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Effect of hormonal growth promotant implants in weaner and hogget ewes on subsequent growth and reproductive performance

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Abstract. Ninety young Merino ewes, depastured on Mitchell (*Astrebla* spp.) grass pastures in North West Queensland, were used in a hormonal growth promotant implantation study. The ewes were given 1 implant of Compudose, Ralgro, Revalor or Synovex-H, either at lamb marking (mid-dry season) or the start of the following summer wet season, which was ~180 days post-marking.

The hormonal growth promotant implanted groups had greater (P<0.05) liveweights than the control group early in the trial (days 22 and 57) and also from the end of the period of activity of the wet season implant (day 277) until the middle of the dry season (day 412). Dry season (at lamb marking) implantation did not improve average daily gain. From the end of the wet season onwards, ewes with a wet season implant were heavier (P<0.05) than those ewes implanted at lamb marking. This liveweight advantage had diminished by the start of the autumn mating. Hormonal growth promotant implantation had a favourable (P<0.05) effect on growth rate, but adversely affected reproduction in the ewes, regardless of time of implantation. Implantation with Compudose or Synovex-H significantly (P<0.001) reduced the demonstration of oestrus, while Revalor or Synovex-H reduced pregnancy rates by up to 100%. Despite Ralgro reducing these variables by up to 25%, its effect was not significant. All ewes that were diagnosed as pregnant at 140 days later produced lambs.

It was concluded from this study that hormonal growth promotant implantation at lamb marking provides no later-life advantage, while wet season implantation provides a growth or liveweight advantage to young Merino ewes and this persists for a long period after implantation. Despite the lack of an effect of Ralgro on oestrus and pregnancy results, however, implantation of young breeding ewes of any age should not be carried out, due to the long term and negative effects on reproductive performance. Wet season implantation may be best used for animals intended for slaughter.

Introduction

The North and Central Western Queensland sheep industry is primarily based on the Mitchell grass (*Astrebla* spp.) downs country and is characterised by poor growth and reproductive performance, as well as high flock mortality rates (Rose 1972). Spring matings are commonly used, with the lambs being weaned onto dry season pastures (Cobon *et al*. 1994) of low nutritional quality (Lorimer 1981). In the period from weaning to mating at 18 months of age, the ewe will experience 2 dry seasons. During this period, the growth rate is often low, so that a significant percentage of maiden ewes fail to attain their target weight for mating (M. Rose, unpublished data). The probability of significant rainfall during the dry season, which could alleviate the nutritional stress, is low. Indeed, small amounts of rain may cause rapid deterioration in the quality of the dry standing pasture. Nutritional supplementation is a recommended practice, but high costs and relatively low product values associated with this practice largely restrict its widespread use to survival feeding of sheep flocks.

Sheep treated with oestrogenic implants have demonstrated higher growth rates than control animals (Wilson *et al*. 1972; Bass *et al*. 1989; Bachman *et al*. 1993; Bortolussi and Bird 1998). Research conducted at 'Toorak' Research Station (D. H. Cobon, unpublished data) has shown that in grazing weaner wethers receiving multiple implants of zeranol, there were consistent advantages across seasons for augmenting liveweight by 5 kg in 12 months. The use of combinations of oestrogens and trenbolone acetate have also been shown to provide advantages for animals consuming a variety of different quality diets (Hynd and James 1987; Hayden *et al*. 1992; Hunter and Vercoe 1988). Trenbolone acetate based implants have been shown to reduce tissue protein breakdown and reduce nitrogen losses (Hunter and

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Magner 1990*a*, 1990*b*), metabolic rate (Hunter *et al*. 1993*b*) and liveweight loss (Hunter *et al*. 1993*a*).

Generally, the primary interest in the use of hormonal growth promotants (HGPs) has been to produce animals with better carcass attributes (weight and fat cover) than unimplanted animals. The use of HGPs in stock intended for breeding and the subsequent effects on reproductive performance of sheep have not received much attention and the results from only a few studies are available. Hess *et al*. (1998) noted that zeranol implantation (12 mg) of ewe lambs had no effect on oestrous activity at mating about 90 days after implantation. Zeranol (36 mg) implantation of heifers did not result in negative effects on reproduction rate (Kirkwood *et al*. 1991). It has been reported that the use of zeranol implants in heifers had no effect on age or weight at puberty, nor the onset of puberty itself (Staigmiller *et al*. 1983; Deutscher *et al*. 1986). Implantation too early in life of sheep or cattle may have detrimental effects on reproductive development or performance (Staigmiller *et al*. 1983; Deutscher *et al*. 1986; Bass *et al*. 1989).

