Are elevated maternal thyroid hormone concentrations after-mid-pregnancy shearing responsible for changes in lamb fleece characteristics?

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ABSTRACT

This study was designed to test the hypothesis that elevated maternal thyroid hormone concentrations in mid-pregnancy are responsible for the observed differences in lamb follicle characteristics as a result of mid-pregnancy shearing. The study involved 51 twin-born lambs in a 2 x 2 factorial design involving dams that were either shorn or unshorn in mid pregnancy and had either normal or elevated thyroid hormone levels. All ewe groups were thyroidectomised except for unshorn-normal ewes which were sham-operated. The thyroxine implant and injection regimes used to manipulate maternal thyroid hormone levels in mid-pregnancy were successful in mimicking the levels previously reported in mid-pregnancy shorn ewes. Lambs born to shorn dams had significantly ($P<0.05$) higher coefficients of variation of mean fibre diameter. Dam shearing treatment had no effect on any other follicle or wool characteristic. Lambs born to ewes with elevated thyroid levels in mid-pregnancy had a significantly ($P<0.05$) higher numbers of secondary fibres, and tended to have more primary fibres ($P=0.08$) and whiter wool ($P=0.06$). The absence of any dam shearing-treatment effect on secondary and primary fibre numbers, fibre diameter and length, suggests that the changes observed in follicles and wool characteristics of lambs born to mid-pregnancy shorn dams are primarily due to elevations in maternal thyroid hormone levels in mid-pregnancy. More work is required to confirm this hypothesis.

Keywords: mid-pregnancy shearing; thyroid hormones; micron; follicle development; wool characteristics

INTRODUCTION

Mid-pregnancy shearing of ewes has been shown to consistently increase lamb birthweight (Morris & McCucheon, 1997; Morris *et al*., 1999; Morris *et al*., 2000; Smeaton *et al*., 2000; Kenyon *et al*., 2002a,b,c) and has tended to increase lamb survival rates (Morris *et al.,* 1999; Kenyon *et al.,* 2002b). Mid-pregnancy shearing has also been shown to inconsistently affect follicle and wool characteristics in resulting progeny. Revell *et al*. (2002) reported that singleton fetuses from mid-pregnancy shorn dams had both higher secondary follicle densities and secondary-to-primary-follicle ratios than their counterparts born to unshorn dams and also tended to have finer wool. In contrast, Sherlock *et al*. (2002) found higher mean fibre diameters in lambs born to shorn dams and a corresponding decrease in secondary follicle density in comparison to those born to unshorn dams.

Mid-pregnancy shearing has been associated with an increase in maternal thyroid hormone concentrations (Symonds *et al*., 1989; Morris *et al*., 2000, Sherlock *et al*., 2003). Revell *et al.* (2002) suggested that an increase in thyroid hormone levels in mid-pregnancy shorn ewes might be the causative factor for the increase in secondary follicle density observed in their study. In pigs elevated foetal T4 levels have been shown to increase follicle numbers (Hausman, 1992) and hyperthyroidism in 5-month Mohair goats, has been associated with a finer fibre diameter (Puchala *et al*., 2001). In sheep foetal thyroidectomy results in failure of initiated follicles to mature and produce a fibre (Hopkins & Thorburn, 1972). Therefore it is possible that elevation of maternal thyroid hormones in mid-pregnancy may result in changes in the fibre characteristics of resulting offspring.

The aims of this study were to re-examine the effects of mid-pregnancy shearing on the lamb follicle population and fleece characteristics and to determine if any effects observed could be explained by elevated maternal thyroid hormone concentrations in mid-pregnancy.

METHODS

Lamb source

In this study 51 mixed-sex twin lambs were born to ewes in a 2 x 2 factorial design, incorporating shearing treatment (mid-pregnancy shorn vs. unshorn (approximately 6 months wool growth)) and maternal thyroid hormone level at mid-pregnancy (elevated vs. 'normal') (as previously described by Kenyon *et al*., 2003). Unshorn-elevated, shorn-elevated and shorn-normal ewes were all thyroidectomized to allow for the manipulation of maternal thyroid hormone concentrations while, unshorn-normal ewes were sham operated (Kenyon *et al*., 2003). All lambs were born to Romney ewes which had been successfully mated during a two-day synchronized mating period in March 2000 to Suffolk rams.

Ewe thyroid hormone manipulation

Ewes were thyroidectomised during the period 48 – 52 days (P48 – 52) after CIDR withdrawal. All

thyroidectomised ewes were implanted with both a 20 and a 30mg T4 implant (Glaxo, UK) at surgery and at P140 with the aim of maintaining maternal thyroid hormone concentrations at a level seen in the unshorn ewe. To achieve a short-term elevation of thyroid hormone levels (mimicking that seen previously in shorn ewes), ewes were injected daily for 10 days from P71-80 with 0.75mg T4 (Sigma Chemical Co, USA) (Kenyon *et al*., 2003). The ewe blood sampling regimen used was as described in Kenyon *et al*. (2003).

