HETEROTIC BASIS OF OVULATORY AND REPRODUCTIVE PERFORMANCE IN EWES OF THREE BREEDS

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SUMMARY

Variation in ovulation rate of ewes was studied with particular reference to the heterosis effect in a 3-breed (Dorset Horn, South Australian Merino, Corriedale) experimental sheep population. For the population as a whole, heterosis effect on the young (1 1/2 year-old) ewes (+0.17 ± 0.06** ova, or 14.5%) was similar to that on the mature (5 1/2 year-old) ewes (+0.19 ± 0.06** ova, or 12.5%), indicating that age of the ewe is of minor or no importance in heterotic variation of ovulation rate. However, some variation was present in the breed-specific estimates, notably for the Dorset Horn/Merino combination due largely to the fact that the mean ovulation rate of the purebred Dorset Horn ewes did not increase with age, as did all other breed-genotypes. This sheep population also provided data for study of variation in number of lambs born per ewe joined, or reproductive rate, at the 2 year-old lambing. The results showed that on average the F_1 crossbred ewes were higher in reproductive rate (+0.17 ± 0.07* lambs, or 26.2%) than their purebred contemporaries but no definite pattern is discernable from a comparison of corresponding heterosis effects on reproductive and ovulation rates of the primiparous 2 year-old ewes. The positive relationship between means of these 2 traits for the 9 breed-genotypes was clearly established.

INTRODUCTION

Utilisation of heterosis by crossbreeding to improve reproductive performance of the ewe for lamb production is an accepted industry practice in Australia. Heterosis, however, is a variable phenomenon whose effect on the ewe's reproductive rate may be modified by a number of factors including age and breeds of sheep (Nitter 1978; Ch'ang and Evans 1978). These same factors may also operate to modify heterosis effect on ovulation rate of the ewe, and some evidence for this suggestion was presented in an interim report by Bindon et al. (1978). The purpose of the present paper is: (i) to characterise heterosis effect on ovulation rate of young (1½ year-old) and mature (5½ year-old) ewes which are otherwise comparable, and (ii) using ovulation rate and reproductive rate data from the same ewes (primiparous 2 year-olds) to estimate comparative heterosis effect on these 2 traits.

MATERIALS AND METHODS

Source of data

The 9 breed-genotypes of ewes which provided the data for this study were generated using a 3 x 3 breed diallel-crossing design as part of the CSIRO Sheep Crossbreeding Experiment at Armidale, N.S.W. A description of the conduct and sheep management of the experiment has been detailed elsewhere (Ch'ang and Evans 1978); only those aspects of direct relevance to the present study will be mentioned here.

The purebred and F_1 crossbred ewe lambs born during the October/November lambing each year were all reared as flock replacements. Soon after weaning, vasectomised rams (2% - 3%) were grazed with the ewe weaners in an attempt to avoid or minimise the 'ram' effect on oestrous activity of these ewes. During

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the last week of March, or first week of April, laparoscopy was conducted over a 2 or 3 day period to assess ovulation rate of the young and mature ewes. The ovulation rate data were thus collected during the ewe's normal breeding season but prior to the scheduled annual flock joining in May each year. Following laparoscopy, all except the mature F_1 ewes were returned to the breeding flock in preparation for the annual joining. The reproductive rate data and pedigree information used in the study were collected daily during the lambing season (October/November) each year.

Statistical methods

(i) Ovulation rate of young and mature ewes The ovulation rate data were analysed by the least-squares method (Harvey 1964). The data from the 876 young ewes were treated separately from those of the 705 mature ewes but the same linear model was assumed to be applicable to each set of data. The model comprised an overall mean, year of observation (1977 to 1983, but not 1980 when no observations were made), ewe's own birth type (single or multiple), paternal (sire) breed of the ewe, maternal (dam) breed of the ewe, paternal x maternal breed interaction and a residual error term.

(ii) Reproductive rate of primiparous ewes The same linear model as for (i) above' was used to analyse the reproductive rate (number of lambs born per ewe joined) data of 665 primiparous 2-year old ewes except that an extra term, defined as the lamb's breed type (purebred or otherwise), was included to standardise the difference, if any, due to foetal genotypic effect on reproductive rate. This effect was non-significant and will not be mentioned further. The ovulation rate data of these primiparous ewes were analysed in the same way to provide comparative information on heterosis effect.

(iii) Linear functions All heterotic effects were evaluated by constructing appropriate linear functions of least-squares means of breed groups from each data set.

RESULTS AND DISCUSSION

The results of analysis of variance showed that the ewe's birth type effect was consistently non-significant in the data sets examined whereas, with few exceptions, all the other effects were significant or highly significant sources of variation.

The mean ovulation rates of the 9 breed-genotypes are presented in Table 1.

