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Effect of premating iodine supplementation of ewes fed pasture or a brassica crop prelambing on the incidence of goitre in newborn lambs

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ABSTRACT

On two sheep farms with different winter feeding systems, namely pasture only (farm A) or pasture then swedes or swedes/turnips/kale for 6 to 8 weeks prelambing (farm B), 700 ewes/farm were randomly assigned to 2 groups of 350 animals to assess animal performance. About 5 weeks premating, one group was injected with 390 mg iodine (as Flexidine iodised oil) intramuscularly. Iodine supplementation increased and maintained serum and milk I concentrations for at least 210 days (µg/L; farm A, serum 43 v 65; milk 72 v 197. Farm B, serum 29 v 45; milk 26 v 132), but did not affect potential lambing percentage at scanning, perinatal mortality, or lambing percent (farm A, 140 v 150%; farm B, 138 v 130%). On farm A no goitre was observed among the 77 lambs post mortemed, regardless of I treatment of the ewes. On farm B goitre was observed in 85% of the 34 lambs post mortemed from untreated ewes, but not among the 36 lambs from treated ewes. In the following year, the trial was repeated with 50 ewes/group to monitor changes in I status, and the treatment significantly increased serum I over time but had no consistent effect on serum T_4 and T_3 concentrations. Supplementing ewes premating with long-acting injectable I prevented goitre in newborn lambs from ewes fed swedes or swedes/turnips/kale as a winter supplement.

Keywords: iodine deficiency; ewes; newborn lambs; thyroid hormones; goitre; swedes; pasture.

INTRODUCTION

Severe I deficiency can occur when ewes are fed brassica crops for long periods prior to lambing (Sinclair & Andrews, 1958). Brassicas such as swedes, turnips and kale have low I content and contain goitrogens, and may lead to newborn lambs that are weak and have enlarged thyroid glands (goitre) (Sinclair & Andrews, 1958). Iodine supplementation has been shown to reduce perinatal mortality and increased lambing percent by 14 to 21%, in a recent study of pasture-fed ewes by Sargison *et al*. (1998), but other I supplementation experiments have failed to demonstrate production gains among grazing ewes assessed to be I-deficient (Parker & McCutcheon, 1989). Reasons for inconsistent response to I supplementation are not fully understood, but variations in plant I concentration with season, changes in the botanical composition of pasture, soil ingestion, and the presence of goitrogens in herbage can influence I intake and utilisation by the ewe. For example, white clover, a common and important pasture component, contains cyanogenic glycosides that are goitrogenic (Crush & Caradus, 1995).

Severe I deficiency is easily diagnosed from enlarged thyroids, but the marginal deficiencies that could lead to non-specific production losses from embryonic mortality or high perinatal lamb death are more difficult to detect (Sargison *et al*., 1998). The use of serum thyroid hormones thyroxine (T_4) and tri-iodothyronine (T_3) as indices of I status is sometimes promoted, but has been questioned, as changes in those hormones are not strongly related to the incidence of goitre in flocks (Clark *et al*., 1998). At present there appears to be no suitable biochemical criteria to predict the occurrence of subclinical I deficiency.

In this study we evaluated the usefulness and validity of serum I, milk I, total T_4, total T_3 and free T_3 concentrations as indices of I status of ewes fed pasture or pasture then brassicas prelambing, and compared those measures to the incidence of goitre in newborn lambs.

MATERIALS AND METHODS

Farms

Two Southland farms in the Wendon Valley near Gore, with mean summer pasture I concentrations <0.17 mg I/kg DM, were selected for this study. Farm A provided only pasture while farm B provided pasture then swedes (1999) or swedes/turnips/kale (2000) for six to eight weeks prelambing.

