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Testis size and endocrine parameters in rams as predictors of aseasonality in their daughters

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ABSTRACT

A progeny test involving Romney (n=5) and Poll Dorset (n=5) rams mated to Romney ewes was conducted to examine the relationship between testis size and endocrine parameters, measured during the transitional period from the non-breeding to the breeding season, in rams, and reproductive performance of their daughters in the first and second breeding seasons. More of the Poll Dorset cross hoggets reached puberty during the first breeding season (80 v. 60%; $P<0.01$) associated with earlier onset (13 v. 22 May; $P<0.10$) at younger ages (264 v. 276 days; $P<0.10$) and more oestrous cycles (2.7 v. 2.0; $P<0.05$) than for Romney hoggets. The date of onset of the second breeding season was influenced by breed ($P<0.001$) and sire within breed ($P<0.05$). These differences between Romney and Poll Dorset cross animals in reproductive performance were associated with differences between their sires in the pattern of seasonal variation in testis size and plasma gonadotrophin concentrations. However, within-breed correlations between testicular and endocrine parameters in the sires and date of onset of the breeding season in the offspring were low. It is concluded that, while some of the testis and endocrine parameters could potentially be used as selection criteria for date of onset of the breeding season in ewes, further studies are needed before these parameters can be incorporated into selection programmes.

Keywords Testis size, LH, FSH, gonadotrophin, GnRH, breeding season, puberty.

INTRODUCTION

The production of lambs outside the normal season has many advantages both to the sheep farmer and to the meat industry (Andrewes & Taylor, 1986). However, in New Zealand, the main sheep breeds normally used for lamb production have a distinct breeding season and can be induced to breed outside the normal breeding season only through the use of expensive hormones. This will remove many of the benefits sheep farmers expect to obtain by producing lambs out of season. Hence there is a need to develop a heavy-wool, fast-growing sheep breed that can breed at most times of the year. Heritability estimates for breeding activity in hoggets (Baker *et al.*, 1979) and for advanced lambing in ewes (Smith *et al.*, 1992) indicate breeding programmes could be initiated for early breeding.

The use of selection in the ewe for date of onset of the breeding season will likely result in only slow genetic progress due both to the fact that oestrous activity is a sex-limited trait on which selection pressure cannot be applied prior to puberty and to the low selection pressure that can be applied to the ewe. As a result, it is desirable to develop techniques that will improve the rate of genetic gain in selection programmes for date of onset of the breeding season. One such technique would involve indirect selection in the ram (Walkley & Smith, 1980). Because of the greater selection pressure that can be applied to rams as compared to ewes, the rate of genetic progress may be greatly increased (Xu, 1991). However, the successful use of ram selection depends on identifying appropriate characteristics (or genetic markers) in the ram that can be used as selection criteria. The general approaches that can be taken to find useful genetic markers have been discussed by Blair *et al.*, (1990). In the first instance, it may be advantageous to study breeds differing greatly in seasonality. Although differences found in the between-breed situation may not be the causes of differences in seasonality within breeds, they do highlight the possible parameters worth examining in a within-breed situation. Recently, we have shown (Xu *et al.*, 1991) that Romney and Poll Dorset rams differ in the pattern of seasonal variation in testis size, LH pulse frequency and plasma FSH concentrations. This makes these characters potentially useful genetic markers. We report here results of a progeny test on the same sires and relationships between testis size/endocrine parameters in the sire and breeding performance of their daughters.

MATERIALS AND METHODS

Animals and management

Five Poll Dorset rams purchased from a local ram breeding farm and five Romney rams from a commercial flock on a Massey University farm were used in a progeny test at the latter site. The rams were about 18 months of age at the time of mating. A flock of 410 mixed age Romney ewes (ranging from 1.5 to 6.5 years old) were involved in the progeny test. They were randomly divided, with restriction to age, into 10 mating groups each of 41 ewes and each group was randomly assigned to be mated by one of the 10 rams. Paddock mating commenced on 15 March 1988 and continued for 5 weeks. After mating, all ewes were managed as a single mob on mixed ryegrass and clover pastures. At lambing, during August-September, data were recorded for date of birth, birth rank, birth weight and identity of the dam which was used to determine a lamb's sire group. Each lamb was uniquely identified by a brass ear tag. The lambs were weaned at 3-4 months of age. Thereafter, all ewe lambs were managed as a single unculled group until the end of the study. The rams used in the progeny test were retained for a further study, the detail of which has been described elsewhere (Xu *et al.*, 1991). Briefly, testis diameters of these rams were measured at 2-3 week intervals during the period from September 1988 to March 1989. On five occasions during this period (22 September 1988, 9 November, 1988, 21 December 1988, 2 February 1989, and 15 March 1989), the rams were blood sampled at 15 min intervals for 8 hours to measure basal LH and FSH concentrations. After the last sample was taken, each animal received an intravenous injection of synthetic GnRH at a dose level of 50 ng/kg liveweight to test the pituitary LH response to GnRH.