There may be a physiological window of opportunity for the implantation of female livestock that are intended for breeding, to increase growth rates without penalising future reproductive performance. The aim of this study was to examine the use of a single implant of 4 commercially available HGPs on weaner (dry season implant) and hogget ewes (wet season implant) as a means of improving liveweight performance to mating age and determining the subsequent effects on reproductive performance (particularly oestrus and pregnancy).

Currently in Australia, hormonal growth promotants (HGPs) are only registered for use in cattle and not in sheep.

Materials and methods

Animals and treatments

Ninety Peppin Merino ewe lambs, (mean liveweight 15.7 kg ± 2.70 s.d.), born February–March 1994 out of locally bred dams, were allocated to 9 treatments on a stratified random liveweight basis at lamb marking. Ten ewe lambs were allocated to each treatment group. The ewes were run as a single flock on native Mitchell grass (*Astrebla* spp.) pastures at 'Toorak' Research Station (21°02′S, 141°48′E), 50 km south of Julia Creek, in North West Queensland.

The treatment groups included one non-implant control group and 8 single implant treatment groups. Four of the latter received implants at lamb marking (day 0, July) and the other 4 received implants before the summer wet season (day 179, late November) (Fig. 1). The implant treatments were: control (no implant); Compudose 200 (recommended cattle dose 24 mg oestradiol 17β; Elanco); Ralgro (recommended cattle dose 36 mg zeranol; Mallinckrodt); Revalor (recommended cattle dose 140 mg trenbolone acetate and 20 mg oestradiol; Roussel ACLAF); or Synovex-H (recommended cattle dose 200 mg testosterone propionate and 20 mg oestradiol benzoate; Syntex). The above products are the doses administered to cattle. For Compudose and Ralgro treatments, the doses administered per head this study were 33% (1 of 3 pellets) of the recommended cattle doses (above). For Revalor and Synovex-H treatments, the doses administered per head were 37.5% (3 of 8 pellets) of the recommended cattle doses (above). The ewe lambs were implanted in the ear, according to manufacturers' recommendations for cattle applications. Dose levels were selected after a survey of the scientific literature (see references this paper) indicated that sheep received implants that ranged from 20% to full strength cattle doses. A Ralgro product for sheep was once available and used a 12 mg dose, or one-third of the cattle dose.

Implantation at lamb marking was intended to take advantage of the high nutritional plane provided by the dam before weaning. It was also intended to assist the weaner make better use of the post-weaning supplementary feeding regimen. The summer wet season implantation was intended to increase the response by the weaner to the high plane of nutrition provided by wet season pastures. The rated life of the implants was as follows: Ralgro, 70 days; Compudose, 200 days; Revalor, 120 days; and Synovex-H, 120 days (Lehman and Rains 1996).

The ewes were managed from weaning to lambing according to recommended practices for the region (Cobon *et al*. 1994).

Grazing management

At the first weighing after lamb marking and implantation, the ewe lambs were weaned (day 22) and moved to a paddock that had recently been cut for native pasture hay. The ewes remained in this paddock for the duration of the experiment and the sheep were run at commercial grazing pressures (0.8 DSE/ha). About 1% of the flock in the weaner paddock was composed of older dry coach ewes. A supplement of cottonseed meal (25 g/day.sheep) was offered for the duration of the dry season. The ewes were offered a proprietary urea-based block during the following dry season.

