meat Commission – R.J. Suiter, personal communication) in less than 100 days after weaning, while those treated with 0.5 mL every three months or 1 mL every six months took more than 150 days to reach this weight. All treated wethers reached 45 kg (a weight suitable for shipper hoggets – C.L. McDonald, personal communication) by the end of the experiment with there being very little difference between the experiments.

In year 3, all weaners, including the untreated sheep, reached 34 kg by 60 days after weaning. This illustrates the rapid growth which can be obtained where there is excessive green feed available during late winter and spring. However, there were differences between treatments in growth to 45 kg. All sheep treated with testosterone at one and two monthly intervals weighed about 45 kg by 300 days after weaning, but only those injected with 2 mL Banrot at three monthly intervals weighed 45 kg at the same time. It should be noted though that the other groups treated at three monthly intervals were almost 45 kg at this time.

These results show that to obtain the best early growth requires frequent injections of about 1 mL of Banrot. However, the results from year 1 would indicate that the production of shipper hoggets requires less frequent treatment whereas those from year 3 suggest that, under conditions of limited feed availability, (this experiment was finished early because the poor feed conditions at Newdegate) frequent treatment is advantageous.

In both years 1 and 2, treatment of 2-tooth wethers with testosterone at two or three monthly intervals resulted in sheep which were heavier than those which were untreated with the differences being statistically significant on occasions. However, the actual differences between groups were not large and it is doubtful whether the differences would have any practical importance for farmers. It would appear that the amount of feed available has a more significant influence on such sheep.

Wool production

As for the effect on liveweights, there were no differences in wool production between the groups in year 2. However, in years 1 and 3 the young wethers grazed at the lower stocking rates produced more greasy wool than did those at the high stocking rates and treatment with testosterone increased the weight of wool. Based on the Australian Wool Corporation reserve wool prices for the seasons when the sheep were shorn, there were no consistent differences between treatments in the net returns.

Treatment of the young wethers with testosterone tended to increase the fibre diameter of the wool (for those grazed at the low stocking rate in year 1, the diameter was increased from 18.9 μ for the untreated wethers up to about 19.6 μ for those treated at one, three or six monthly intervals, while in year 3 the diameter was increased from 20.2 μ up to about 20.7 μ for the similar wethers treated at one, two or three monthly intervals). Hence, although there was a higher average clean fleece weight from the treated sheep, this may have been counterbalanced by the increase in diameter which, in the current wool market, probably would have a more significant impact on wool returns.

Increases in the growth of wool from sheep treated with testosterone have been reported previously (e.g. Slen and Connell 1958; Osborne and Widdows 1961; Southcott 1962; Osborne 1966; Southcott and Royal 1971). Osborne and Widdows (1961) reported that the wool from wethers treated with testosterone 'becomes slightly stronger' with the effects being more pronounced at higher dose rates. Our results do not show that wethers treated with high doses of testosterone consistently have thicker fibres.

Osborne (1966) concluded from his study that under conditions of adequate nutrition, testosterone enhances wool growth independently of any effects on food intake.

We showed that the production of wool and the fibre diameter were increased in the testosterone treated wethers grazed at the lower stocking rates in years 1 and 3. These changes in production would generally reflect an increased intake of available feed. As a consequence, this would effectively increase the stocking rate, but in years 1 and 3 it was insufficient to produce a decrease in fibre diameter as occurred in the wethers grazed at the higher stocking rates. It would appear that stocking rate had an overriding effect, and only at the lower rates were the conditions suitable for testosterone to influence wool growth. Presumably, this was related to the availability of feed and not to a change in use of the feed.

Treatment of the older wethers with testosterone did not significantly affect clean wool production. The effect of stocking rate was more pronounced with the wethers at the lower stocking rates producing more wool of a higher diameter.

