Segregation of a major gene influencing ovulation rate in progeny of Booroola sheep in commercial and research flocks

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ABSTRACT

Ovulation rate records from female progeny of 3 Booroola-type rams and the daughters of 8 to 10 male progeny of the same rams were recorded in commercial flocks. When a segregation criterion of at least 1 record of ovulation rate ≥ 3 was used to identify carriers of the putative gene, the results support the hypothesis of genetic segregation for fecundity in Booroola sheep.

A comparison of the genotype ascertained from progeny tests with that estimated from the parental genotypes showed that 21 of 22 rams' performance was consistent with a single gene effect.

Keywords Booroola; ovulation; sheep; breeding methods; animal breeding; progeny testing

INTRODUCTION

The hypothesis that the high fecundity of Booroola Merinos is influenced by a single gene with a major effect on fecundity was proposed by Piper and Bindon (1982 a, b). Other recent studies involving litter size and ovulation rate (OR) records of Booroola cross ewes (Davis *et al.*, 1981; Davis *et al.*, 1982; L. R. Piper and B. M. Bindon, pers. comm.) have further supported the single gene hypothesis. In these studies any F_1 observations have been limited to only the female progeny of a Booroola parent. The present paper is the first report where both the F_1 female and male progeny of Booroola rams have been studied to further test the single gene hypothesis.

MATERIALS AND METHODS

Two imported Booroola-type sires (75-1232, 75-1492) were single sire mated to Coopworth ewes on a South Otago property in 1978. The OR of female progeny of these sires and contemporaneously generated Coopworth controls was determined by laparoscopy once as two-tooths and again as four-tooths. On another South Otago property a third Booroola-type sire (77-358) bred in New Zealand was joined with Romney ewes in 1979. The ORs of female progeny of this sire and contemporary Romney controls were determined at the two-tooth and four-tooth stages. Each progeny group was segregated into carriers or non-carriers of the putative Booroola (F) gene according to the presence of absence of a record of OR ≥ 3 (Davis *et al.*, 1981). Data from ewes which had OR records at both observations are presented.

In 1980 eight F_1 sons of sire 75-1232 were single sire mated on 3 properties and the ORs of their two-tooth progeny and contemporary controls were recorded. Ten F_1 sons of sire 77-358 were single sire mated to Romney ewes on 1 property in 1980 and the ORs of their two-tooth progeny and contemporary Romneys were recorded.

In 1978 two F_1 sons of sire 75-1492 were single sire mated on 2 properties. A further 4 sons of 75-1492 were group mated in pairs on 2 properties and 4 group mated on another property. The ORs of hogget progeny of these rams and contemporary controls were recorded. One farmer only retained the progeny beyond the hogget stage, the others having culled the progeny on the basis of the hogget OR results.

RESULTS AND DISCUSSION

Table 1 shows that on the basis of the proportion of female progeny with at least 1 record of OR ≥ 3 sire 75-1232 would be classified as a homozygous carrier (FF), sire 77-358 a heterozygous carrier (F+) and sire 75-1492 a non-carrier (++). Because only 2 records of OR were available for each ewe it is probable that a few ewes carrying the F gene did not have a record of OR ≥ 3 and have been classified as non-carriers (Davis *et al.*, 1982). Also, the incidence of ewes with records of OR ≥ 3 in the control flocks (0.06 to 0.07) would suggest that a small number of ++ animals may be misclassified as carriers of the gene. Because these sources of error have opposing effects on the proportion observed to have at least one record of OR ≥ 3 they are likely to have only a small effect on the proportions in Table 1.

TABLE 1 Mean ovulation rate (± standard error) and proportion with at least 1 record of ovulation rate ≥ 3 in F_1 progeny of 3 Booroola rams.

Sire	*n*	Joining weight at 2.5 yr (kg)	Prop^n ≥ 3	Ovulation rate	
				Carrier	Non-carrier
75-1232	29	46	0.97	2.90 ± 0.10	—
Control	71	58	0.07	—	1.67 ± 0.05
77-358	58	49	0.52	3.24 ± 0.10	1.65 ± 0.06
Control	54	53	0.06	—	1.51 ± 0.05
75-1492	44	51	0.04	—	1.53 ± 0.06
Control	71	58	0.07	—	1.67 ± 0.05

The incidence of OR records ≥ 3 in all 8 progeny groups of F_1 sons of sire 75-1232 suggests that each son carried 1 copy of the F gene (Table 2). The proportion of progeny with a record of ovulation rate ≥ 3 ranged from 0.17 to 0.49 which is similar to the range 0.13 to 0.50 recorded at 1 observation of two-tooth progeny of 11 heterozygous rams on a Lands and Survey Department block at Hindon (R. W. Kelly, unpublished). Sire 75-1232 was classified as a homozygous carrier (FF) on the basis of his daughters' performance and the performance of the two-tooth progeny of the 8 F_1 sons supports this classification. The ORs of hogget progeny of a further 2 F_1 sons of sire 75-1232 have been recorded on a property in Manawatu (OR = 1.79 and 1.87 *v* control OR = 1.40) and suggest that they also were both carriers of the F gene (M. F. McDonald, pers. comm.).