Mating management

Two attempts were made to mate the ewes: first, in October 1995 (spring) and second in May 1996 (autumn). Two weeks before the inclusion of Siresine crayon harnessed rams in October 1995, 4 teaser wethers were injected subcutaneously with 1 mL Banrot (Testosterone cypionate 75 mg/mL, Coopers) and run with the ewes. Oestrous activity was recorded weekly during the mating period. Due to the poor condition and inactivity of the rams, they were removed after 5 weeks. They were replaced with 4 Banrot injected, crayon harnessed wethers, for a further 4 weeks until the mating period ended. The ewes were pregnancy tested in February 1996 (~140 days post mating) and no pregnancies were recorded. This was presumably due to the poor seasonal conditions, the resultant poor ram condition and thus libido and low ewe mating liveweights (<30 kg). A second attempt to mate the ewes was begun in May 1996 (autumn) and continued for 7 weeks. As in October 1995, 4 teaser wethers were injected subcutaneously with 1 mL Banrot and run with the ewes 2 weeks before the inclusion of Siresine crayon harnessed rams. Oestrous activity was again recorded weekly. The ewes were pregnancy tested by ballotment (abdominal palpation) 2 weeks before lambing in October 1996. All ewes that had a positive pregnancy test also had lambs.

The major husbandry events for the experiment and seasonal rainfall are presented in Figure 1.

Measurements

The ewes were weighed on a monthly basis throughout the trial and at key points such as the end of expected implant activity and commencement and conclusion of joining. Oestrous activity, as indicated by crayon marks from the rams, was recorded during the mating period and pregnancy status was determined.

Climatic conditions

The mean annual rainfall for 'Toorak' Research Station is 426 mm. In 1995 and 1996 when the study was conducted, however, only 53% (225 mm) and 84% (357 mm) of the mean rainfall was recorded. Generally, >85% of the mean annual rainfall occurs in the summer wet season (October–March), but in 1995 and 1996, 77 and 94%, respectively, of the annual rainfall was recorded for this period.

Statistical analyses

The experiment was a randomised block design. Liveweights at specific time points were analysed by standard analysis of variance (ANOVA). These time points were the start and completion of both the marking implant and the wet season implant (days 0, 22, 57, 89, 179 and 277, respectively), the end of the wet season (day 320), day 390, mid dry season (day 412) and for both the first and second mating (days 488 and 670, respectively). In addition, average daily gains during marking implant (days 0–22, 0–57, 0–89), wet season implant (days 179–277) and wet season (days 179–320) were also analysed by ANOVA.

A set of orthogonal contrasts was constructed to compare the effects of specific treatments and their timing. The contrasts compared the control group with all treatment groups, implants at marking with implants at the beginning of the wet season (main effect: time of implant) and implants used (main effect: class of implant). Ralgro and Compudose, being single ingredient oestrogenic implants, were grouped for the comparison with Revalor and Synovex-H (double ingredient implants). These latter implants are not oestrogenic by nature. The deviations term is representative of the implant timing × implant type interactions. Normality and variance assumptions were checked and although there were some departures from these assumptions, none were of sufficient magnitude to require transformations. Ewes intended for the wet season implant were not included in the control group. Over the period of the trial, a number of animals went missing, either due to death or incomplete musters. All these values were treated as missing and were fitted by the method of least squares. The number of missing animals from each treatment at the end of the trial was as follows: control, 2; Ralgro-marking, 2; Ralgro-wet, 1; Compudose-marking, 2; Compudose-wet, 1; Revalor-marking, 1; Revalor-wet, 0; Synovex-H-marking, 2; and Synovex-H-wet, 1.

Results

Liveweights

There were no differences in liveweight (Table 1) between the treatment groups at the start of the trial (day 0). There were, however, treatment differences ($P<0.05$) at various time points analysed thereafter. The HGP groups had significantly ($P<0.05$) greater liveweights than the control group early in the trial (days 22 and 57) and from the end of the wet season implant (day 277) until the middle of the dry season (day 412). From the end of the wet season onwards, implant ewes tended to be heavier ($P<0.05$) than those implanted at marking (Table 2).

The Ralgro and Synovex treatment groups had lower liveweights ($P<0.01$) than those treated with Compudose or Revalor, from the completion of the marking implant until the end of the study (Table 1). For much of the trial, Ralgro-treated ewes were lighter ($P<0.01$) than Compudose-treated ewes. Differences ($P<0.05$) in the liveweights of Revalor- and Synovex-treated ewes became evident only after the end of the wet season implant (day 277). Significant deviations (i.e. interaction between HGP and timing of implant) were only observed at the end of the marking implant (day 89) and at the wet season implant (day 179).

Average daily gain

During the first 90 days of the trial, the ewes implanted with Compudose grew faster ($P<0.05$) than those implanted with Ralgro (Table 2). Ralgro had no effect on liveweight change. During the wet season, the implanted ewes grew faster ($P<0.01$) than the ewes implanted at marking.