Experimental Design

Ewe reproductive performance trial 1999

In mid March 1999, 700 ewes on each farm were eartagged and randomly assigned to two groups of 350 animals each such that one group was the untreated control while the other group was injected with 390 mg I (1.5 ml Flexidine, Bomac) into the anterior neck region. The groups were managed as a single mob, were joined with the ram in late April, and were scanned at 90 days in July to determine the numbers of dry, single- and twin-bearing ewes. At about 10 days before lambing in late September, the ewes were separated into untreated and treated groups and set-stocked so that the number of dead lambs could be recorded during twice-daily checks. At least 34 dead lambs/group were submitted for post mortem and their thyroid : liveweight ratios determined. Goitre was diagnosed when the ratio of thyroid gland weight (as g) to body weight (as kg) was >0.4 (Clark *et al*., 1998). Lambs were docked in late October and lambing percent determined. Blood and milk samples were collected at docking from 10 monitor ewes/group.

Iodine status monitoring trial 2000

In the second year the experiment was repeated with 50 new ewes/group. The I-supplemented ewes were injected in mid March 2000 and the untreated and treated animals were managed as described above. Blood samples were collected from 10 monitor ewes/group at five times: prior to I injection, premating, at the time of pregnancy scanning (i.e., prior to the ewes being fed swedes/turnips/kale on

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farm B), prelambing, and at the time of docking.

Sample collection

Jugular blood was collected using a plain 10 ml vacutainer. Serum was harvested following centrifugation at 2000 x g for 20 minutes, then stored at 20°C. Ewes were given 0.5 ml of oxytocin s.c. before 30 ml milk was expressed to plastic containers and stored at 20°C. Pasture herbage samples were collected along a 100-200 m transect from representative paddocks, bulked, dried at 60°C for 48 hours, then ground. Likewise 10 plants of swedes, turnips and kale were collected, separated into leaf and washed bulbs, bulked, dried and then ground.

Analytical methods

The I content of pasture herbage, brassica components, milk and serum was determined following double alkaline ashing by an oxidation-reduction reaction (Sandell & Kolthoff, 1937), or by aqueous tetramethylammonium hydroxide digestion at 90°C (Fecher *et al*., 1998) followed by ICP-mass spectroscopy. In a pilot study, the I concentrations in serum and plasma were found to be equivalent (data not shown). The serum total T_4, total T_3 and free T_3 were determined using a radioimmunoassay kit (Millar & Albyt, 1985) (TT_4P: Kalhestad manufacturers' procedure).

Statistical methods

Lambing and prenatal mortality percent between groups were compared using chi-squared analyses. Repeated-measures analyses of variance of serum I, total T_4, total T_3 and free T_3 were carried out using SAS statistical procedures (version 6.11, SAS Institute, Cary, North Carolina).

RESULTS

Seasonal changes in the I concentrations of pasture herbage and the leaf and bulbs of swedes, turnips and kale are shown in Table 1. Concentrations were less than 0.17 mg I/kg DM, except for the leaves of swedes, and pasture herbage in July. There were no significant differences in pasture I concentrations between farms A and B, except for July 1999.

The effects of premating I supplementation and prelambing feeding of brassicas on perinatal mortality, lambing percent and the incidence of goitre among newborn lambs in 1999 are shown in Table 2. Supplementation and feeding had no effect on potential lambing percent, perinatal mortality or lambing percent. Goitre was observed only among lambs of untreated ewes on farm B fed swedes prelambing. On that farm, I supplementation eliminated incidence of goitre and significantly reduced the mean thyroid:liveweight ratio in newborn lambs (P<0.01). In year 2000, perinatal mortality was low but goitre was again observed only on farm B; of the six farm-B lambs post-mortemed, one lamb out of the two from untreated ewes had goitre (data not shown).

On both farms, I treatment had significantly increased and maintained serum and milk I concentrations when measured on day 210 during the 1999 reproductive performance trial (Table 2). Among untreated ewes, serum and milk I concentrations were significantly higher on farm A than on farm B. Likewise, during the year 2000 monitoring trial, serum I was significantly increased on both farms (peak at day 37) as shown in Figure 1. Only on farm B during 2000 were serum thyroid hormones significantly affected, such that total T_4 concentration was greater until day 108, and total T_3 and free T_3 concentrations were greater for 37 days (free T_3 not shown).

