GENETIC RELATIONSHIPS BETWEEN MALE AND FEMALE REPRODUCTIVE TRAITS

by

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PREFACE

The work reported in this thesis was conducted by the author while in the Department of Animal Science at the University of New England under the supervision of Associate Professor T. N. Edey and Dr. L. R. Piper. The thesis has not been submitted in its present form or any other form, for a degree at any other University.

The experimental programme which investigated testicular diameter and serving capacity at Trangie Agricultural Research Centre was initiated by R. J. Kilgour and he was responsible for data collection in 1980 and 1981. Data on ovulation rate, from an investigation led by Drs. L. R. Piper and B. M. Bindon, has also been utilised in this study. With the exception of the above, information derived from the work of others has been acknowledged in the text and a list of such work is contained in the "References".

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- Dr. Laurie Piper, again, for teaching me that if there is a job to be done, rise early, do it quickly and with good humour, and then you will appreciate a wee drop at the end of the day.

SUMMARY

The suggestion by Land (1973) that it might be possible for genes with positive effects on female reproductive performance to be identified in males, has provided the stimulus for many studies in sheep populations throughout the world. The review of literature (Chapter 1) established, however, that these studies have largely been restricted to between-breed comparisons or within sheep populations which have been selected for components of reproduction rate. The review of literature also established that, although physiological and endocrine aspects of gonadal growth and function in rams has been extensively studied, relatively little research has been directed at sources of variation in male reproductive traits with a view to estimating genetic parameters. A similar situation was found when the literature relating to ram libido and serving capacity was reviewed.

The aim of the studies described in Chapters 3 and 4 of this thesis was to identify, in a large random breeding Merino flock maintained at Trangie, NSW, the sources of variation in measures of gonadal growth and serving capacity, and to estimate genetic parameters for these traits. Utilising appropriate variances from these studies and other sources, an investigation (Chapter 5) was conducted, aimed at quantifying the genetic relationship between male and female measures of reproductive performance.

The study described in Chapter 6 is the result of an investigation of a related aspect of male and female genetic relationships. Studies of rams of the Booroola strain of Merino, which largely owes its exceptional prolificacy to the segregation of a major gene (the *F* gene) affecting ovulation rate, have not been able to identify any aspect of

their phenotype which would allow prediction of the _F_ gene status. Reported in Chapter 6 are comparisons of a range of physiological and endocrinological traits in male crossbred Booroola and ordinary (Control) Merino genotypes.

The results of the study described in Chapter 3, of variation in testicular diameter (TDM) at ages between 4 and 19 months, showed again, the very large impact that the environment can have on physiological traits in areas such as Trangie, NSW, where the incidence and reliability of rainfall is low. TDM growth patterns were found to vary considerably between the 3 year-of-birth groups under study, to the extent that relatively frequent changes in the ranking of the TDM of the year-of-birth groups occurred.

Differences in TDM between animals born as singles or multiples were highly significant from 4 to 8 months of age, with singles having larger testes. Between 10 and 19 months of age differences between the two birth-type categories were not significant. Day of birth accounted for a significant component of variation in TDM at all ages between 4 and 19 months of age.

Four strains of Merino were represented by the rams in the study and, although significant differences in TDM between strains were found, these differences did not show a consistent pattern relative to heritability estimates, derived from the sire component of variance (sire degrees of freedom between 54 and 106) ranged between 0.22 ± 0.17 at 19 months of age and 0.75 ± 0.15 at 8 months of age, with the average value, weighted for the sire degrees of freedom, being 0.52. Genetic correlations between the 10 age-based TDM traits were all positive and relatively high and indicative of a large degree of common genetic control at all the ages under study. Likewise, phenotypic correlations were also positive, but showed a pattern of decreasing relationship with increasing time between ages.

Although a close genetic relationship was found between liveweight at weaning and TDM at 5 months of age (0.84 ± 0.18), the relationship was much lower (0.11 to 0.26) when the TDM measurement was taken at later ages. In contrast, liveweight at 12 months of age was relatively highly correlated genetically with TDM at all ages.

Testicular diameter at 4 specific liveweights (17, 23, 28 and 33 kg) was predicted by curvilinear regression techniques from the TDM and liveweight data. In contrast to the age-based measures of TDM, multiple-born rams had greater PTDM than those born in single litters. The heritability estimate of PTDM at 17 kg liveweight (0.34 ± 0.15) was lower than at 23, 28 (0.71 ± 0.17) and 33 kg (0.64 ± 0.17).

The study described in Chapter 3 suggests that, although testicular size is moderately to highly heritable once the masking effect of maternal influence is negated, environmental influences can have a significant influence on variation in gonadal size at all ages up to 19 months.

In Chapter 4, phenotypic and genetic variation in measures of libido and serving capacity in Merino rams aged 20 months, was examined. The rams utilised in the study of testicular size described in Chapter 3, together with another year-of-birth group of 231 rams from the same flock, formed the basis of the investigation. Each ram was given a series of 2 x 20-minute introductory and 2 x 1-hour pen-tests with oestrous ewes and observations on mounting and serving performance were made.

A feature of the study was the relatively high level of sexual inactivity among the rams. Of the 837 rams tested, 53.4% did not serve in the first 1-hour pen-test, 42.7% did not serve in the second test, and 37.9% failed to serve in either test. Mounting activity, but not service, was displayed by 21.1% and 23.3% of rams in the first and second tests, respectively. Analysis of the sources of variation in number of serves and index values (a parameter which took account of mounting and service activity), revealed year of birth (and measurement) to be highly significant for all measures. Significant variation in serving capacity was also detected between the lines and between birth-type classifications.

