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AGE AND BREED EFFECT OF RAM ON EWE'S REPRODUCTIVE PERFORMANCE

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SUMMARY

An experiment of factorial design, involving 1051 ewes and 30 rams of 3 different breeds (Dorset Horn, Merino, Corriedale), was conducted under grazing conditions in Armidale, N.S.W., Australia, to study the effect due to age of ram (1½- versus 2½-year-old) on ewe's performance during mating and ensuing lambing. In the Dorset Horn ram breed, the use of 1½-year-old rams resulted in lower rates of conception in the mated ewes compared with those mated to 2½-year-old rams. This age-of-ram effect did not occur in the Corriedale ram breed. In the Merino ram breed some evidence of an age-of-ram effect was found but the differences in lambing performance were not statistically significant. No evidence was found that occurrence of the age-of-ram effect, such as that observed in the Dorset Horn ram breed, had biased the estimate of maternal heterosis of the ewe's reproductive rate. Implications of these findings for sheep breeding practices are discussed.

INTRODUCTION

As a source of variation in sheep reproduction, the age-of-ram effect has been examined in a number of studies, mainly from the flock management point of view. For example, Lightfoot and Smith (1968) working with Merino sheep in Western Australia, and Allison (1978) using the New Zealand Romneys, have reported the occurrence of age-of-ram effects in relation to the changing ratios of number of ewes joined per ram under flock-mating conditions. The results from these and some other studies (Haughey, 1959; Mattner *et al.*, 1971, 1973; Croker and Lindsay, 1972) suggest that, as a limiting or depressive factor of the ewe's reproductive performance, the critical age for the ram is at the two-tooth or 1½-year-old stage.

The age-of-ram effect in the present study refers only to the difference between the 1½- and 2½-year-old rams of the same breed. In contrast with the studies mentioned above, the ratio of the number of ewes joined per ram was held, by design, as a constant, and the age-of-ram effect was investigated with specific reference to:

1. Its occurrence in each of three ram breeds (Dorset Horn, Merino and Corriedale) under purebred and crossbred mating conditions;
2. Its nature in terms of performance under the conditions of joining, and
3. The extent to which heterosis estimates for the ewe's reproductive rate may be biased by its occurrence.

The practical implications arising from the present study are therefore concerned mainly with the application of genetics to sheep breeding.

EXPERIMENTAL

DATA SOURCE AND ANIMAL MANAGEMENT

Sheep of the Dorset Horn, Merino and Corriedale breeds were maintained in a single management unit for studying the effects of crossbreeding on productivity under grazing conditions on the CSIRO property "Arding", located near Armidale, N.S.W., Australia. During phase 1 (1971 to 1973-4) of the experiment, purebred progeny of each breed and their contemporary reciprocal crossbreds between each pair of the breeds were produced every year based on a three-breed diallel mating design. In phase 2, commencing 1975, the daughter ewes of phase 1 were mated to purebred rams of the three breeds using an experimental design appropriate for the estimation of maternal heterosis (h^M , Dickerson, 1969) of reproductive traits of the F_1 hybrid ewes. The data used in the present study were obtained from this sheep breeding experiment in 1977.

In 1977, as in other years of the experiment, the ewes, allocated at random to individual rams, were mated in single-ram groups. For 1977 joining, each ram breed was represented by 10 rams (5 per age group) selected at random from the 1½- and 2½-year-old groups. A total of 1051 ewes were thus joined to 30 rams.

Within a given breed of ram, every mating group was standardized with respect to composition of ewes' age and breed and the number of ewes per ram. The actual numbers of ewes joined and present at lambing per mating group were 37 and 37 for Dorset Horn rams, 36 and 35 for Merino rams, and 31 and 30 for Corriedale rams of the 1½- and 2½-year-old age groups, respectively.

The rams were all fitted with marking crayons, and during the 5-week joining period from mid-May a daily record was kept

of the individual ewes marked by the rams. Lambing took place in October-November. All lambs born (dead or alive) each day were identified individually and their dams recorded; mortalities were noted. All sheep were treated alike in husbandry routines such as shearing, drenching, dipping, etc.

MATING DESIGN AND ANALYSIS OF DATA

Each ram in the present experiment was joined for mating with ewes of its own breed (P/P system), with ewes of the other two breeds (P/C system), and with the crossbred (F_1) ewes whose breed composition did not include the mating ram's own breed (C/C system). The experiment therefore has a factorial design comprising three main factors: ram's age (two levels), ram's breed (three levels) and mating system (three levels). This, among other things, enabled an assessment of the age-of-ram effect to be made simultaneously under purebred (P/P) and crossbred (P/C and C/C) systems of lamb production.