Wool and skin measurements

Mid-side wool samples and fleece weights were collected from twin-born lambs at approximately five months of age. After collection, all wool samples were conditioned at 65% relative humidity and 20^{o}C until (and during) fibre testing. In addition each lamb had a skin biopsy taken from within the clipped mid-side area. Wool and skin samples were processed and analysed as described by Sherlock *et al*. (2002).

The trial was undertaken with the approval of the Massey University Animal Ethics committee.

Data analysis

Lamb live weight and follicle and wool characteristics were subjected to analysis of variance using the Generalised Linear Model procedure of the statistical package 'Minitab' (Minitab, 1998). The main effects of sex of lamb, dam shearing treatment and thyroid hormone treatment and their interactions were fitted. No interactions were significant and were thus removed from the models. The raw S:P data were more normally distributed than the data following log transformation and were therefore analysed in their raw state.

RESULTS

Daily injections with T4 significantly (P<0.05) increased both T3 and T4 concentrations for at least 10 days (Figure 1). However, by late pregnancy T3 and T4 concentrations were lower in all thyroidectomised groups than in the unshorn-normal T4 group (sham operated).

Dam shearing treatment had no effect on the number of primary or secondly follicles or the secondary to primary ratio (Table 1). Lambs born to ewes with elevated thyroid hormone concentration in mid-pregnancy had significantly (P<0.05) greater secondary fibre numbers and tended to have more primary fibres (P=0.08) than those born to 'normal' ewes. Secondary to primary ratio was not affected by dam thyroid hormone treatment.

Neither dam shearing nor thyroid hormone treatment affected mean fibre diameter (Table 2). Lambs born to mid-pregnancy shorn dams had significantly (P<0.05) higher coefficient of variation of MFD than those born to unshorn dams. Dam shearing treatment had no effect on yield, staple length, bulk and Y-Z colour value. Dam thyroid hormone treatment had no effect on yield, staple length or bulk (Table 3). Lambs born to ewes with elevated thyroid hormone concentration in mid-pregnancy tended to have whiter wool (P=0.06) than those born to 'normal' ewes.

DISCUSSION

This study was designed to separate the effects of maternal shearing and maternal thyroid hormone concentration in mid-pregnancy on lamb follicle and wool characteristics. If elevated maternal thyroid hormone concentrations was the mechanism responsible for previously observed changes (Revell *et al*., 2002; Sherlock *et al*., 2002) in lamb follicle and wool characteristics following mid-pregnancy shearing, it would be expected in the present study that lambs born to ewes with elevated thyroid hormone levels regardless of shearing treatment would be affected. However, if the shearing effect operated through some other mechanism(s), one would expect the follicle and wool characteristics of lambs born to shorn ewes, regardless of maternal thyroid manipulation, to differ from those born to unshorn dams.

TABLE 1: The effect of dam shearing and thyroid hormone level in mid-pregnancy on the wool follicle populations of 5-month-old lambs (Mean ±SE). Means within treatments having differing superscripts are significantly different (P<0.05).

		N^{o} of primary follicles		N^{o} of secondary follicles		Secondary: primary ratio	
Treatment	n	Mean	± SE	Mean	± SE	Mean	± SE
Shearing							
Unshorn	24	6.62	0.39	49.70	1.75	9.28	0.56
Shorn	23	6.96	0.38	50.06	1.67	8.91	0.53
Hormone							
Normal	22	6.30	0.40	46.75^{a}	1.76	9.22	0.56
Elevated	25	7.29	0.38	53.00^{b}	1.68	8.97	0.53

TABLE 2: The effect of dam shearing and thyroid hormone level in mid-pregnancy on the fibre diameter of 5-month-old lambs (Mean ±SE). Means within treatments having differing superscripts are significantly different (P<0.05).

		Liveweight (kg)		Mean Fibre Diameter (MFD) (μm)		Coefficient of variation of MFD (%)	
Treatment	n	Mean	± SE	Mean	± SE	Mean	± SE
Shearing							
Unshorn	27	28.97	0.60	30.97	0.44	23.72[a]	0.36
Shorn	24	28.73	0.63	31.23	0.46	24.78[b]	0.38
Hormone							
Normal	24	30.50[b]	0.63	31.35	0.46	24.03	0.38
Elevated	27	27.50[a]	0.60	30.85	0.44	24.46	0.36