The repeatability of number of serves achieved in the first and second pen-tests was, overall, 0.54 ± 0.02. For the 520 rams which served in at least one of the two tests, the repeatability was 0.26 ± 0.04, whilst for the 318 rams which achieved at least one service in both tests, the repeatability was 0.30 ± 0.05. The sire component of variance, derived from the Least Squares ANOVA, was a negative value for 7 of the 8 measures of serving capacity. Half-sib heritability estimates ranged from -0.095 to 0.002 , and all had standard errors of greater magnitude than the estimates themselves. These results suggest that Merino rams raised under social and climatic conditions similar to those pertaining to this study, may not attain, by 20 months of age, a stability of serving performance in pen-tests which would allow accurate assessment of their serving capacity, both in terms of "current" and "future" flock evaluation.

Chapter 5 describes the results of a study, again with the random-breeding D flock, of the genetic relationships between ovulation rate

(OR) at 4 ages and male gonadal size (TDM) at 3 ages. The male animals were those born in 1979-1981 and utilised in the study of male gonadal traits reported in Chapter 3. Also involved in this investigation were their dams, born during the period 1975-1980, and the D flock female progeny born during 1979-1981. Genetic correlations (rg) between TDM and OR were estimated from dam-son phenotypic covariances derived by Least Squares ANOVA methods and from half-sib genetic covariances derived using Restricted Maximum Likelihood (REML) methods. In the former case data from approximately 450 dam-son pairs were utilised to calculate each of the 12 TDM-OR covariances. Genetic variances for TDM at 5, 8 and 12 months of age were taken from the study described in Chapter 3, and for OR at 18, 30, 42 and 54 months of age from (i) a study by Piper et al. (1984) on genetic variation in OR in the Trangie D flock (Source 1) and (ii) estimates generated by the paternal half-sib REML analyses in this study (Source 2). These two sets of genetic variances showed substantial differences for several of the female traits, despite being estimated from largely the same population. The 12 individual rg's were regarded as small sample estimates and were pooled, where appropriate across ages at OR measurement. For rg's calculated using Source 1 variances, this was appropriate only for those involving TDM at 12 months of age and yielded a pooled value of 0.21 ± 0.16. Using Source 2 genetic variances gave rg values of 0.38 ± 0.17, 0.31 ± 0.12 and 0.37 ± 0.14 between OR and TDM at 5, 8 and 12 months of age and an overall value of 0.35 ± 0.08.

Due to the computational requirements of the REML procedure, paternal half-sib rg's were initially estimated within year-of-birth groups. Pooling over years and then ages was then employed to obtain one overall value for the genetic correlation between OR and TDM. The value so obtained was 0.16 $\pm$ 0.11 which was not significantly different from the value obtained by the dam-son covariance analysis.

The experiments described in Chapter 6 utilized ram lambs, from a CSIRO crossbred flock, which had been characterised on the basis of their dams' strain and ovulation rate records as being carriers (F+) or non-carriers (++ or C) of the Booroola F gene. Comparisons between these genotypes allowed examination of whether the F gene status (F+ vs ++) or strain of Merino (B vs C) were correlated with measures of gonadal morphology, gonadal activity or plasma gonadotrophin concentrations. In Experiment 1 (lambs born in 1982) 7 ram lambs of each genotype were compared and in Experiment 2, 10 ram lambs of the F+ and C genotypes and 3 of the ++ genotype were compared.

The results of Experiments 1 and 2 re-affirmed earlier findings that testicular size at 8 to 12 months of age does not differ between crossbred Booroola rams with and without a copy of the Booroola F gene, nor does it differ between crossbred Booroola and Control Merino rams. Comparisons made in Experiment 2 extended this conclusion to include ages from 3 weeks to 8 months of age. Examination of testicular morphology, as measured by sperm per gram of testicular tissue, total testicular sperm reserves and seminiferous tubule diameter in the 21 rams, aged 9.5 months, from Experiment 1, established that the 3 genotypes also did not differ in these parameters.

Plasma FSH and LH concentrations were measured in the rams in Experiment 2, at 7 ages between 3 weeks and 8 months. At none of the 7 ages were differences between the 3 genotypes significant. Differences between genotypes in mean plasma LH were detected at 10 weeks of age, with ram lambs from the F+ group, having significantly lower concentrations than the ++ group. Examination of LH profile characteristics at this age, revealed that F+ rams, although not differing from ++ rams in basal concentrations or number of pulses in 8 hours, did differ significantly in maximum LH peak height. The F+ group had significantly smaller peak heights (4.8 ± o.4 ng/ml) than either the ++ group (20.2 ± 6.0 ng/ml) or the control group (15.6 ± 1.2 ng/ml).

Taken together, the results of the studies described in Chapters 3-5, show that selection of Merino rams on testicular size at 8-12 months of age will result in relatively rapid responses. Due to the positive genetic correlation between testicular size and ovulation rate, positive response could also be expected in the female trait. Further work is required to identify the optimum method of incorporating these traits in selection indices.

The study of the Booroola F gene in crossbred Booroola males has identified an endocrine characteristic, the magnitude of which may be correlated with F gene status. More detailed study of plasma LH profiles of similar genotypes at 8-12 weeks of age is required to test the validity of this finding.

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