The ram was considered as the experimental unit in the analysis of data. Age of ram was nested within ram's breed. Two interaction terms were fitted (see Table 1). The method of least squares (Harvey, 1964) was used to estimate the constants. Linear functions from the least squares means were constructed to test the significance of differences between certain subclasses.

PERFORMANCE TRAITS

A total of five performance traits were used to characterize the age-of-ram effect in the data. Thus its effect on lambing performance of the ewe was measured in terms of two traits: the ewe's fertility and the incidence of multiple-birth. For present purposes both traits are expressed on the basis of 100 ewes (joined and present at lambing), and ewe's fertility refers to the number of ewes lambing, whereas multiple-birth is defined as twin- or triplet-birth.

The effect of the ram on ewe's lambing performance is probably produced during the joining period. In the analysis, two joining performance traits were used to examine the nature of age-of-ram effect. As a measure of the ram's libido under the conditions of joining, the number of different ewes marked per 100 ewes joined was used. A second joining performance trait was that based on the proportion (%) of once-marked ewes returning to service at the second oestrous cycle. This is a measure of age-of-ram effect on conception rate to first service.

The fifth trait was reproductive rate of the ewe, defined as the number of lambs born and reared to day 7, *post partum*, per 100 ewes joined and present at lambing. This was the only trait examined in relation to the effect which age of ram may have on maternal heterosis (h^M).

RESULTS

ANALYSIS OF VARIANCE

The results of analysis of variance for each of the five performance traits are presented in Table 1.

TABLE 1: MEAN SQUARES OF PERFORMANCE TRAITS

Source	d.f.	Ewes Lambing	Multiple Births	Ewes Marked	Return Rate	Reproductive Rate
Mating system (MS)	2	332.6**	205.9	32.7	16.0	2041.0**
Ram's breed (RB)	2	228.7*	141.7	116.6	98.7	1044.2*
Age of ram (AG):						
Within DH ¹ breed	1	1240.8**	505.5	159.6	532.5*	1338.5*
Within MO breed	1	267.6*	327.2	65.9	7.5	871.6
Within CO breed	1	151.7	11.2	52.2	23.6	11.0
Interactions						
(MS) × (RB)	4	209.0*	469.7*	73.8	22.3	838.3*
(MS) × (AG):						
Within DH breed	2	307.6**	53.9	16.4	25.5	549.0
Within MO breed	2	4.2	93.4	84.7	36.5	140.5
Within CO breed	2	185.9*	62.7	11.1	93.1	220.9
Remainder	12	43.5	139.0	58.6	69.4	243.8

¹DH = Dorset Horn; MO = Merino; CO = Corriedale.

The lambing traits (fertility, multiple-birth) and reproductive rate were significantly affected by the interaction between Mating System (MS) and Ram's Breed (RB). For these traits, the result implies the occurrence of joint effects and suggests that age-of-ram effect which is nested within Ram's Breed should be examined on a within-subclass basis.

AGE-OF-RAM EFFECT ON LAMBING PERFORMANCE

Lambing performance of the ewes joined to rams 1½ and 2½ years old is shown in Tables 2 and 3.

JOINING PERFORMANCE

Joining performance of the sheep is presented in Tables 4 and 5.

TABLE 2: LEAST SQUARES MEANS OF NUMBER OF EWES LAMBING/100 EWES JOINED AND PRESENT AT LAMBING ACCORDING TO RAM'S BREED AND MATING SYSTEM

<i>Ram's Breed and Age</i>	<i>P/P</i>	<i>P/C</i>	<i>C/C</i>
Dorset Horn			
1½ years	75.0	44.6	58.0
2½ years	80.0	89.7**	78.3*
Merino			
1½ years	59.1	60.0	81.1
2½ years	67.4	73.3	92.2
Corriedale			
1½ years	82.2	61.2	84.9
2½ years	84.4	85.5**	83.1
Standard error	9.3	6.6	6.6

TABLE 3: LEAST SQUARES MEANS OF NUMBER OF MULTIPLE BIRTHS/100 EWES JOINED AND PRESENT AT LAMBING

<i>Ram's Breed and Age</i>	<i>P/P</i>	<i>P/C</i>	<i>C/C</i>
Dorset Horn			
1½ years	38.9	21.2	23.4
2½ years	48.6	45.3	34.6
Merino			
1½ years	20.4	25.4	41.1
2½ years	20.9	37.5	64.7
Corriedale			
1½ years	46.7	30.6	45.5
2½ years	53.3	38.0	38.1
Standard error	16.7	11.8	11.8