DISCUSSION

In this study, goitre was observed among newborn lambs from ewes fed brassicas six to eight weeks prelambing (farm B), whereas lambs from ewes fed only pasture (farm A) showed no such sign of I deficiency. This was not entirely unexpected, as swedes and turnips have low I content (especially the bulbs; Grace *et al*., 2000) and contain goitrogens which reduce uptake and utilisation of dietary I. Brassica feeding occurred during the last month of gestation, when foetal lamb I requirements are highest

TABLE 1: Means (and ranges) of I concentrations as mg/kg DM in pasture herbage and brassica crops. Farm A provided only pasture while farm B provided pasture then swedes/turnips/kale for six to eight weeks prelambing. Note that the effects of I supplementation on ewe reproductive performance were studied in 1999, and in 2000 its effects on the I status of ewes were determined.

	1998	1999			2000		
	December	February	July	December	April	August	December
Farm A							
Pasture	0.11 (.09-.13)	0.07 (.05-.08)	0.23[a] (.22-.30)	0.07 (.07-.08)	0.13	0.07	0.12
Farm B							
Pasture	0.17 (.07-.26)	0.07 (.07-.08)	–[b]	0.06 (.05-.07)	0.11	–	0.09
Swedes							
leaf			0.28			0.28	
bulb			<0.05			<0.05	
Turnips							
leaf			–			0.08	
bulb						0.06	
Kale							
leaf			–			0.07	
stem						0.15	

[a] Soil contamination increased pasture iodine concentrations.

[b] Although no pasture was fed during this period, the measured herbage I concentration was 0.50 (0.40-0.70).

TABLE 2: Effects of I supplementation of ewes premating in 1999 on ewe reproductive performance (n=350 per farm), and on serum and milk I concentrations (mean ± SEM, n=10). Farm A provided only pasture while farm B provided pasture then swedes for six to eight weeks prelambing.

	Farm A		**Farm B**	
	Untreated+	Iodine	Untreated	+ Iodine
Potential lambing (%)[a]	167	169	153	156
Perinatal mortality (%)	19.3	18.9	28.3	27.3
Lambing (%)[b]	140	150	138	130
Mean thyroid : liveweight ratio	0.21	0.21	2.29	0.37**
and range	(0.08-0.31)	(0.09-0.33)	(0.24-8.2)	(0.21-0.61)
Incidence of goitre among dead lambs post mortemed	0 of 35	0 of 422	9 of 34	0 of 36
Serum (µg I/L)	43 ± 5.0c	65 ± 4.0*	29 ± 3.0[c]	45 ± 5.0*
Milk (µg I/L	72 ± 14.0d	197 ± 34.0**	26 ± 7.0[d]	132 ± 25.0**