Table 1 Least-squares mean ovulation rate per ewe laparoscoped

Breed † genotype	1½ year old DH	1½ year old MO	1½ year old CO	1½ year old Paternal breed	5½ year old DH	5½ year old MO	5½ year old CO	5½ year old Paternal breed
DH	1.46	1.36	1.51	1.44	1.46	1.78	1.67	1.63
MO	1.25	0.83	1.18	1.08	1.58	1.31	1.67	1.52
CO	1.52	1.22	1.24	1.32	1.85	1.71	1.79	1.79
Maternal-breed	1.41	1.13	1.31	Over-all mean= 1.28	1.63	1.60	1.71	Over-all mean= 1.65
±SE Range	0.04-0.08	0.04-0.06	0.03-0.05	0.02-0.04	0.05-0.10	0.04-0.09	0.04-0.07	0.03-0.05

† DH = Dorset Horn, MO = Merino, CO = Corriedale.

The means for breed-genotypes in Table 1 are based on subclass numbers varying from 50 to 148 for the young ewes, and 43 to 122 for the mature ewes. The difference between the over-all means, in favour of the mature ewes (+0.37 ova/ ewe) is statistically significant and represents a 29% increase for the population as a whole. The results demonstrate that variation exists among breed-genotypes in ovulation rate increase between the 2 ages, ranging from no change for the purebred Dorset Horn, to +58% for the purebred Merino. While this difference between the Dorset Horn and the Merino ewes may be a consequence of the earlier sexual maturity in ovarian function of the former, further studies. would be required to confirm the suggestion.

The breed-genotype means of reproductive rate for the 2 year-old ewes and their ovulation rate at 1½ years of age are presented in Table 2.

Table 2 Least-squares mean of primiparous 2 year-old ewes

	(a) Ovulation rate				(b) Reproductive rate			
Breed † genotype	DH	MO	CO	Paternal breed	DH	MO	CO	Paternal breed
DH	1.53	1.47	1.54	1.51	0.81	0.85	1.02	0.89
MO	1.28	0.86	1.21	1.12	0.79	0.32	0.63	0.58
CO	1.58	1.20	1.30	1.36	0.92	0.70	0.83	0.82
Maternal-breed	1.46	1.17	1.35	Over-all mean= 1.33	0.84	0.63	0.83	Over-all mean= 0.76
±SE Range	0.05-0.09	0.05-0.08	0.04-0.06	0.04-0.05	0.07-0.12	0.06-0.10	0.05-0.08	0.05-0.06

† DH = Dorset Horn, MO = Merino, CO = Corriedale.
(a) Number of corpora lutea per ewe laparoscoped at 1½ years of age
(b) Number of lambs born (dead or alive) per ewe joined and present at lambing

The data in Table 2 showed that on a population basis, there is a considerable reproductive wastage between ovulation and the ensuing parturition at 2 years of age, if it is assumed that the mean ovulation rates for each breed-genotype studied remained unchanged between the time of laparoscopy, and that of actual mating. There is, however, a positive relationship between mean ovulation and reproductive rates for the 9 breed-genotypes in Table 2, demonstrating on a breed basis the well-known effect of ovulation rate on litter size in ewes (Hanrahan 1980).

The results presented in Tables 1 and 2 are summarised in terms of heterosis effect in Table 3.

Table 3 Estimates of crossbreeding genetic parameters

Heterosis effect (h^I) †	(a) Ovulation rate of ewes				Primiparous 2 year-old ewes			
	1½ year old		5½ year old		(a) Ovulation rate		(b) Reproductive rate	
	h^I	$\%h^I$	h^I	$\%h^I$	h^I	$\%h^I$	h^I	$\%h^I$
Population estimate								
Crossbreds minus purebreds	0.17**	14.5	0.19**	12.5	0.15**	12.2	0.17*	26.2
Breed specific estimates ††								
DH and MO	0.16**	14.0	0.30**	21.7	0.18*	15.1	0.25*	44.2
DH and CO	0.17**	12.6	0.13	8.0	0.14*	9.9	0.15	18.4
MO and CO	0.16**	15.5	0.14	9.0	0.12	11.1	0.09	15.7
±SE range	0.04-0.06		0.06-0.09		0.05-0.08		0.07-0.10	

*P<0.05; **P<0.01
† h^I = Mean of reciprocal F_1 crosses minus mean of purebreds in actual units
% h^I = (h^I X 100/mean of purebreds)
†† DH = Dorset Horn, MO = Merino, CO = Corriedale
(a) Number of corpora lutea per ewe laparoscoped
(b) Number of lambs born (dead or alive) per ewe joined and present at lambing

Although on a population basis, the F_1 crossbreds significantly exceeded their purebred contemporaries in both ovulation and reproductive rates, some variation due to the breeds is evident in estimates of heterosis effect. The enhanced heterosis effect of the Dorset Horn/Merino breed-combination at the 5½ years of age is due to the fact that the mean ovulation rate of the purebred Dorset Horn ewes did not increase with age, as did all other breed-genotypes (see Table 1). The present results when considered as a whole suggest that ovulation rate of the F_1 ewes studied is a moderately heterotic trait, averaging between 12 to 15% higher than the purebred population mean.

ACKNOWLEDGEMENT

Financial support provided for this project by the Australian Meat Research Committee is much appreciated.

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