TABLE 4: LEAST SQUARES MEANS OF NUMBER OF EWES MARKED/100 EWES JOINED

<i>Ram's Breed and Age</i>	<i>P/P</i>	<i>P/C</i>	<i>C/C</i>
Dorset Horn			
1½ years	95.0	80.4	79.0
2½ years	97.4	91.3	90.9
Merino			
1½ years	82.2	79.4	95.3
2½ years	86.0	94.7	92.3
Corriedale			
1½ years	95.6	88.7	93.2
2½ years	97.8	97.6	96.5
Standard error	10.8	8.3	8.3

TABLE 5: LEAST SQUARES MEANS OF NUMBER OF EWES RETURNING TO SECOND SERVICE/100 EWES MARKED

Ram's Breed and Age	P/P	P/C	C/C
Dorset Horn			
1½ years	28.9	29.7	24.6
2½ years	10.5	11.2*	15.4
Merino			
1½ years	13.5	11.4	12.8
2½ years	24.3	8.4	10.5
Corriedale			
1½ years	16.3	24.1	12.6
2½ years	15.9	10.0	17.4
Standard error	11.8	8.3	8.3

AGE-OF-RAM EFFECT ON MATERNAL HETEROSIS OF REPRODUCTIVE RATE

Maternal heterosis (h^M) of reproductive rate was estimated as a difference between the mean of reciprocal crossbred (C/C) and the mean of the corresponding purebred (P/C) ewes all joined to the same rams of a third breed and rearing crossbred lambs. The data used to compute maternal heterosis estimates are presented in Table 6.

TABLE 6: LEAST SQUARES MEANS OF NUMBER OF LAMBS BORN AND REARED/100 EWES JOINED AND PRESENT AT LAMBING

Ram's Breed and Age	P/P	P/C	C/C
Dorset Horn			
1½ years	77.8	58.5	76.6
2½ years	71.4	109.3**	105.3
Merino			
1½ years	65.6	70.8	103.8
2½ years	72.1	86.9	138.3*
Corriedale			
1½ years	115.3	77.8	117.8
2½ years	120.0	92.4	103.2
Standard error	22.1	15.6	15.6

The procedure used in computing maternal heterosis utilized only a part of the data (*i.e.*, crossbred lambs) in Table 6. This eliminates the complication due to difference in mortality which may exist between purebred and crossbred lambs. The difference in maternal heterosis between age groups within a ram's breed was tested against the standard error to determine the statistical significance. The results are summarized in Table 7.

TABLE 7: THE AGE-OF-RAM EFFECT ON MATERNAL HETEROSIS (h^M) OF EWE'S REPRODUCTIVE RATE (NUMBER OF LAMBS BORN AND REARED/100 EWES)

<i>Mating Ram's Breed</i>	<i>Ewe's Breed</i>	<i>2½ yr- 1½ yr</i>	<i>Statistical Significance</i>
DH	CO×CO, MO×MO, CO×MO, MO×CO	-22.1	n.s.
MO	DH×DH, CO×CO, DH×CO, CO×DH	18.1	n.s.
CO	MO×MO, DH×DH, MO×DH, DH×MO	-29.2	n.s.
	Standard error	22.1	

DISCUSSION

The age-of-ram effect represents only one aspect of the role which the male occupies in sheep reproduction. In the lamb production process the ram is a means to an end, and the causal relationship between its behavioural or physiological traits and lambing performance of the ewe is frequently difficult to demonstrate on a quantitative basis. The intention in the present experiment was to examine the age-of-ram effect under narrowly defined and rather specific conditions but, at the same time, to map its behaviour under contrasting sets of conditions with the objective of making some generalizations.

The pattern of results obtained from this study suggests that the age-of-ram effect on ewe's reproductive performance cannot be generalized. Not only is it likely to differ according to the performance trait used in its evaluation, but for a given trait its effect is subject to modification by the mating system involved (see Table 1). A detailed examination for an age-of-ram effect in the data was therefore made on a within-subclass basis, as in Tables 2 to 6. The implications of these results are discussed here with reference to some aspects of reproductive biology of the sheep and application of genetics to sheep breeding practices.