Oestrous detection

On 1 March 1989, the ewe hoggets were joined with vasectomized teaser rams fitted with mating harnesses to detect the date of onset of puberty (defined as the first overt oestrus) and the number of pubertal oestrous cycles. The colour of marking crayons was changed every two weeks and tupping marks were recorded weekly until 15 July 1989 (three weeks after the winter solstice), when fewer than 5% of the hoggets were still cycling. The animals were weighed on 16 April when the first hogget was observed to be marked.

For detection of the date of onset of the second (two-tooth) breeding season, the ewes were weighed and joined with 5 entire Perendale-Romney rams fitted with mating harnesses on 1 November, 1989. Tupping marks were recorded weekly until the end of April 1990 when all the ewes had been mated.

Statistical analyses

Records relating to the incidence of puberty during the first breeding season were coded as binomial data describing whether a particular hogget had reached puberty or not. The coded data were then analysed using an iterative weighted least squares procedure after logit transformation of the data (Gilmour, 1985). All other analyses were performed using the general linear models procedure of the SAS statistical package (Statistical Analysis System Institute, 1988). Data for number of pubertal oestrous cycles were subjected to the square root transformation (Steel & Torrie, 1980) before analysis in order to correct for lack of normality. For the purpose of statistical analyses, dates of onset of puberty and the second breeding season were coded as the number of days from a particular date. To enable the genetic effects of breed and sire within breed to be assessed independently of liveweight the general model fitted included, where appropriate, the non-genetic factors birth rank, date of birth, birth weight, and liveweight at the beginning of the breeding season. The genetic factors fitted in the model included breed as a fixed effect and sire within breed as a random effect.

RESULTS

Incidence of puberty

A total of 170 ewe hoggets (84 Romney and 86 Poll Dorset cross) were present throughout the first breeding season. Of these, 118 reached puberty during the first breeding season. The proportions of ewe hoggets that reached puberty during the first breeding season are presented in Table 1 for each sire. The first ewe hogget was observed to be marked on 16 April. There was a significantly ($P < 0.01$) higher proportion of Poll Dorset x Romney hoggets (79.6%) reaching puberty in the first breeding season than straightbred Romney hoggets (59.9%). The incidence of puberty was also affected by date of birth ($P < 0.05$) and April liveweight ($P < 0.01$). There was no significant effect of sire within breed on the proportion of hoggets reaching puberty during their first autumn.

Date and age at puberty

The mean date and age at onset of puberty for animals born to each sire are shown in Table 1. The date of onset of puberty was earlier ($P < 0.10$) for Poll Dorset x Romney hoggets than for Romney hoggets. There was also a significant ($P < 0.05$) effect of birth rank on the date of onset of puberty. The age at puberty was significantly affected by birth rank ($P < 0.01$) and date of birth ($P < 0.001$). Animals born as singles reached puberty earlier in the year and were younger at the time of puberty than those born as twins, even after adjustment for liveweight. Lambs born earlier in the season reached puberty at an older age than those born later. The difference between breeds in the age at puberty was marginally significant ($P < 0.10$). No significant effects of sire within breed were found.

Number of pubertal oestrous cycles

Among those hoggets that reached puberty during the first breeding season, Romney hoggets had fewer ($P < 0.05$) oestrous cycles than Poll Dorset x Romney hoggets (Table 1). There was also a marginally significant ($P < 0.10$) effect of sire within breed on number of oestrous cycles. Liveweight in April ($P < 0.05$) and date of onset of puberty ($P < 0.001$) had significant effects on the number of oestrous cycles. Those hoggets reaching puberty earlier in the season had more oestrous cycles than those reaching puberty later.