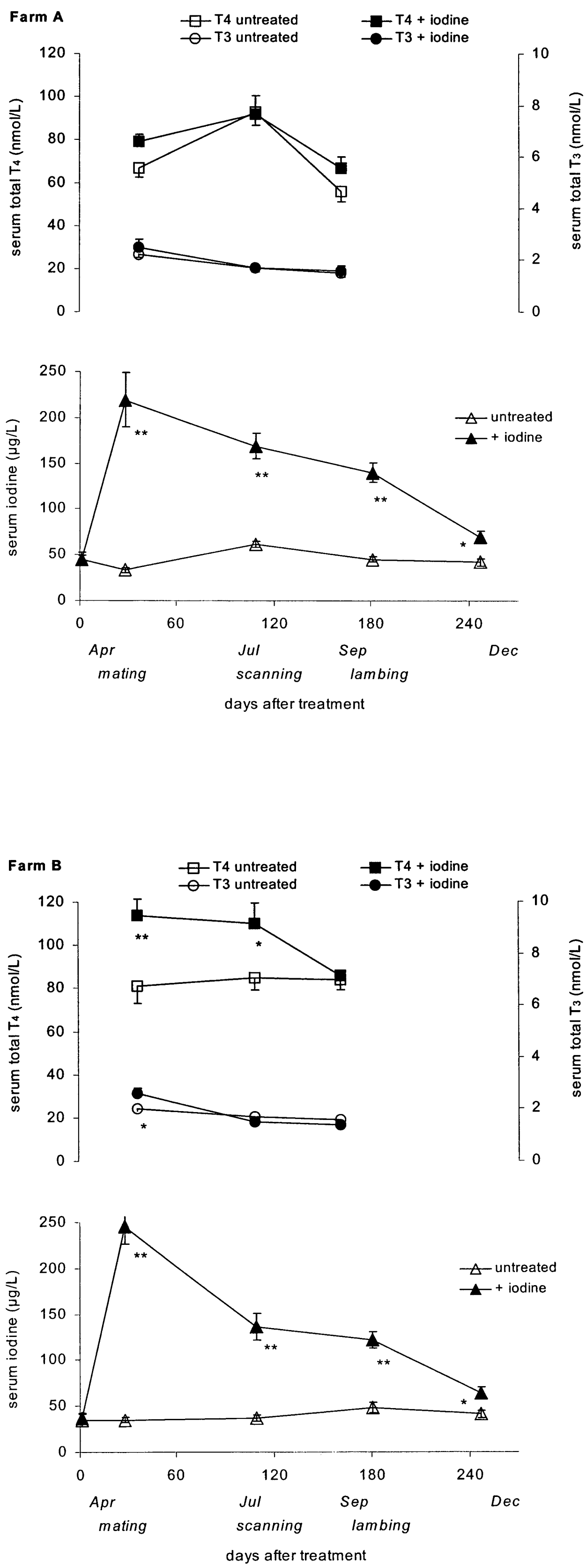
[a] Percentage of foetus per ewe scanned
[b] Percentage of lambs docked per lambing ewe
Significantly different by I treatment: ** P<0.01, * P<0.05
Significantly different by farm: serum [c] P<0.05, [d] milk P<0.01

(Wright & Sinclair 1959), but by treating ewes premating with iodised oil, the I status of ewes was improved throughout gestation and lactation, thereby increasing the I status of the foetus, the milk I concentration, and the I intake of the suckling lamb. Efficacy of the injection providing 390 mg I was at least 210 days, based on elevated ewe serum and milk I concentrations. These results confirm the earlier work of Azuolas & Caple (1984) in which iodised poppy seed oil prevented goitre in lambs for two years.

The pasture I concentrations on both farms were similar, averaging 0.10 mg I/kg DM throughout non-winter months. During July and August however, wet weather and close grazing would have caused soil contamination of pasture and the bulbs of the swedes and turnips. As soil I concentration is at least 10-fold greater than grasses or forages, the soil ingested by ewes would result in additional but widely varying amounts of dietary I during gestation (Healy *et al.*, 1972). Under the conditions of the current study, pastures containing 0.06 to 0.23 mg I/kg DM can be considered to provide adequate I intake, because I supplementation did not affect ewe performance such as foetal numbers per ewe, perinatal mortality or lambing percent.

Other studies have reported varying results when relating I responses in animal performance to pasture I concentrations. A recent two-year trial by Sargison *et al.* (1998) showed that, for ewes grazing pasture containing 0.31 mg I/kg DM (measured only once, in September 1997), supplementation with I decreased perinatal mortality, increased lambing 14%, and decreased the mean thyroid:liveweight ratio from 0.48 to 0.28 among control and treated groups respectively. The ratio had been found to be unaffected by treatment (0.22 v 0.24) during the 1996 period of the above trial. Clark *et al.* (1998) reviewed sheep performance in New Zealand and found that flocks not supplemented with I and having newborn lambs with a thyroid:liveweight ratio >0.4 generally have significantly greater perinatal mortality than I-supplemented flocks. In high-fecundity Booroola Merino x Romney ewes grazing ryegrass/white clover pasture containing 0.10 to 0.18 mg I/