LAMBING PERFORMANCE

The age-of-ram effect was found to occur more frequently in relation to ewe's fertility (Table 2) than with respect to the incidence of multiple-birth (Table 3). A considerable range in the estimates of the age-of-ram effect on ewe's fertility was evident in Table 2. They ranged from a negligible value (1 or 2 ewes/100) for the Corriedale rams to a highly significant estimate of substantial magnitude (45.1 ewes/100) for the Dorset Horn rams in the P/C Mating System. In the Merino ram breed, estimates of the age-of-ram effect were all non-significant.

NATURE OF AGE-OF-RAM EFFECT

The possibility of depressed libido as a contributing or major cause of the observed age-of-ram effect on lambing performance was examined. The results presented in Table 4, based on the number of ewes marked by the ram, showed that the age-of-ram effect was non-significant for each ram breed, and its estimates, for different mating systems, were all relatively small. Thus libido depression was considered unlikely to be the critical factor involved. This finding is in agreement with the result reported by Kelly *et al.* (1975), who found no significant age-of-ram differences in New Zealand Romneys for either pre-joining libido testing or the actual mating performance under field conditions.

In the analysis of return rate data (Table 5), some differences between ages of ram, particularly for the Dorset Horn breed, were established. These results therefore were different from those based on the analysis of libido data. The mean return rates, in the Dorset Horn ram breed, for the 1½- and 2½-year-old rams ranged from 25 to 30% and 11 to 15%, respectively, resulting in approximately a twofold difference due to age. Differences similar to these, however, were not present in the Merino or the Corriedale ram breeds. It is worth noting that the interbreed difference in this trait (or other traits) could not be attributed to systematic nutritional or managemental treatment differences, as the rams used in the experiment were treated alike from birth. Therefore, failure of the 1½-year-old Dorset Horn rams to cause rates of conception in the marked ewes comparable with those achieved by the 2½-year-old rams is the most likely explanation for the age-of-ram effect on lambing performance. This is consistent with the observed reduction in ewe's fertility as discussed earlier. The particular physiological mechanism giving rise to the observed phenomenon in the Dorset Horn breed is unknown at present.

AGE-OF-RAM EFFECT ON MATERNAL HETEROSIS OF REPRODUCTIVE RATE

Maternal heterosis of reproductive rate is a genetic parameter of considerable practical importance. It is used in characterizing the effect of crossbreeding and for assessing the relative efficiency of alternative breeding programmes (Dickerson, 1973). There is a considerable amount of variation in the published estimates of heterosis in ewe's reproductive rate. Little published information, however, is available to indicate the nature of this observed

variation. According to McGuirk (1977), for a trait such as "number of lambs born per ewe joined" the published estimates of heterosis varied from -1.0 to 42.5% . A part of the variation may be attributed to sampling errors, but in a given set of data the occurrence of systematic errors or bias should not be overlooked.

The possibility that age-of-ram effects are a source of bias in estimated maternal heterosis of reproductive rate was examined. In Table 6 the age-of-ram effect was significant in certain subclasses (Dorset Horn, P/C, Merino, C/C) but not in others, thus indicative of bias. However, the results presented in Table 7 do not suggest that the age-of-ram effect was a source of systematic error in the estimate of maternal heterosis for sheep reproductive rate.

APPLICATION TO SHEEP BREEDING PRACTICES

The breeding practices used in the sheep industry may be classified as producing either purebred or crossbred lambs. In stud flocks producing purebred animals, rams of $1\frac{1}{2}$ years of age or younger are frequently used in preference to older rams. This practice is considered as a relatively simple means to increase the rate of genetic improvement from selection by reducing the generation interval on the sire's side. It is usually assumed that age-of-ram effect on reproductive rate is either absent or negligible. The validity of this assumption, however, requires experimental verification. The results in Table 6 (P/P) provide no evidence to discard this assumption for the Dorset Horn, Merino and Corriedale breeds.

The major role of the Dorset Horn in Australia and New Zealand is in siring crossbred lambs. As sires of crossbred lambs in the present experiment, the age of Dorset Horn rams significantly and substantially affected lambing performance (or reproductive rate) of the ewes joined to them. This finding contrasts with that for the same rams used to sire purebred lambs. Thus, even within the same set of rams, age-of-ram effect could not be generalized. To what extent the results of the present study, using single-ram mating groups, may be extrapolated to different joining situations is difficult to predict. However, in the interest of making continuing effort to improve reproductive efficiency for lamb production, further and close attention should be paid to this problem.

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