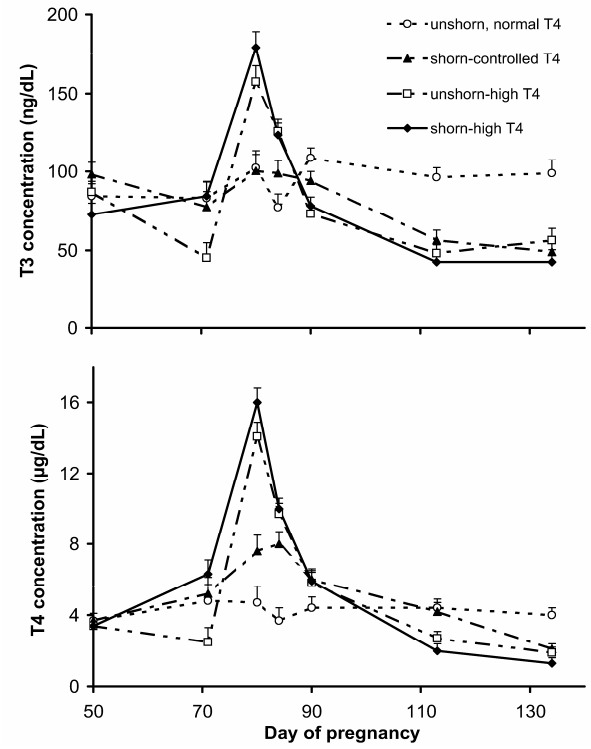

FIGURE 1. Effect of dam treatment on mean maternal plasma T3 (ng/dL) (upper graph) and T4 (μg/dL) (lower graph) concentrations during mid- to late-pregnancy (Figure adapted from Kenyon *et al*., 2003). The vertical bars indicate standard errors of the means.

To successfully test the role of elevated maternal thyroid hormones on lamb follicle and wool characteristics the manipulated thyroid hormone elevation must be similar to that previously observed in mid-pregnancy shorn ewes. The relative elevation in maternal T3 concentration above that seen pre-treatment in the present study was similar to that observed by Morris *et al*. (2000) although the period of the present elevation was shorter. This shorter elevation period may have limited the ability of this study to effectively determine the role of maternal thyroid hormones. It is also apparent that the T4 implants used failed to maintain maternal T4 and T3 concentrations at a level seen in the sham-operated ewes in late pregnancy. Thus, there is the potential for these lower levels to affect any responses observed from elevation of T3 and T4 in mid-pregnancy. However, this is unlikely as the T3 levels observed are still within the naturally occurring 39 – 66 ng/dL range previously reported in ewes during late pregnancy (Symonds *et al*., 1989, Morris *et al.,* 2000, Polk *et al*., 1991). In addition, Hocking-Edwards *et al*. (1996) observed that in Romneys a larger proportion of primary follicle initiation was completed by day 83 of pregnancy. They also reported that secondary follicle fibre initiation began around day 80 of pregnancy and was all but completed by day 111. Given the small overlap, it is likely that the low levels of T3 and T4 in late pregnancy had little, if any effect on the follicle population.

Elevation of maternal thyroid hormones in the present study increased secondary fibre numbers and tended to increase primary follicle numbers. In contrast no such effect was observed from shearing. Thus an elevation in maternal thyroid hormone concentrations in mid-pregnancy is the primary candidate as the mechanism responsible for increases in secondary fibre numbers in lambs born to mid-pregnancy shorn ewes. This requires further study under conditions in which the period of T3 and T4 elevation is similar to that observed in mid-pregnancy shorn ewes and where maternal T3 and T4 concentrations do not differ in late pregnancy. Despite the fact that in the present study skin samples were not individually adjusted for shrinkage, which may have added to the variation, differences in secondary follicle number were detected. If adjustments had been made it is possible that the level of significance may have been greater.

In contrast to the present findings and those of Revell *et al*. (2002), Sherlock *et al*. (2002) observed that lambs born to shorn dams had lower secondary follicle numbers and higher fibre diameter. However, in the studies of Revell *et al*. (2002) and Sherlock *et al*. (2002) the effects of pregnancy shearing on maternal

TABLE 3: The effect of dam shearing and thyroid hormone level in mid-pregnancy on wool characteristics of 5-month-old lambs (Mean ±SE). Means within treatments having differing superscripts are significantly different (P<0.05).

		Yield (%)		Length (mm)		Bulk (cm^3/g)		Colour (Y-Z)	
Treatment	n	Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE
Shearing									
Unshorn	27	80.90	0.53	74.54	1.76	26.60	0.48	2.17	0.32
Shorn	24	81.70	0.56	74.46	1.85	26.36	0.51	2.41	0.34
Hormone									
Normal	24	80.68	0.56	75.72	1.85	26.90	0.51	2.74	0.34
Elevated	27	81.92	0.53	73.29	1.76	26.05	0.48	1.84	0.32

thyroid hormone concentrations are not known. Prolonged cold exposure is known to cause an elevation in both T3 and T4 concentrations (Westra and Christopherson, 1976). Thus differences in environmental temperatures may be responsible for the difference of results observed between mid-pregnancy studies. Furthermore, there were breed differences between studies.

CONCLUSION

This study was designed to test the effects of elevated maternal thyroid hormone concentrations in mid-pregnancy on lamb fibre follicle and wool characteristics. The lack of a shearing effect (irrespective of thyroid hormone treatment) and the presence of a maternal thyroid concentration effect (irrespective of shearing treatment) suggests that elevation of maternal thyroid hormones is the mechanism responsible for the changes in fibre follicle characteristics observed in lambs born to mid-pregnancy shorn ewes. Further study is required to confirm these findings.

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