Performance

The performances of the young wethers fed the mix of 75% oat grain/25% lupin seed by weight *ad libitum* in year 1 was better during the initial period than that observed in year 2. In both years, a large quantity of the 'grain' mix was eaten with the apparent conversion ratios being more than 8.5:1 and about 7.5:1 in years 1 and 2, respectively. More wool was produced by these wethers than by the unsupplemented wethers grazed at the lower stocking rates, but the fibre diameter was increased by 3.2 and 1.6 μ in years 1 and 2, respectively. Based on the 1983 and 1984 wool prices, the extra wool did not cover the cost of the 'grain' consumed.

Treatment with testosterone did not greatly affect the performance of the wethers fed *ad libitum*. In year 2, the efficiency of the treated wethers fed a restricted ration (500 g/head.d) was improved with the apparent conversion ratio decreasing to about 5:1. The wethers fed the restricted ration produced less clean wool, which was slightly finer, than did those on the *ad libitum* ration.

The usual advice to farmers is that wethers would not be fed *ad libitum* rations for prolonged periods in Western Australia, but that they be fed to attain predetermined weights. In year 1, the wethers weighed about 34 kg two months after weaning when feeding started, and they reached 45 kg five to six months after weaning whereas, in year 2, the *ad libitum* fed wethers weighed 34 kg about four months after weaning, which was about one month after feeding started, and 45 kg six to seven months after weaning. The wethers fed 500 g/head.d required a longer time to reach these weights, being five months (about two months after the start of feeding) to grow to 34 kg and eight months to get to 45 kg.

These results provide further evidence to that of Suiter and Croker (1980) that it is feasible to feed for growth, but they suggest that testosterone only influences the efficiency of use of 'grain' where intake is restricted. The desirability of this type of feeding would depend upon the economics prevailing and so it would not be a venture to consider without careful evaluation of potential markets.

Testosterone levels

Low levels of testosterone were found in the sera samples obtained in years 1 and 2, except where the samples were collected shortly after the wethers were injected with testosterone in year 1 and where one wether had an abnormally high level in year 2. These results suggest that, when testosterone is injected into wethers, it enters the blood stream extremely rapidly and then, irrespective of the dose, is metabolized relatively fast so that it would normally be expected that, as reported by Croker *et al.* (1982), 1 month after injection the levels in the blood of wethers would be below that normally found in entire rams. Our observations of very low levels of testosterone within a month of injection contrast with those of Sackett *et al.* (1987), who reported that the levels in cross-bred wethers treated with 1 mL of Banrot were still elevated 30 days after treatment.

Sackett, Wright and Darvill (1987) also reported differences between testosterone preparations in the duration of detectable blood testosterone with a pellet form producing a longer duration of elevated testosterone. It would be expected that the use of the pellet form would maintain the wethers in a responsive situation for a longer period than would the injectable form and so could be advantageous. Associated with the maintenance of testosterone in the blood would be a need for less frequent treatment which could be an additional advantage.

However, the problem of requiring a prolonged withdrawal period would arise with the use of pellets. The use of an injectable form of testosterone minimizes the length of the withdrawal period and so is more attractive for management decisions.

Profitability

The cost of treating wethers with 1 mL of Banrot during a 12 month period would range from \$0.35 to \$4.20 for one injection to monthly injections where the contract price for treatment is 35¢ per sheep (Banrot - 20.4¢/mL at April 20, 1988 and yarding, injection, - 14.6¢/hd). Considering wool production, there would have been very few treatments in the three years where costs were recovered by extra wool returns at the prevailing wool prices in 1983 to 1985. Even following conversion to the 1988/89 reserve prices, which were much higher than those prevailing in the earlier seasons, there was no consistent benefits in returns following treatment with testosterone.

It is more difficult to evaluate the likely monetary returns from sending the weaners to the Western Australian Meat Commission, or keeping them until they become suitable as shippers. There were some advances in the growth of treated wethers, but only at the lower stocking rates. However, it appeared that a time of about 12 months was required for the wethers to get near to 45 kg with testosterone treatment only producing small weight increases. Therefore, based on these results, it is unlikely that treatment of young Merino wethers with testosterone will significantly increase income and there does not appear to be any major benefit following treatment of 2-tooth wethers.