Ewes treated with Compudose or Ralgro had higher average daily gains than those treated with Revalor or Synovex-H ($P<0.10$). There is evidence ($P<0.01$) of a HGP × timing of HGP interaction for average daily gains over all selected periods, as the deviations were generally significant.

Oestrus and pregnancy

For the 1995 mating, oestrus was unaffected by the various treatments (Table 3). However, the demonstration of oestrus in the 1996 mating was lowest in the ewes treated

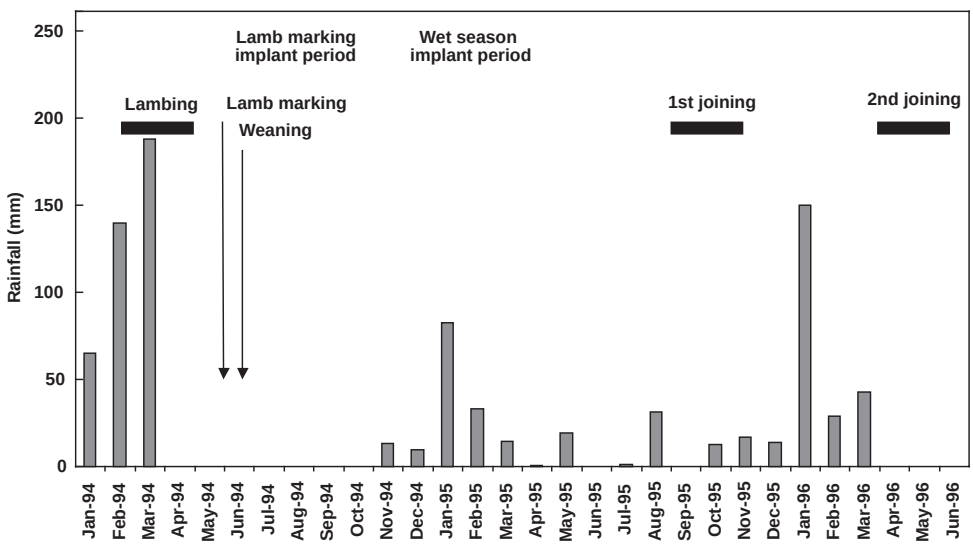

Figure 1. 'Toorak' Research Station rainfall and husbandry events during the HGP ewe trial, in which ewes were implanted with one of 4 HGP implants, either at marking or at commencement of the wet season.

Table 1. Liveweight (kg), treatment effects and treatment contrasts for ewes implanted with one of four HGP implants

Ewes were implanted at marking or at commencement of the wet season and were grazed on Mitchell grass pastures
Least squares means presented; comparisons can only be made within columns

No. of days of experiment:	0	22	57	89[A]	179[B]	277[C]	320[D]	390[E]	412[F]	488[G]	670
					Liveweight (kg)						
Treatment											
Control	15.6	15.6	19.0	21.3	21.9	27.3	30.9	33.2	33.7	28.5	33.9
Ralgro-marking	15.6	16.6	19.7	20.8	20.1	25.8	30.1	32.5	32.5	27.1	33.6
Ralgro-wet	15.7	16.4	19.8	22.0	22.4	28.1	32.1	34.6	34.4	28.3	34.0
Compudose-marking	15.9	15.9	20.3	21.8	22.7	29.9	34.3	37.5	37.4	31.9	35.5
Compudose-wet	15.6	16.6	20.3	22.5	23.7	31.2	35.9	38.7	39.2	33.7	38.3
Revalor-marking	15.6	17.0	21.0	22.9	25.2	30.5	34.3	35.8	37.0	30.0	34.6
Revalor-wet	15.7	16.9	20.3	23.2	24.1	31.0	36.3	39.8	39.8	33.7	37.3
Synovex-H-marking	15.9	17.5	20.6	22.6	24.9	29.7	32.8	35.0	35.2	29.4	33.8
Synovex-H-wet	15.8	16.2	18.8	20.2	21.1	28.8	33.0	35.2	35.2	28.9	32.9
l.s.d. ($P = 0.05$)	0.5	1.3	1.4	1.6	2.2	2.6	2.5	2.8	2.8	2.9	2.7
s.e.m.	0.18	0.46	0.50	0.55	0.78	0.90	0.88	1.00	0.99	1.02	0.96
Treatment effects	n.s.	n.s.	0.043	0.003	<0.001	<0.001	<0.001	<0.001	< 0.001	< 0.001	0.002
					Contrasts						
Control *v.* HGP	n.s.	0.033	0.034	n.s.	n.s.	0.039	0.005	0.007	0.015	0.079	n.s.
Marking *v.* wet	n.s.	n.s.	0.089	n.s.	n.s.	n.s.	0.025	0.011	0.026	0.035	0.072
Ralgro/Compudose *v.* Synovex/Revalor	n.s.	n.s.	n.s.	n.s.	n.s.	0.097	n.s.	n.s.	n.s.	0.095	n.s.
Ralgro *v.* Compudose	n.s.	n.s.	0.082	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.028
Synovex *v.* Revalor	n.s.	n.s.	n.s.	n.s.	0.069	n.s.	0.012	0.003	0.003	<0.001	<0.001
Deviations (HGP × timing interaction)	n.s.	n.s.	n.s.	0.007	0.001	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