Table 1 Summary by breed and sire of the percentage of ewe hoggets reaching puberty during the first breeding season (%Pub), date of onset of puberty (Dof_1, 1 = 1 April), age at puberty (Age_Pub), number of pubertal oestrous cycles (No_Cycle) and date of onset of the second breeding season (Dof_2, 1 = 1 December).[1]

Sire breed	Sire	No.[2]	% Pub (days)	Dof_1 (days)	Age_Pub	No_Cycle (days)	Dof_2
Romney	1	11(2)	63.6	65 ± 5	284 ± 9	1.3 ± 0.2	93±10
	2	25(2)	68.0	49 ± 5	272 ± 6	2.2 ± 0.3	76 ± 8
	3	14(6)	50.0	45 ± 7	273 ± 6	1.9 ± 0.5	100 ± 15
	4	17(0)	47.1	47 ± 7	274 ± 7	2.4 ± 0.4	98 ± 9
	5	17(1)	70.6	56 ± 5	280 ± 5	1.9 ± 0.3	102 ± 9
Breed mean		84(11)	59.9	52 ± 3	276 ± 3	2.0 ± 0.2	92+4
Dorset	1	18(1)	83.3	46 ± 6	268 ± 6	2.3 ± 0.4	42±3
	2	14(0)	92.9	44 ± 6	265 ± 6	2.5 ± 0.3	54 ± 7
	3	19(0)	84.2	50 ± 4	272 ± 4	2.8 ± 0.3	43 ± 2
	4	17(1)	76.5	36 ± 6	253 ± 6	3.0 ± 0.5	43 ± 6
	5	18(0)	61.1	39 ± 7	258 ± 8	3.0 ± 0.4	53 ± 7
Breed mean		86(2)	79.6	43 ± 3	264 ± 3	2.7 ± 0.2	47=3

[1] Values presented are means ± SEM.

[2] Number of animals present during the first breeding season. Numbers in parentheses are the numbers of animals which died or were missing between the first and second breeding season.

Date of onset of the second breeding season

One hundred and fifty seven two-tooth (ca 18 months old) ewes (73 Romney and 84 Poll Dorset cross) were present at the second breeding season. The date of onset of the second breeding season was significantly ($P < 0.001$) earlier in Poll Dorset x Romney ewes than in straightbred Romney ewes (Table 1). The mean dates of onset of the second breeding season were 17 January for Poll Dorset x Romney ewes and 3 March for Romney ewes. There was also a significant ($P < 0.05$) sire within breed effect on date of onset of the second breeding season. Liveweight in November significantly ($P<0.01$) affected date of onset of the breeding season in Romney ewes (regression coefficient = -2.65 ± 0.90 days/kg liveweight), but not in Poll Dorset x Romney ewes (regression coefficient = 0.02 ± 0.27 days/kg liveweight). The date of onset of the second breeding season was not influenced by whether the ewe had reached puberty during the first breeding season.

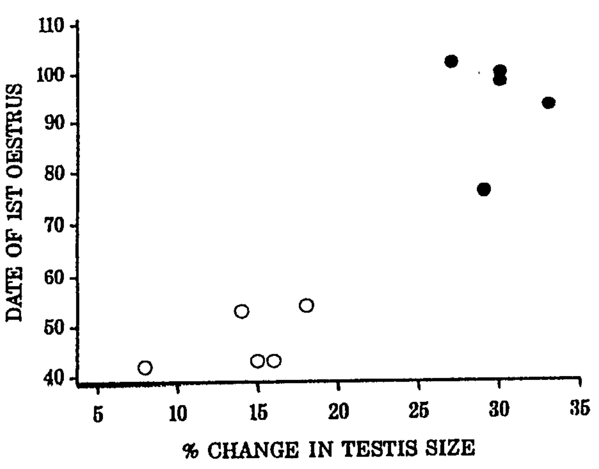
Correlation between sire traits and date of onset of the second breeding season

Since there were few significant effects of sire within breed on pubertal oestrous activity, only correlations with date of onset of the second breeding season were calculated. The seasonal variation in testis size, gonadotrophin secretion and pituitary responsiveness to GnRH has been described elsewhere (Xu *et al.*, 1991). Between breeds, the significant differences in date of onset of the second breeding season were associated with breed differences in the pattern of seasonal variation in testis size and plasma gonadotrophin concentrations. Compared with Romney rams, Poll Dorset rams exhibited:

a) Smaller magnitude of seasonal variation in testis size.
b) Less marked seasonal variation in LH pulse frequency.
c) An earlier increase in plasma FSH concentrations.