Conclusions

There may be more favourable environments where treatment with testosterone may give larger responses, but the results we obtained suggest that there is not likely to be a response to treatment when an unlimited amount of feed is available. However, while this may be the case, the results imply that there is no use injecting testosterone where there is not good quality feed or it is in short supply.

Since this project started the European Community has stated that carcasses from animals treated with hormone preparations will not be accepted by them after January 1, 1989, despite the large amount of evidence showing that the hormones commonly used to stimulate growth do not leave residues. It would appear unlikely that testosterone preparations would be registered for growth promotion in Australia. In addition, the evidence from our experiments do not support the widespread use of testosterone for growth promotion because of the variable results obtained following treatment.

Acknowledgements

The authors express appreciation for the assistance provided by the Manager and other staff at the Agricultural Research Station, Newdegate.

The observations on the wool samples were done by Mr A. Ingleton, Mrs R. Bradley and Miss R. McDonald of the Western Australian Department of Agriculture's Fleece Measurement Laboratory.

Coopers Animal Health, Cabarita, N.S.W. provided the Banrot used in experiment 2.

The manuscript was typed by the Word Processing Centre and the design and graphics were done by Ms F. Roberts, Information Branch, Department of Agriculture, Western Australian.

References

Andrews, F.N., Beeson, W.M. and Harper, C. (1949). The effect of stilbestrol and testosterone on the growth and fattening of lambs. *Journal of Animal Science* **8**: 578.

Croker, K.P., Butler, L.G., Johns, M.A. and McColm, S.C. (1982). Induction of ovulation and cyclic activity in anestrous ewes with testosterone treated wethers and ewes. *Theriogenology* **17**: 349.

Galbraith, H. and Tipps, J.H. (1981). Effect of hormones on the growth and body composition of animals. *Nutrition Abstract and Reviews - Series B* **51**: 521.

Heitzman, R.J. (1979). The efficacy and mechanism of action of anabolic agents as growth promoters in farm animals. *Journal of Steroid Biochemistry* **11**: 927.

Hoffmann, B. (1982). The use of hormones in food producing animals. *World Health Organization Euro Reports and Studies* **59**: 16.

Osborne, W.B. (1966). Effects of testosterone on wool growth in wethers. *Proceedings of Australian Society of Animal Production* **6**: 240.

Osborne, W.B. and Widdows, F.A. (1961). Sheath rot and testosterone - its effects and side effects on health and production. *Wool Technology and Sheep Breeding* **8**: 99.

Sackett, D.M., Wright, P.J. and Darvill, F.M. (1987). Plasma testosterone concentrations in wethers treated with commercial preparations of testosterone. *Australian Veterinary Journal* **64**: 386.

Slen, S.B. and Connell, R. (1958). Wool growth in sheep as affected by the administration of certain sex hormones. *Canadian Journal of Animal Science* **38**: 38.

Southcott, W.H. (1962). The prevention and treatment of ovine posthitis with testosterone propionate. *Australian Veterinary Journal* **38**: 33.

Southcott, W.H. and Royal, W.M. (1971). Effect of implanted testosterone propionate on the growth and wool production of Merino wethers. *Australian Journal of Agricultural Research* **22**: 271.

Southcott, W.H. and Shorthose, W.R. (1972). Effect of testosterone propionate on the carcass and meat of Merino wethers. *Australian Veterinary Journal* **48**: 105.

Suiter, R.J. and Croker, K.P. (1980). Effect of varying proportions of oat and lupin grain supplements on lamb growth. Technical Bulletin No. 51, Department of Agriculture, Western Australia.