[A]Marking implant finished; expected end of the activity of the implant applied at marking.
[B]Wet season implant; wet season implant applied.
[C]Finish of wet season implant; expected end of the activity of the implant applied at the start of the wet season.
[D]End of wet season.
[E]Mid dry season.
[F]First mating (spring) aborted due to poor seasonal conditions.
[G]Second mating (autumn).

with Compudose. This resulted in lower pregnancy rates for Compudose treated ewes. The use of Revalor also reduced pregnancy rates, as did a wet season Synovex-H implant. Ralgro had the least effect of any of the implants on reproduction. The contrast for implantation at marking or before the wet season was not significant.

Discussion

Despite implantation improving growth rates of Merino ewes, treatment with these agents at any age pre-mating had detrimental effects on subsequent reproduction. Although liveweight performance was improved, dry season implantation (post-marking and weaning performance) did not confer any later life advantages to the ewes. The strong liveweight responses in the wet season period are attributed to there being sufficient available nutrients to support growth, which was also found for cattle (Hunter and Vercoe 1988) where implantation conferred no advantage in steer liveweight gain, until a diet that supported moderate growth rates was fed.

What is of interest in our results is that the effects of a single implant of one of a range of HGP products, particularly Compudose, had long lasting adverse effects on oestrus and reproduction. Poor reproductive performance was manifest more than 2 years after the last implants were administered. Our study investigated the effects of a single HGP implantation on the productivity of ewes through 1 reproductive cycle and experiencing a seasonal variation in the plane of nutrition. Many studies investigating the effects HGP implantation of female sheep have not investigated the effects of implantation on reproductive performance beyond the first oestrous period. These studies were conducted under comparatively good, or stable, nutritional conditions and often involved multiple implantations over time (Cooper 1981*a*, 1981*b*, 1985; Fitzsimons and Crosby 1985; Hess *et al*. 1998). This study was conducted under comparatively harsh nutritional conditions.

The period of sexual development in the ewe is protracted and is slow to recover from long-term suppression of the hypothalamo-pituitary-axis by prepubertal androgen and/or oestrogen implantation (Papachristoforou *et al*. 1986; Papachristoforou 1987). Recovery from this hormonal-induced retardation of sexual development appears to last from a few days or weeks to a few months (Cooper 1981*a*,

Table 2. Liveweight change, expressed as average daily weight gain (g/day), treatment effects and treatment contrasts for ewes implanted with one of four HGP implants

Ewes were implanted at marking or at commencement of the wet season and were grazed on Mitchell grass pastures
Least squares means presented; comparisons can only be made within columns