Notwithstanding these between-breed differences, the pooled within-breed correlation coefficients between dates of onset of the second breeding season and the magnitude of seasonal variation in testis size, LH pulse frequency and plasma FSH concentrations were 0.22, 0.12 and -0.32 respectively ($P > 0.10$). This relationship is illustrated in Figure 1 for percentage change in testis diameter.

FIGURE 1 Illustration of the relationship between the percentage of seasonal variation in testis diameter in the sire and the date of first oestrus (days from December 1) during the second breeding season in progeny of Romney (●) and Poll Dorset (○) sires.



DISCUSSION

The main objectives of this study were to investigate the within-breed genetic variation in pubertal oestrous activity and date of onset of the second breeding season, and to correlate the testicular and endocrine parameters in the sire with breeding performance of the daughters. As expected, this study found significant differences between Poll Dorset cross and straightbred Romney hoggets in the incidence of puberty, the date and age at puberty and the number of oestrous cycles during the first breeding season. Few sire within breed effects on pubertal oestrous activity were found. It is known that liveweight has a determinative effect on the onset of puberty (Ch'ang & Rae, 1970; Baker *et al.*, 1979; Quirke, 1979; Foster *et al.*, 1986). In the present study, the incidence of puberty and the number of pubertal oestrous cycles were significantly affected by liveweight at the beginning of the breeding season (fitted after breed in the model). Heavier hoggets were more likely to reach puberty during the first breeding season and had more oestrous cycles than lighter hoggets. Therefore, pubertal oestrous activity would not be an accurate predictor for early onset of the breeding season in adult ewes unless all confounding factors such as date of birth, birth rank, birth weight and nutritions were eliminated.

A large difference between Romney and Poll Dorset cross ewes in the date of onset of the second breeding season was observed. This agrees with other studies demonstrating the superior genetic merit of Poll Dorset animals for early onset of the breeding season (Kelly *et al.*, 1976; Knight *et al.*, 1989). Heterosis might also have contributed to the observed between-breed differences in pubertal oestrous activity and date of onset of the second breeding season (Hanrahan and Quirke, 1986), but this effect can not be quantified in the present study. The early onset of the breeding season in Poll Dorset x Romney ewes was associated with early but small increases in testis size, less marked variation in LH pulse frequency and early increases in plasma FSH concentrations during the transitional period from the nonbreeding to the breeding season in their Poll Dorset sires (Xu *et al.*, 1991). These results indicate that, at least in the between breed situation, seasonal variation in testis size and gonadotrophin secretion during the transitional period from the nonbreeding to the breeding season are good indicators of seasonality. However, these between-breed differences offer no guarantee of a cause and effect relationship and have to be verified in a within-breed situation (Blair *et al.*, 1990).

Within breeds, there were significant sire effects on date of onset of the second breeding season, indicating a within-breed genetic variation in this trait. This suggests that selection in the ram will lead to expected changes in the date of onset of the breeding season in their progeny. Unfortunately, unlike the between-breed situation, the within-breed correlations between date of onset of the breeding season in the ewe and the seasonal variation in testis size and gonadotrophin secretion in the sire were low and not significantly different from zero because of the small number of sires that could be tested in the present study. However, this situation does not mean that some of the physiological and endocrinological characteristics in the ram are not useful selection criteria for date of onset of the breeding season. Rams used in this progeny test were randomly selected from a commercial flock. Therefore, within-breed variation in date of onset of the breeding season was likely to have been small. More importantly, as these are phenotypic correlations (r_p), they are related to the genetic correlations (r_g) by the factor $0.5.h_{ram}.h_{ewe}$ ($r_p = 0.5.h_{ram}.h_{ewe}.r_g$), where h_{ram} is the square root heritability of the ram trait and h_{ewe} is the square root heritability of the ewe trait. Since both h_{ram} and h_{ewe} are less than unity, this means that a large genetic correlation is needed for the exhibition of a small phenotypic correlation. Because of this intrinsic low phenotypic correlation between a ram's trait and its offspring's reproductive performance, it follows that a large number of sires need to be tested before a significant phenotypic correlation can be obtained.

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