Sire 77-358 was classified as heterozygous (F+) on his daughters' performance and therefore on average, half of his F_1 sons would be expected to carry the F gene. Results in Table 2 show that from the sample of 10 sons, 5 progeny groups had ewes with records of ≥ 3 ovulations (proportion = 0.13 to 0.37) whereas the other 5 progeny groups had no records of ≥ 3 ovulations. This result is consistent with the F+ classifiction of sire 77-358.

The 13 F_1 carrier sons of sires 75-1232 and 77-358 could only be heterozygous (F+) and thus in their progeny groups approximately 0.50 of the ewes should be carriers of the F gene. The lower proportions observed with ≥ 3 ovulations (0.17 to 0.49 and 0.13 to 0.37) probably result from only 1 observation of OR as other studies have shown only about 64% of carriers having a record of OR ≥ 3 at any 1 observation (Davis *et al.*, 1982). The proportion with ≥ 3 ovulations in each of the 13 progeny groups was within the 99% confidence interval for progeny of a heterozygous ram in a flock with an expression rate among carriers of 64%.

Sire 75-1492 was a non-carrier of the F gene according to the performance of his F_1 daughters (Table 1). Unfortunately most of the sons of this ram

TABLE 2 Mean ovulation rate and proportion of flock with ovulation rate ≥ 3 in progeny groups of F_1 sons of 3 Booroola sires (1 observation/ewe).

Two-tooth progeny of 8 sons of Booroola sire 75-1232 (FF)				Two-tooth progeny of 10 sons of Booroola sire 77-358 (F+)				Hogget progeny of 10 sons of Booroola sire 75-1492 (++)			
Sire	n	OR	Prop^n ≥ 3	Sire	n	OR	Prop^n ≥ 3	Sire	n	OR	Prop^n ≥ 3
A	16	1.88	0.31	I	19	2.16	0.37	1	15	1.07	0.00
B	11	1.73	0.27	J	12	1.83	0.25	Control	43	1.05	0.00
C	10	2.00	0.20	K	16	1.63	0.13				
Control	15	1.33	0.00	L	12	2.00	0.33	2	34	1.21	0.00
				M	17	1.94	0.24	Control	19	1.20	0.05
D	39	2.36	0.41	N	13	1.31	0.00				
Control	17	1.35	0.06	O	12	1.33	0.00	3-4	42	1.36	0.02
				P	12	1.50	0.00	Control	47	1.21	0.00
E	41	2.41	0.49	Q	18	1.39	0.00				
F	18	1.83	0.17	R	17	1.41	0.00	5-6	15	1.27	0.00
G	15	1.87	0.27	Control	15	1.33	0.00	Control	14	1.14	0.00
H	61	2.49	0.46								
Control	32	1.66	0.03					7-10	25	1.04	0.00
								Control	11	1.00	0.00

were group mated and their progeny were only available for hogget observations. However, within these limitations the mean OR of hogget progeny and the records of OR ≥ 3 do not show that any of the sons of 75-1492 carried the Booroola gene (Table 2). On 1 property the progeny of 1 son were retained and OR measurements on these animals as two-, four- and six-tooths showed only 1 of 16 with an OR record ≥ 3 (control = 1 of 42) confirming this ram as a non-carrier.

The transfer of the F gene has also been studied in 22 rams bred at the Tara Hills High Country Research Station. The possible genotypes of each ram had been determined from dam and sire genotypes, based on performance and progeny test records respectively. For the 22 rams, the OR records of their two-tooth progeny indicate that 5 rams are homozygous carriers (0.58 to 0.96 progeny with ≥ 3 ovulations) 8 rams heterozygous (0.13 to 0.40 progeny with ≥ 3 ovulations) and 9 rams non-carriers. A comparison of this genotype ascertained from progeny tests with that estimated from the parental genotypes (Table 3) shows that the performance of 21 of the 22 rams was consistent with a single gene effect. One ram was F+ from apparently non-carrier parents. However, the dam of this ram had only 3 observations of OR (2,2,1) and previous records at Tara Hills (Davis *et al.*, 1982) have shown that 5% of F+ ewes do not have a record of OR ≥ 3 after only 3 observations. It is therefore possible that this dam has been misclassified due to insufficient records.

TABLE 3 Genotype of 22 Booroola ram progeny from parents of designated genotype (expected number in brackets).

Parent genotype		Genotype from progeny test		
Sire	Dam	FF	F+	++
FF	FF	1 (1)	(0)	(0)
FF	F+	2 (2)	2 (2)	(0)
FF	++	(0)	3 (3)	(0)
F+	F+	2 (2)	2 (4)	4 (2)
F+	++)	(0)	(1.5)	3 (1.5)
++	F+)			
++	++	(0)	1 (0)	2 (3)

Results of this study of F_1 female and male progeny of Booroola rams and the performance of 22 inter-bred Booroola rams support the hypothesis of genetic segregation for fecundity in Booroola sheep. These results highlight the necessity for breeders to differentiate between progeny tested homozygous and heterozygous carrier rams. They also suggest that pedigree information may be a useful tool to estimate animal genotypes.

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