Appendices

Appendix 1a. The length of time taken for young wethers treated with Banrot at different intervals while grazing at low stocking rates to reach identified liveweights in years 1, 2 and 3

Treatment			Months to reach average weight greater than			
Volume of Banrot (mL)	Injection interval (mths)	Starting weight (kg)	30 kg	34 kg	40 kg	50 kg
Experiment 1						
Not treated		21.9	5	9	12	-
0.5	1	21.9	2	8	9	12
1.0	1	22.9	2	3	9	12
2.0	1	22.3	2	5	10	12
4.0	1	22.7	2	8	12	-
0.5	3	22.2	2	8	12	-
1.0	3	22.0	2	8	12	-
2.0	3	21.9	3	8	12	-
4.0	3	22.4	2	8	12	-
0.5	6	21.8	2	8	12	-
1.0	6	22.5	2	8	10	-
2.0	6	23.4	2	8	12	-
4.0	6	21.9	3	8	12	-
0.5	12	21.4	3	9	12	-
1.0	12	21.9	2	8	12	-
2.0	12	21.8	5	9	12	-
4.0	12	22.4	2	8	12	-
Experiment 2						
Not treated		24.4	6	8	10	-
0.5	1	25.6	6	8	10	-
1.0	1	24.1	6	8	10	-
2.0	1	23.7	5	8	10	-
4.0	1	22.8	8	8	10	-
0.5	2	23.6	8	8	10	-
1.0	2	24.6	6	8	10	-
2.0	2	23.2	8	8	10	-
4.0	2	24.1	8	8	10	-
0.5	4	24.6	8	8	10	-
1.0	4	25.1	6	8	10	-
2.0	4	24.1	5	8	10	-
4.0	4	25.6	8	8	10	-
0.5	12	24.7	8	8	10	-
1.0	12	24.5	5	8	10	-
2.0	12	26.3	5	8	10	-
4.0	12	23.6	8	8	10	-
Experiment 3						
Not treated		19.9	2	3	10	-
0.5	1	19.9	2	2	4	-
1.0	1	20.3	2	2	5	-
2.0	1	20.1	2	2	4	-
0.5	2	20.2	2	2	4	-
1.0	2	20.1	2	3	4	-
2.0	2	20.1	2	2	4	-
0.5	3	20.0	2	3	6	-
1.0	3	20.1	2	3	5	-
2.0	3	19.8	2	3	4	-

Appendix 1b. The length of time taken for young wethers treated with Banrot at different intervals while grazing at high stocking rates to reach identified liveweights in years 1, 2 and 3

Treatment: Volume of Banrot (mL)	Treatment: Injection interval (mths)	Starting weight (kg)	Months to reach average weight greater than: 26 kg	30 kg	34 kg	40 kg
Experiment 1						
Not treated		22.2	2	9	11	-
0.5	1	22.2	2	9	10	12
1.0	1	23.0	1	9	11	12
2.0	1	21.3	2	9	11	12
4.0	1	21.4	2	10	11	12
0.5	3	22.0	2	9	11	-
1.0	3	21.7	2	10	11	-
2.0	3	22.2	2	8	11	12
4.0	3	22.2	2	9	11	-
0.5	6	22.1	2	9	11	-
1.0	6	22.2	2	10	11	-
2.0	6	22.3	2	9	11	12
4.0	6	22.2	2	9	11	12
0.5	12	22.0	2	10	11	-
1.0	12	21.9	2	10	11	-
2.0	12	24.1	1	9	11	12
4.0	12	22.3	2	9	11	-
Experiment 2						
Not treated		24.5	1	8	8	10
0.5	1	23.7	1	7	8	10
1.0	1	24.7	1	5	8	9
2.0	1	23.9	1	8	8	10
4.0	1	23.4	1	7	8	9
0.5	2	24.6	1	5	8	9
1.0	2	22.7	1	8	8	10
2.0	2	22.4	1	8	8	10
4.0	2	24.1	1	7	8	10
0.5	4	24.6	1	7	8	10
1.0	4	23.4	1	8	8	10
2.0	4	22.4	1	8	8	10
4.0	4	25.9	1	5	8	10
0.5	12	22.5	5	8	8	10
1.0	12	23.3	1	8	8	10
2.0	12	24.0	1	8	8	10
4.0	12	23.5	1	8	8	10
Experiment 3						
Not treated		20.3	1	2	3	10
0.5	1	20.2	1	2	3	9
1.0	1	20.2	1	2	3	10
2.0	1	20.2	1	2	3	10
0.5	2	20.2	1	2	3	10
1.0	2	20.1	1	2	3	10
2.0	2	20.2	1	2	6	10
0.5	3	20.1	1	2	3	10
1.0	3	20.1	1	2	3	10
2.0	3	19.9	1	2	3	10