Period (days):	0–22	0–57	0–89[A]	179–277[B]	179–320[C]
	Average daily weight gain (g/day)				
Treatment					
Control	0	61	65	56	64
Ralgro-marking	45	72	58	58	71
Ralgro-wet	34	73	71	58	69
Compudose-marking	5	80	68	73	85
Compudose-wet	43	83	77	76	87
Revalor-marking	64	94	82	54	65
Revalor-wet	55	81	84	70	86
Synovex-H-marking	73	84	76	54	59
Synovex-H-wet	18	53	49	79	84
l.s.d. ($P = 0.05$)	58	22	17	14	12
s.e.m.	20.6	7.9	5.9	5.0	4.1
Treatment effects	n.s.	0.019	0.001	<0.001	<0.001
	Contrasts				
Control *v.* HGP	0.058	0.057	n.s.	n.s.	0.012
Marking *v.* wet	n.s.	0.072	n.s.	0.003	<0.001
Ralgro/Compudose *v.* Synovex/Revalor	n.s.	n.s.	n.s.	0.005	0.048
Ralgro *v.* Compudose	n.s.	0.064	0.003	n.s.	n.s.
Synovex *v.* Revalor	n.s.	0.096	0.09	0.098	<0.001
Deviations (HGP × timing interaction)	n.s.	n.s.	0.004	0.055	0.002

[A]Marking implant; liveweight gain over the expected period of activity of the implant applied at marking.
[B]Wet implant; liveweight gain over the expected period of activity of the implant applied at start of wet season.
[C]Wet season; liveweight gain over period of the summer wet season.

Table 3. Proportion of ewes demonstrating oestrus and pregnancy after being implanted with one of four HGP implants

Ewes were implanted at marking or at start of the wet season and were grazed on Mitchell grass pastures
Least squares means presented; comparisons can only be made within columns

	Oestrus 1995	Oestrus 1996	Pregnancy 1996
	Proportion of ewes (%)		
Treatment			
Control	10.0	99.1	100.0
Ralgro-marking	10.0	99.2	77.6
Ralgro-wet	10.0	89.4	76.4
Compudose-marking	39.1	2.9	0.0
Compudose-wet	30.0	21.1	9.8
Revalor-marking	1.5	91.0	44.1
Revalor-wet	20.0	89.3	58.7
Synovex-H-marking	3.4	72.4	72.1
Synovex-H-wet	20.0	98.8	23.0
l.s.d. ($P = 0.05$)	33.0	26.4	36.6
Standard error of mean	11.68	9.33	12.93
Treatment effects	n.s.	<0.001	<0.001
	Contrasts		
Control *v.* HGP	n.s.	0.005	<0.001
Marking *v.* wet	n.s.	n.s.	n.s.
Ralgro/Compudose *v.* Synovex/Revalor	n.s.	<0.001	<0.001
Ralgro *v.* Compudose	n.s.	n.s.	0.053
Synovex *v.* Revalor	0.055	<0.001	0.001
Deviations (HGP × timing interaction)	n.s.	n.s.	0.059

1981*b*, 1985; Papachristoforou *et al*. 1986; Papachristoforou 1987), as assessed by plasma gonadotrophin levels. Oestradiol implantation was less effective than androgens in suppressing gonadotrophin secretion, but it did adversely affect the cyclicity of ewe, despite accelerating the onset of puberty (Papachristoforou 1987). Similar effects were reported by Papachristoforou (1987) with Revalor implantation.

Implantation is also reported to negatively affect development of the ovine reproductive tract where oestradiol treatment depressed ovarian weights (Bass *et al*. 1989). Treatment with oestradiol/progesterone combined with trenbolone acetate has also been reported to restrict ovarian size and activity, as well as follicular development (Fitzsimons and Crosby 1985). Implantation with zeranol appears to have a variable effect on the reproductive development in young ewes ranging from no apparent effect (Hess *et al*. 1998) to restricted physical and hormonal development (i.e. delayed puberty, low ovarian weights, reduced LH and FSH secretion), with subsequent adverse effects on ovulation rate (Cooper 1981*a*, 1981*b*, 1985; Fitzsimons and Crosby 1985).

Based on the above observations in the literature, it is suggested that the observed poor reproductive performance may have been due to the restricted development of the reproductive organs in the implanted ewes. The results also suggest a high level of non-ovulatory oestrus, which has been observed in heifers implanted with various HGPs (Moran *et al*. 1990).

We conclude from this study that the pre-mating implantation of Merino ewes is likely to have detrimental effects on reproduction, despite implantation having favourable effects on liveweight or growth rates. Accordingly, HGPs are not recommended for use in young breeding ewes, although they may be of value in animals destined for slaughter, due to their positive impact on carcass composition (Coelho *et al*. 1981; Galbraith and Topps 1981) and their ability to limit reproductive function.

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