FIGURE 1: Effect of I supplementation of ewes via injection of iodised oil containing 390 mg I during the year 2000 ewe iodine status monitoring trial (mean ± SEM, n=10 per farm). **Farm A** provided only pasture while **Farm B** provided pasture then swedes/turnips/kale for six to eight weeks prelambing.



kg DM, I supplementation premating increased litter size (Davis & Barry, 1983). The variable response to I in pasture-fed ewes may be related to the white clover content of the pasture, as clover contains cyanogenic glycosides that are potential goitrogens (Crush & Caradus, 1995).

The I-containing thyroid hormones T_4 and T_3 are synthesised from tyrosine,secreted under the stimulation of thyrotrophin, and transported in association with thyroxine binding protein. T_4 is converted to its active form T_3 in peripheral tissues such as the liver and kidneys. Very small fractions of T_4 and T_3 remain unbound or free (Wellby & O'Halloran, 1966). These hormones regulate animal basal metabolic rate and heat production (see Grace, 1994). Cold weather can significantly impact perinatal mortality and lambing percent, and newborn lambs from ewes of low I status are more prone to hypothermia (Caple & Nugent, 1982) and, therefore, are likely to be slower to suckle. Perhaps because the Southland winters of 1999 and 2000 were milder than usual there was no difference in perinatal mortality and lambing percentage between untreated and I-supplemented ewes, despite the incidence of goitre being much higher among the untreated swede-fed animals. Under more severe winter conditions, lamb losses from untreated ewes on farm B would likely have been greater.

The injectable I supplement markedly increased I status, as indicated by ewe serum I concentration, on both farms. In year 1999, the groups in which postlambing serum I concentrations were >43 µg/L had no goitre among 113 lambs post mortemed, whereas the group with mean serum I of 29 µg/L had 85% goitre among 34 post-mortemed lambs (Table 2). In year 2000, postlambing serum I was >40 µg/L for all groups and there was some evidence of goitre only among lambs from a small group of untreated ewes fed brassicas. The responses of ewe thyroid hormones were not consistent, with serum total T_4 increasing for 108 days, and total and free T_3 increasing for 37 days on farm B only. Clark *et al*. (1998) and Sargison *et al*. (1998) observed similar variability for total T_4 and T_3, while Parker and McCutcheon (1989) observed an increase in plasma T_4 but not T_3 in pasture-fed ewes at 113 days after treatment with iodised oil.

In the 1999 ewe performance trial, goitre was associated with a mean milk I concentration of 26 µg/L, but not when values were >72 µg/L. These results support those of a survey of the I status of 54 flocks in Victoria, Australia, which found goitre in only two flocks, and those ewes had milk I ranging from 45-98 µg/L (Azuolas & Caple, 1984). Similarly, when the incidence of goitre in lambs was related to the I content of milk of their dam, it was observed that milk I values ranging from 23 to 98 µg/L were associated with goitre (Mason, 1976).

The incidence of severe I deficiency can be assessed from thyroid gland histology and from the thyroid:liveweight ratio (Clark 1998; Clark *et al*., 1998). Biochemical criteria used to determine marginal I deficiency such as serum T_4 and T_3 are not satisfactory, but we have shown ewe serum and milk I concentrations of >43 and >72 µg/L respectively to be associated with a very low risk of goitre in newborn lambs. Factors such as the presence of goitrogens and climatic conditions at lambing can have marked, but difficult to assess, effects on I metabolism and lamb survival. At present the only way to detect a marginal I deficiency is to compare the performance of untreated and I treated groups of ewes (n=350 to 500), managed under the same conditions, in terms of number of foetuses/ewe at scanning, perinatal mortality and lambing percent.

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