Appendix 2. The length of time taken for young wethers treated with Banrot while fed an oat/lupin 'grain' mix to reach identified liveweights in years 1 and 2

Treatment: Volume of Banrot (mL)	Treatment: Injection interval (mths)	Starting weight (kg)	Months to reach average weight greater than: 34 kg	40 kg	50 kg	60 kg
Experiment 1 *ad libitum*						
Not treated		21.5	3	4	8	-
2.0	3	22.3	2	4	7	10
2.0	6	22.2	3	4	8	-
Experiment 2 *ad libitum*						
Not treated		23.4	4	6	8	-
2.0	1	23.9	4	6	8	-
2.0	2	23.1	4	6	8	-
	500 g grain/head.d					
2.0	1	23.4	5	8	10	-
2.0	2	23.6	5	7	9	-

Appendix 3a. The average production of wool by wethers following treatment with different volumes of Banrot at different intervals. Year 1 (n = 6-8)

Age at start (mths)	Treatment: Volume of Banrot (mL)	Treatment: Injection interval (mths)	Greasy fleece weight (kg)	Clean fleece weight (kg)	Fibre diameter (μ)	Value: Av./hd ($)	Value: Treated - not treated ($)
Low stocking rate							
3	not treated		4.2	2.6	18.9	15.85	-
	0.5	1	4.9	3.0	19.4	17.57	+ 1.72
	1.0	1	5.0	3.2	20.1	18.01	+ 2.16
	2.0	1	4.6	3.0	19.8	18.11	+ 2.26
	4.0	1	4.6	2.8	19.2	16.72	+ 0.87
	0.5	3	4.6	3.0	19.8	17.60	+ 1.75
	1.0	3	4.4	2.9	19.6	17.35	+ 1.50
	2.0	3	4.0	2.7	18.8	15.34	- 0.41
	4.0	3	4.5	2.9	20.0	17.10	+ 1.25
	0.5	6	4.3	2.9	20.4	16.39	+ 0.54
	1.0	6	4.7	3.0	19.2	17.74	+ 1.89
	2.0	6	4.7	3.1	20.0	18.08	+ 2.23
	4.0	6	4.3	2.8	19.3	16.26	+ 0.41
	0.5	12	4.1	2.7	19.2	16.42	+ 0.57
	1.0	12	4.5	3.1	19.0	19.80	+ 3.95
	2.0	12	4.6	3.0	18.7	18.07	+ 2.22
	4.0	12	4.8	3.1	19.9	17.42	+ 1.57
15	not treated		5.7	3.9	22.4	21.13	-
	2.0	3	5.4	3.7	22.1	20.18	- 0.95
High stocking rate							
3	not treated		3.7	2.4	18.4	13.42	-
	0.5	1	3.9	2.4	19.6	14.15	+ 0.73
	1.0	1	3.9	2.5	19.2	14.41	+ 0.99
	2.0	1	3.9	2.4	18.9	14.41	+ 0.99
	4.0	1	3.5	2.2	18.7	11.84	- 1.58
	0.5	3	3.5	2.2	18.4	12.78	- 0.64
	1.0	3	3.6	2.3	18.1	13.60	+ 0.18
	2.0	3	3.5	2.2	19.1	12.28	- 1.14
	4.0	3	4.0	2.6	19.6	13.85	+ 0.43
	0.5	6	3.6	2.3	19.0	11.96	- 1.46
	1.0	6	3.8	2.3	18.0	12.53	- 0.89
	2.0	6	3.7	2.3	19.2	12.50	- 0.92
	4.0	6	3.6	2.2	18.3	13.10	- 0.32
	0.5	12	3.6	2.2	18.7	11.94	-1.48
	1.0	12	3.6	2.2	18.4	12.66	- 0.76
	2.0	12	3.6	2.3	18.2	13.37	- 0.05
	4.0	12	3.6	2.2	19.2	11.04	- 2.38
15	not treated		4.9	3.3	21.1	18.58	-
	2.0	3	5.1	3.3	21.0	18.02	- 0.56
Ad libitum 'grain'							
3	not treated		7.2	5.0	22.1	27.03	-
	2.0	3	7.3	5.1	22.4	27.58	+ 0.55
	2.0	6	7.4	4.9	22.6	26.08	- 0.95

Appendix 3b. The average production of wool over a ten month period by wethers following treatment with different volumes of Banrot at different intervals. Year 2 (n = 7-8)

Age at start (mths)	Treatment: Volume of Banrot (mL)	Treatment: Injection interval (mths)	Greasy fleece weight (kg)	Clean fleece weight (kg)	Fibre diameter (μ)	Value Av./hd ($)	Treated - not treated ($)
Low stocking rate							
3	not treated		4.0	2.8	19.6	16.60	-
	0.5	1	4.0	2.8	20.0	16.69	+ 0.09
	1.0	1	4.1	2.7	20.2	13.21	- 3.39
	2.0	1	4.2	2.8	19.0	17.60	+ 1.00
	4.0	1	4.4	3.0	19.9	17.56	+ 0.96
	0.5	2	3.9	2.8	19.8	15.89	- 0.71
	1.0	2	3.7	2.6	19.3	15.54	- 1.06
	2.0	2	3.7	2.6	19.3	15.54	- 1.06
	4.0	2	3.9	2.7	19.0	16.95	+ 0.35
	0.5	4	4.2	2.8	19.8	15.89	- 0.71
	1.0	4	4.3	2.8	19.2	17.51	+ 0.91
	2.0	4	3.9	3.0	19.6	17.34	+ 0.74
	4.0	4	3.8	2.5	18.5	13.11	- 3.49
	0.5	12	3.8	2.8	18.9	15.20	- 1.40
	1.0	12	3.7	2.7	19.6	15.28	- 1.32
	2.0	12	4.4	3.0	19.8	16.63	+ 0.03
	4.0	12	4.0	2.7	18.5	16.50	- 0.10
15	not treated		5.5	3.9	21.7	21.30	-
	2.0	2	6.0	4.0	21.8	21.70	+ 0.40
High stocking rate							
3	not treated		4.0	2.7	19.5	14.79	-
	0.5	1	4.0	2.8	19.5	15.97	+ 1.18
	1.0	1	4.2	2.8	19.0	17.27	+ 2.48
	2.0	1	4.4	3.0	20.5	15.87	+ 1.08
	4.0	1	4.1	2.7	19.8	15.15	+ 0.36
	0.5	2	4.0	2.8	19.5	15.97	+ 1.18
	1.0	2	4.1	2.8	19.4	17.02	+ 2.23
	2.0	2	3.7	2.6	19.2	15.61	+ 0.82
	4.0	2	3.9	2.8	19.2	16.10	+ 1.31
	0.5	4	4.1	2.9	20.1	16.95	+ 2.16
	1.0	4	3.9	2.7	19.8	14.10	- 0.60
	2.0	4	4.0	2.7	20.2	15.20	+ 0.41
	4.0	4	4.0	2.7	19.0	17.10	+ 2.31
	0.5	12	4.0	2.7	20.0	15.11	+ 0.32
	1.0	12	4.0	2.9	19.0	18.48	+ 3.69
	2.0	12	4.0	2.8	19.3	17.67	+ 2.88
	4.0	12	4.0	2.8	19.9	14.65	- 0.14
15	not treated		5.4	3.5	20.6	20.63	-
	2.0	2	5.8	3.8	21.2	21.00	+ 0.37
Supplemented - *ad libitum* 'grain'							
3	not treated		5.5	3.9	21.2	22.02	-
	2.0	1	6.5	4.5	21.5	24.65	+ 2.63
	2.0	2	6.0	4.1	22.1	22.37	+ 0.35
Supplemented - 500 g 'grain'/head.d							
3	2.0	1	4.9	3.4	20.0	18.64	
	2.0	2	5.3	3.8	21.2	21.66	

Appendix 3c. The average production of wool by wethers following treatment with different volumes of Banrot at different intervals. Year 3 (n = 6-9)

Treatment		Greasy fleece weight (kg)	Clean fleece weight (kg)	Fibre diameter (μ)	Value	
Volume of Banrot (mL)	Injection interval (mths)				Av./hd ($)	Treated - not treated ($)
Low stocking rate						
not treated		4.0	2.4	20.2	16.13	-
0.5	1	4.0	2.6	20.2	17.12	+ 0.99
1.0	1	3.8	2.5	21.9	14.94	- 1.19
2.0	1	4.5	2.7	20.5	18.16	+ 2.03
0.5	2	4.3	2.7	20.6	18.79	+ 2.66
1.0	2	4.0	2.5	20.0	17.48	+ 1.35
2.0	2	4.3	2.4	20.1	16.52	+ 0.39
0.5	3	4.4	2.8	20.7	16.96	+ 0.83
1.0	3	4.0	2.6	21.3	15.82	- 0.31
2.0	3	4.0	2.5	21.2	15.33	- 0.80
High stocking rate						
not treated		3.8	2.1	19.0	15.67	-
0.5	1	3.9	2.4	20.7	15.37	- 0.30
1.0	1	4.0	2.6	21.4	15.82	+ 0.15
2.0	1	4.0	2.5	21.0	15.46	- 0.21
0.5	2	3.9	2.4	20.1	16.52	+ 0.85
1.0	2	3.7	2.4	20.3	16.46	+ 0.79
2.0	2	3.7	2.3	20.7	15.33	- 0.34
0.5	3	3.9	2.5	20.2	17.12	- 1.45
1.0	3	3.8	2.4	19.9	17.37	- 1.70
2.0	3	4.0	2.5	20.9	15.57	- 0.10

Appendix 4. The average concentrations of testosterone in the peripheral blood sera of samples of wethers at three times during year 2 (n = 4) (± standard deviations)

Age at start (mths)	Treatment		Concentration (nmol/L)		
	Volume of Banrot (mL)	Injection interval (mths)	At start	At about 34 kg liveweight	At finish
3	not treated		0.6 ± 0.6	< 0.2	< 0.2
	0.5	1	1.0 ± 1.0	-	0.8 ± 2.8
	1	1	< 0.2	< 0.2	< 0.2
	2	1	< 0.2	0.4 ± 0.4	< 0.2
	4	1	0.3 ± 0.2	22.1 ± 38.0[1]	0.3
	1	2	0.8 ± 0.8	< 0.2	< 0.2
	2	2	< 0.2	< 0.2	< 0.2
	4	2	< 0.2	0.4 ± 0.4	0.2 ± 0.1
15	not treated		0.2 ± 0.1	-	< 0.2
	2	2	< 0.2	-	< 0.2

1. One wether had a very high concentration (66 nmol/L) for this sample only.

05847/2/92-1M-L/5785

DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA