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LAMBING DATE AND LAMB PRODUCTION OF SPRING-MATED RAMBOUILLET, DORSET AND FINNSHEEP EWES AND THEIR F_1 CROSSES[1]

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ABSTRACT

The reproductive performance of 255 Rambouillet (R), Dorset (D), Finnsheep (F) and F_1 ewes born in 1978–1979 (group I) and 1979–1980 (group II) and managed in a semiconfinement fall/winter lambing system was evaluated through 4 yr of age of all ewes and through 5 yr for a portion of group I ewes. Ewes were with rams from approximately May 1 to late September each year, with a 2-wk break late in July/early August. Traits considered were fertility (ewes lambed/ ewes exposed), lambing date, litter size, lamb survivial and 70-d lamb weights. Breeds and crossbred groups differed significantly in lambing date, with DR crossbred ewes earliest and F ewes latest. Repeatabilities for groups I and II were .31 and .22, .24 and .24 and .11 and .07 for lambing date, fertility and litter size, respectively. There was no significant heterosis in lambing date, although DR ewes in both groups I and II were superior to (D+R)/2, by about 1 wk on average. There was significant positive heterosis for fertility and traits of which fertility is a component in FR ewes in group I, but none in group II. The FD ewes showed negative heterosis for litter size, −.23 ($P<.05$) for group I and −.09 for group II. The results indicate: 1) F and FD ewes are not well adapted to the Mediterranean climate where this experiment was conducted; 2) there is little, if any, useful heterosis in crosses among these three breeds for lambing date or other reproduction traits and 3) RD and R ewes are most suitable of the groups tested, while late onset of the breeding season limits the usefulness of even 50% Finnsheep ewes for an autumn lambing system in this environment.

(Key Words: Sheep, Breeding Season, Lamb Production, Repeatability, Heterosis.)

Introduction

Seasonal variation in reproduction in ewes represents a constraint to sheep production in environments where the pattern of forage growth favors fall lambing, and in many situations where market considerations favor lambing seasons other than spring. California, with a mediterranean climate, represents an important sheep producing area where autumn lambing is the goal of most producers.

The Rambouillet breed, of Merino origin, is one of the better breeds for early breeding, and this breed and the Targhee and Columbia derived from it, or crosses among the three, form the basis of most commercial ewe flocks in Western United States. However, in few, if any, flocks do all ewes show estrus in May and June, and even among ewes that mate at that time, fertility and twinning rates are lower than if mating is in late summer or fall. The result is a lambing season extended over several months, and relatively low lambing percentages. For mature Rambouillet ewes in Texas, Shelton and Morrow (1965) reported 84, 96, 127 and 135 lambs born per 100 ewes exposed in March, June, September and December, respectively.

The Dorset Horn breed enjoys a reputation for good out-of-season breeding performance, although this trait is less well documented for current strains of Polled Dorsets. The Dorset breed as a purebred lacks the hardiness, flocking instinct and fleece characteristics to be well adapted to many range environments, but

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Dorset-Rambouillet crosses have been reported to be superior to Rambouillet type ewes under spring mating management in Oklahoma (Thrift and Whiteman, 1969).

The ability of the Finnsheep breed to transmit prolificacy in an additive manner to its crossbred progeny is well documented (e.g., Donald et al., 1968; Dickerson, 1977). Summer breeding performance of the breed is generally not good, but Wheeler and Land (1977) have documented an extension of the mating season into April and May, and Walton and Robertson (1974) have reported good performance of Finnsheep ewes in accelerated lambing systems.

We report here an evaluation of the spring mating/autumn lambing performance of Rambouillet, Dorset, and Finnsheep ewes and their F_1 crosses under conditions of good nutrition in the central valley of California.

Materials and Methods

A total of 255 Rambouillet, Dorset, Finnsheep and F_1 ewes born in two consecutive lambing seasons, late 1978 and early 1979 (group I) and late 1979 and early 1980 (group II) was used for the experiment. The majority of the ewes in both years were born in January and February.

The Rambouillet (R) dams of Rambouillet and F_1 ewes were from the U.S. Sheep Experimental Station (USSES), DuBois, Idaho, and a few of their daughters. The eight rams of this breed that had daughters in the experiment included two rams from Texas, two from USSES, one from the USDA Meat Animal Research Center (MARC) and three produced in the flock. Dorset dams of Dorset (D) and F_1 experimental ewes were a group of 56 polled yearlings acquired in 1977 from the flock of George Nicholas, Sonoma, California. Parents of these ewes had come from several California and Midwest flocks. The 11 Dorset sires included three from MARC, two from different long-established California flocks and six born in the flock. The Finnsheep dams included two groups, one consisting of registered ewes descended from imported sheep and one group of high grades (7/8, 15/16 and 31/32 Finnsheep) bred in the University of California flock from a Targhee base. The 10 sires of experimental Finn (F) and F_1 ewes were all registered rams, and thus all Finnsheep ewes in the experiment carried at least 15/16 (or a higher proportion) of Finnsheep inheritance. The sires included one from a California purebred flock, two from MARC and seven bred in the flock from six different sires not including any of the three first-listed sires of experimental ewes.

Crosses were made reciprocally but reciprocal crosses (RD/DR, RF/FR and FD/DF) were combined in the analysis, as explained later, making for three purebreds and three F_1 groups (designated RD, RF and DF).

All ewes in each birth group (I and II) were managed as a single flock at the sheep facility on the Davis campus. The two age groups were combined at the start of the 1981 mating season. As lambs, the ewes were raised in drylot to weaning, then grown out on irrigated pasture their first summer. They were maintained on drylot throughout their reproductive life, except for occasional pasture grazing between weaning and next mating. Alfalfa, either hay or cubes, was the principal feed used, with the amount offered sufficient to keep them in good but not overfat condition. All ewes were weighed at the start of each mating season.

In both groups I and II, a random sample of the ewes in each breed or cross was mated or exposed to rams as ewe lambs (E1), beginning in October, with the remaining ewes left open their first year (E0).

A study of age at puberty and duration of the first and second breeding seasons was superimposed on the original experiment, using 48 ewes sampled from group II. Results of the puberty study have been published elsewhere (Quirke et al., 1985).

Beginning with their second season, most ewes from group I and samples of the ewes from group II were placed with groups of rams (treatment R1 in table 1) in April or May each year and usually left continually with the rams until late September, except for the period July 23 to August 8, to avoid lambing December 20 to January 1. Ewes in the puberty study, and some additional ewes in some years, were checked daily for estrus with vasectomized rams (treatment R0 in table 1) beginning on the date that rams were placed with the R1 group, and hand-mated as they came in estrus. Breed of service sire varied from year to year, but ewes in different breed groups were exposed to the same breed or breeds of rams within each year.

No culling of ewes was practiced until after lambs from the fourth lambing season of each age group were weaned, except for unsoundness (e.g., severe mastitis, prolapse or emaciation) or

TABLE 1. NUMBERS OF EWES BY *BIRTH GROUP*, PRODUCTION YEAR AND MATING TREATMENT[a]

	Group I (birth year 1978–1979)							Group II (birth year 1979–1980)									
		1979–1980[b]		1980–1981	1981–1982	1982–1983	1983–1984		1980–1981[b]		1981–1982			1982–1983		1983–1984	
												E1		E1		E1	
Breed[c]	N	E0	E1	E1/R1	E1/R1	E1/R1	E1/R1	N	E0	E1	E0	R0	R1	R0	R1	R0	R1
R	19	13	6	19	15	15	12	20	10	10	8	6	5	9	9	14	2
D	38	19	19	34	25	23	16	14	8	6	8	6		8	5	13	
F	19	8	11	18	16	12		18	12	6	9	5	4	9	7	13	
RD	16	10	6	16	15	15	14	29	12	17	8		17	8	14	12	8
RF	23	13	10	23	21	19	17	17	11	6	8		8	7	7	11	1
DF	24	12	12	24	23	20		18	12	6	8	6	4	9	9	12	4
Total	139	75	64	134	115	104	59	116	65	51	49	23	38	50	51	75	15

[a]N = no. of ewe lambs assigned to the experiment; E0 = ewes left open; E1 = ewes exposed; R0 = daily estrus check and hand-mating; R1 = ewes flock-mated (two or more rams per pen).

[b]Year of observation.

[c]R = Rambouillet; D = Dorset; F = Finnsheep; RD, RF, DF = F_1 crosses (reciprocals combined).

failure to lamb two consecutive years exposed (only six of the 255 were removed on the latter basis). All F and DF ewes of group I were eliminated after their fourth year, but ewes of the remaining four breed groups were kept to provide additional data on repeatability within birth group, and a comparison of birth groups I and II in 1983–1984.

Numbers of ewes by birth year, breed group, mating management treatment and production year are presented in table 1.

Lambs were weighed and weaned at 60 to 74 d of age, and their weights adjusted to 70 d by linear interpolation between birth and weaning weights.

Data Analyses. Data on performance at 1 yr were excluded from the main analyses because age at puberty and date of introduction of the rams precluded combining these with later years' data for comparison of lambing dates or effect of season on litter size.

Data on groups I and II were analyzed separately throughout because of the differences in mating management described earlier, and the unavoidable confounding of birth year and age in each production year. Nevertheless, to study cumulative distributions of lambing date based on a large sample size and no trend differences between groups, data from both birth groups were combined.

A preliminary test, to determine the magnitude of differences between reciprocal crosses, was performed on the averages of all traits involved in the experiment. Because such differences were consistently nonsignificant (P>.05), each set of reciprocal crosses was pooled and treated as a single crossbred group.

Table 2 includes a list of the traits analyzed and those effects that were presumed to contribute to variability in these traits. In addition to the traits listed, the effect of birth date of the ewes within group I, which had a wider range in birth date than in group II, was also examined. Only one trait was affected by this variable, and it is therefore not listed in table 2.

Estimation of fixed effects was made by least squares. Best linear unbiased estimators (B.L.U.E.) of differences among the levels of a given fixed effect were then obtained by subtracting the least-squares solutions of those levels from a selected reference group. Estimates of repeatability (r) were computed as the intraclass correlation after application of Henderson's method 3 to estimate the corresponding variance components. The contribu-

TABLE 2. TRAITS AND MODEL EFFECTS INVOLVED IN THE ANALYSIS

	Model effects[a]								No. of	
Traits	Year (i)	Status (j)	Breed (k)	Management (l)	Lambing date (m)	TBR (n)	Sex (q)	Animal within breed	Ewes	Records
Lambing dates										
Group I	x	x	x					x	128	369
Group II	x	x	x	x				x	101	226
Fertility										
Group I	x	x	x					x	134	407
Group II	x	x	x	x				x	105	246
Litter Size										
Group I	x	x	x		x			x	128	369
Group II	x	x	x	x	x			x	101	226
Lambs weaned										
Singles	x	x	x		x					227
Multiples	x	x	x		x					302
Total lamb weaned (kg) per										
Ewe exposed										
Group I	x	x	x							395
Group II	x	x	x							243
Ewe lambed										
Group I	x	x	x		x					359
Group II	x	x	x		x					220
Individual lamb weaning weights										
Group I	x		x		x	x	x			483
Group II	x		x		x	x	x			285

[a]Year of observation (excluding the first; i): i=1,2,3,4 and i=1,2,3 for groups I and II, respectively. Status of ewes in the previous year (j): lambed (j=1); exposed but failed to lamb (j=2); not exposed (j=3). Breeds (k): Rambouillet (k=1); Dorset (k=2); Finn (k=3); Rambouillet X Dorset (k=4); Rambouillet X Finn (k=5); Dorset X Finn (k=6). Estrus check and hand-mating (l): (l=1) or flock-mating only (l=2). Lambing date (m): before December 1 (m=1); December 1 to December 31 (m=2); after December 31 (m=3). Type of birth and rearing (TBR;n): singles reared as singles (n=1); multiples as singles (n=2); multiples as twins (n=2). Sex of the lamb (q): female (q=1); male (q=2).

tion that a ewe (animal in table 2) within a breed made each year was considered the random component of a mixed model such that the variance of an individual observation is Vy = Va + Ve; with y representing that observation, and a and e the animal and residual random effects, respectively. Thus, r = Va/Vy.

Results and Discussion

Ewe Body Weights. Body weights, as an indication of the general condition of the ewes, are shown in table 3. Finn ewes tended to be lighter than other groups, and Rambouillets and both Rambouillet crosses heavier. Weights of Dorset ewes as a percentage of weights of Rambouillets, 104 and 92% in the two groups at 4 yr of age, were higher than the 80% reported by Dickerson (1977) for ewes of similar ages.

Persistency. The culling policies followed were such that any difference in the number of records contributed by the breed groups and in the proportion of ewes remaining in the flock should reflect differences in persistence and viability of the groups. Differences among the average number of records per ewe and breed, as summarized in table 4 by birth groups, were relatively small. Breed differences in persistency were inconsistent in the two groups but, on average, crossbreds (83%) were superior to purebreds (74%) in percent ewes remaining in the flock after 4 yr, and pure Finn ewes were lowest. A similar conclusion for ewes with Finn background under an accelerated lambing system in Virginia has been documented by Notter and Copenhaver (1980).

The lower average number of records per ewe in group II is explained by the fact that a sample of these ewes were left open for two consecutive years (treatment E0 in table 1).

Lambing Performance

The analysis of factors with potential effects on lambing performance is reported in table 5, where the statistical significance of the causes of variation is summarized with the B.L.U.E. of deviations from a selected level (bracketed in the table) in each class. In addition, raw means of the performance of each of the breed groups are presented in table 6.

Lambing Dates. The cumulative distributions of lambing dates of purebreds and F_1 crosses, combining both birth groups, are plotted in figure 1. In addition, table 7 provides information relative to selected distributional percentiles and statistics.

Differences among the breed and crossbred groups in lambing dates were significant in both birth groups (table 5). Finn and Finn crosses

TABLE 3. WEIGHTS (KG) OF RAMBOUILLET, DORSET, FINNSHEEP AND F_1 EWES

Item	Years				
	1979–1980	1980–1981	1981–1982	1982–1983	1983–1984
Group I					
R	39.4 (15)[a]	42.9 (18)	50.7 (15)	53.8 (13)	62.1 (12)
D	39.4 (37)	44.0 (35)	48.1 (28)	55.7 (23)	60.9 (18)
F	31.8 (19)	39.4 (18)	42.2 (16)	43.7 (12)	
RD	36.3 (15)	43.7 (16)	50.2 (15)	56.9 (15)	62.9 (15)
RF	36.3 (21)	44.3 (22)	49.0 (21)	53.7 (19)	58.1 (17)
DF	33.6 (23)	40.8 (22)	46.7 (23)	52.5 (20)	
Date	10/12/79	4/22/80	5/9/81	5/6/82	4/4/83
Group II					
R		38.2 (19)	41.1 (11)	53.2 (17)	59.3 (15)
D		39.3 (13)	41.2 (6)	49.1 (13)	51.6 (13)
F		32.2 (18)	34.1 (9)	45.6 (15)	52.6 (14)
RD		40.2 (29)	43.6 (25)	51.5 (22)	56.4 (21)
RF		36.3 (17)	41.9 (16)	49.1 (14)	56.8 (13)
DF		36.2 (18)	41.1 (11)	49.3 (18)	53.8 (16)
Date		10/6/80	5/9/81[b]	5/6/82	4/4/83

[a]Numbers of observations given in parenthesis.

[b]Weights of R, D, F and DF ewes left open not recorded.

TABLE 4. NUMBERS (N) OF RAMBOUILLET, DORSET, FINNSHEEP AND F_1 EWES PROVIDING RECORDS ON FERTILITY, LAMBING DATE AND LITTER SIZE AT 2, 3 AND 4 YR OF AGE

Breed	Fertility				Lambing date and litter size				Ewes remaining at age 4	
	I[a]		II[a]		I		II		I	II
	NR[b]	NR/N[c]	NR	NR/N	NR	NR/N	NR	NR/N	NS/N[d]	NS/N
R	48	2.53	46	2.30	47	2.61	41	2.05	.79	.80
D	81	2.13	31	2.21	77	2.03	28	2.00	.60	.93
F	45	2.37	36	2.00	34	1.79	33	1.83	.63	.72
RD	45	2.81	57	1.96	46	2.87	54	1.86	.94	.69
RF	63	2.74	34	2.00	61	2.65	32	1.88	.83	.71
DF	66	2.75	42	2.33	52	2.36	38	2.11	.83	.69
Total	348	2.50	246	2.10	317	2.28	226	1.93	.75	.77

[a]I and II = ewes born in 1979–1980 and 1980–1981, respectively.
[b]NR = Number of records.
[c]NR/N = No. of records per ewe assigned.
[d]NS/N = Ratio of surviving ewes to ewes assigned.

lambed generally later, and Dorset × Rambouillet ewes were earliest of these six genotypes.

Considering all groups, about one-half of the Rambouillet and Dorset ewes lambed by January 10 to 14, whereas Finn ewes did not lamb on average until 16 to 20 d later. A difference of approximately 11 to 14 d was still evident when 95% of the flock had lambed (table 7 and figure 1). Very few Finn ewes lambed before January 1.

The influence of crossing Finn with Dorset and Rambouillet breeds is clearly evident in figure 1 and table 7. Finn crosses tended to lamb at least 8 to 11 d earlier on average than pure Finn ewes. A similar trend can be observed comparing the percentage of ewes lambed by November 30 or December 31. Inspection of the coefficients of variation in table 7 suggested that such changes in means were not accompanied by important changes in the variance.

Effects due to year of observation in both birth groups and due to estrus checking followed by hand-mating, in ewes born 1979–1980, were significant (table 5). Years 1980–1981 and 1981–1982 were "late" and "early" years, respectively. The reasons for this are not known. Year effects of similar magnitude with differences up to 31 d between years in lambing dates were reported for Southdown sheep by Thrift et al. (1971).

Ewes checked daily for estrus (group II) lambed 15 d later than their counterparts in pens with rams, suggesting that the continuous presence of rams stimulated onset of the breeding season, as documented in the literature (Edgar and Bilkey, 1963).

The estimates of breed group effects differed considerably for the two birth year groups, (table 5), in particular for Finnsheep ewes and their crosses. The reasons for this birth year × breed interaction are not known. Only 10 group II ewes were sired by rams with daughters in group I, but the dams of the two birth groups were essentially the same set of ewes. Thus genetic differences between the two groups are unlikely to account for very much of the observed interaction.

The period in which a ewe was born had a significant effect on her own lambing date. Ewes born early in the lambing season (September to December) tended to lamb 12 to 17 d earlier than those born later (January to June),

TABLE 5. LAMBING PERFORMANCE AND ITS REPEATABILITY FOR RAMBOUILLET, DORSET, FINNSHEEP, AND F_1 EWES AT 2, 3, AND 4 YR OF AGE

Item	Lambing date		Fertility (%)		Litter size	
	I	II	I	II	I	II
Breeds	*	*	*	NS[b]	*	*
[R][a]	0	0	0	0	.00	.00
D	+ 4	+ 1	− 2	+ 3	+.31	+.16
F	+56	+ 8	−24	+ 4	+.79	+.66
RD	− 3	− 9	+ 1	+ 5	+.20	+.10
RF	+22	+ 5	− 3	+ 5	+.45	+.33
DF	+24	+ 8	−17	+ 2	+.32	+.35
Year	*	*	*	NS	*	*
1980–81	+10		+ 9		−.15	
1981–82	−32	− 5	+ 7	+ 1	−.32	−.42
[1982–83]	0	0	0	0	.00	.00
1983–84	+ 1	−22	− 4	− 6	+.28	+.09
Status in previous year	NS	NS	*	*	NS	*
[Lambed]	0	0	0	0	.00	.00
Failed to lamb	+11	+ 2	−30	−19	−.31	−.09
Not exposed	+ 5	0	− 4	− 2	+.04	+.32
Management		*		NS		NS
[With rams]		0		0		.00
Estrus check, hand-mated		+15		− 2		+.01
Lambing date					*	NS
[Before Nov. 30]					.00	.00
Dec. 1–Dec. 31					−.03	+.38
After Dec. 31					+.24	+.32
Repeatability	.31	.22	.24	.24	.11	.07

[a]In brackets: the reference level from which deviations were taken.

[b]NS = nonsignficant.

*P<.05.

although this trend was not as evident as the ewes became older.

Repeatability for lambing date differed somewhat between birth groups, .31 for group I ewes and .22 for group II ewes. In contrast, estimates of residual variance were fairly consistent (Ve = 686 vs Ve = 680). Thrift et al. (1971), estimated the heritability of lambing dates in Southdown ewes under a spring lambing program to be .21. It seems possible that much of the present repeatability estimate is due to the genetic component.

Fertility. Fertility values as presented in table 5 were calculated as the percentage of ewes exposed that lambed.

Differences due to breeds were apparent only in the 1978–1979 group (P<.05). Finns and Finn crosses had lower fertility in this group. It is believed this is a reflection in part of their late onset of estrus because rams were removed in late September, and some ewes had apparently not cycled by then. This result agrees with other fall-lambing evaluations (e.g., Thomas and Whiteman, 1979). A high incidence of respiratory problems in Finn ewes may also have contributed to their relatively poor performance.

Ewes that fail to lamb in any year tend to have lower fertility in the following year (P<.05), as can be observed in table 5. It is not known yet whether this might be due to chronic health problems, or to real genetic differences in fertility.

As concluded by Edgar and Bilkey (1963), fertility did not seem to be influenced by managing the ewes with rams continuously or under estrus checking and hand-mating (P>.05). Litter size also was not affected.

The repeatability of fertility (r = .24 in both groups) was higher than estimates reported in other studies (Shelton and Menzies, 1970; Clarke and Hohenboken, 1983). The difference

TABLE 6. AVERAGES OF LAMBING AND POST-LAMBING PERFORMANCE OF RAMBOUILLET, DORSET, FINNSHEEP AND F_1 EWES AT 2, 3, AND 4 YR OF AGE

Item	Lambing dates		Fertility, %		Litter size		Birth type (%)		Litter weaned		Total weight of lambs weaned/ ewe exposed (kg)	
	I	II	I	II	I	II	S[a]	M[a]	S	M	I	II
R	Dec. 27	Jan. 15	98	89	1.27	1.33	71	29	.91	1.61	23.2	20.0
D	Jan. 1	Jan. 18	95	90	1.52	1.57	51	49	.84	1.61	21.3	21.4
F	Feb. 18	Jan. 23	76	92	2.06	2.12	18	82	.75	1.65	17.6	22.2
RD	Dec. 24	Jan. 2	98	95	1.46	1.42	59	41	.88	1.73	24.6	20.9
RF	Jan. 17	Jan. 18	95	94	1.77	1.69	36	64	1.00	1.65	25.6	20.8
DF	Jan. 18	Jan. 24	81	90	1.55	1.74	44	56	.82	1.60	16.1	21.6
Ewes	128	101	134	105	128	101						
Records	369	226	407	246	369	226	277	302	277	302	395	243

[a] S and M groups lambed as singles and multiples, respectively.

might be due either to a different date of onset of the breeding season of different experiments or to methodological consequences of analyzing a binary trait with the present technique.

Litter Size. As expected, Finns and Finn crosses had significantly higher litter sizes (table 5), whereas Rambouillets ranked lowest. The average prolificacy of Finns is shown in table 6, which presents the percentage distribution of single and multiple births. In fact, the mean litter size of Finn and Finn cross ewes was lower than reported from most other studies involving this breed. This is probably attributable, at least in part, to the fact that litter size in this experiment was measured following mating at the first estrus of the season.

It is interesting to notice that an "early" year, such as 1981–1982, contributed to a pronounced drop in litter size. In addition, the inclusion of lambing period in the model, as a seasonal effect, showed that ewes lambing in January tended to have higher litter sizes than those lambing October to December (.24 more lambs, table 5). Notter and Copenhaver (1980) observed a similar trend in Finn cross ewes under an accelerated lambing program, where January lambing produced .38 more lambs than those occurring in September.

Ewes that failed to lamb in the previous year tended to have lower litter sizes and, as mentioned before, lower fertility, in spite of a later lambing (table 5).

Repeatability of litter size was found to be consistent with the reports of other studies (Notter, 1981). The magnitude of estimates of residual variance were relatively similar in both birth groups (Ve = .241 and Ve = .291 for ewes born 1978--1979 and 1979–1980, respectively.

Performance Post-Lambing

Lambs Weaned Per Ewe Lambed and Total Weight of Lambs Weaned. Due to the close relationship of the number of lambs weaned with type of birth, the analyses were carried out within types, i.e., whether the ewes gave birth to singles or multiples. Records of groups I and II were combined in studying this trait.

Post-lambing performance reflecting maternal ability is summarized in table 8 in terms of deviations; raw means appear in table 6.

Among the purebreds, Rambouillet ewes weaned a higher percentage of single-born lambs than did Finns, the poorest performers. This ranking was reversed for lambs born as multiples. Lambs from RF ewes had the best

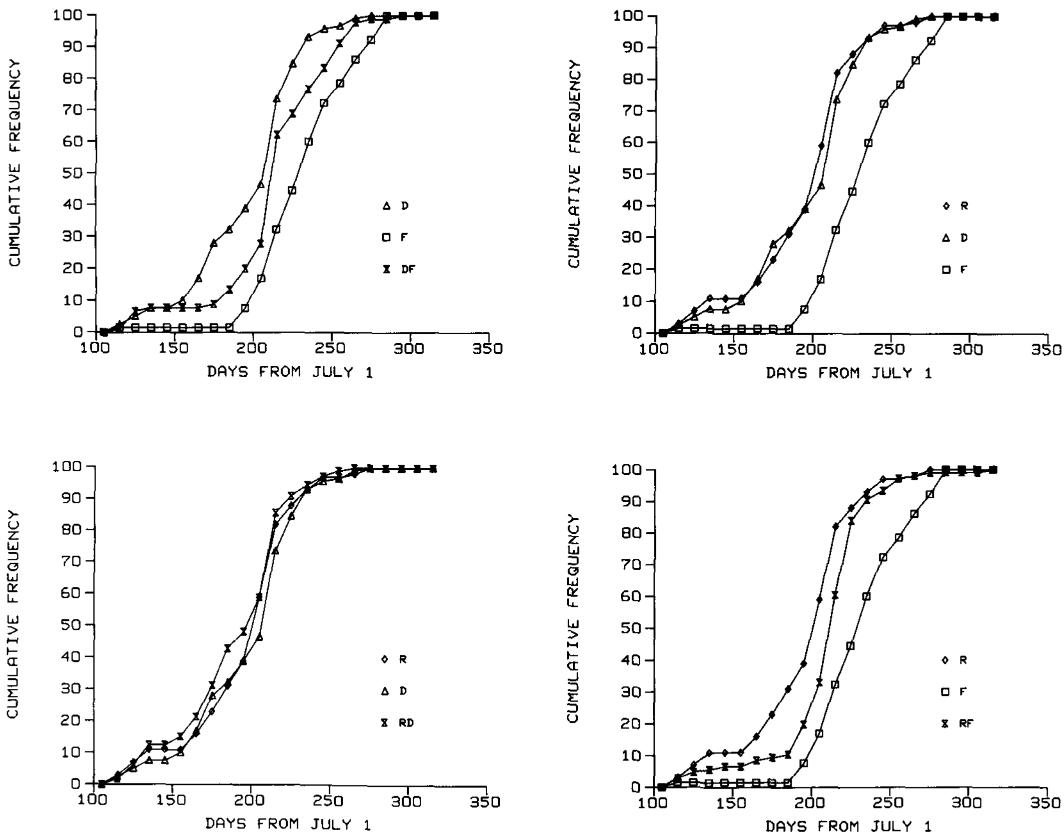

Figure 1. Cumulative distribution of lambing dates at 2, 3 and 4 yr of age for Rambouillet (R), Dorset (D), Finnsheep (F) and F_1 crossbred ewes.

TABLE 7. PERCENTILES AND STATISTICS OF THE CUMULATIVE DISTRIBUTIONS OF LAMBING DATES

Item	Breeds					
	R	D	F	RD	RF	DF
Percentile						
50	Jan. 10	Jan. 14	Jan. 30	Jan. 6	Jan. 22	Jan. 20
70	Jan. 18	Jan. 22	Feb. 7	Jan. 20	Jan. 28	Jan. 24
95	Feb. 13	Feb. 10	Feb. 24	Feb. 6	Feb. 17	Feb. 18
100	Feb. 22	Feb. 23	Feb. 28	Feb. 25	Feb. 27	Feb. 28
Lambed by:						
Nov. 30	15	14	5	17	8	12
Dec. 31	34	39	7	42	13	21
Average	Jan. 1	Jan. 1	Jan. 23	Dec. 29	Jan. 15	Jan. 12
C.V.[a], %	18	18	16	18	14	17

[a]C.V. = coefficient of variation.

TABLE 8. POST-LAMBING PERFORMANCE OF RAMBOUILLET, DORSET, FINNSHEEP AND F_1 EWES

Item	Lamb survival		Total weight of lamb weaned per ewe lambed (kg)		Total weight of lamb weaned per ewe exposed (kg)	
	Singles	Multiples	I	II	I	II
Breed	*	*	NS[b]	NS	NS	NS
[R][a]	.00	.00	.0	.0	.0	.0
D	−.08	+.14	− .1	+1.2	−1.1	+ .7
F	−.12	+.15	+2.4	+2.0	−4.4	+2.1
RD	−.06	+.17	− .7	+1.0	+1.3	+ .6
RF	+.15	+.12	+4.2	+ .2	+2.3	+ .5
DF	−.07	+.10	+ .10	+2.1	−5.6	+1.3
Year	NS	NS	*	*	NS	*
1980–81	−.12	−.37	−6.5		−3.4	
1981–82	−.03	+.05	−3.7	− .3	−1.5	−3.2
[1982–83]	.00	.00	.0	.0	.0	.0
1983–84	+.05	+.09	+3.3	+8.7	+2.3	+6.1
Status in previous year	NS	NS	NS	NS	*	NS
[Lambed]	.00	.00	.0	.0	.0	.0
Failed to lamb	+.17	−.40	−4.8	+ .2	−10.1	−3.4
Not exposed	+.11	−.12	+ .5	+1.5	− .8	+.2
Lambing date	*	NS	NS	NS		
[Before Dec. 1]	.00	.00	.0	.0		
Dec. 1–Dec. 31	−.04	−.12	+2.0	+3.2		
After Dec. 31	−.19	−.06	− .5	+1.8		
Residual variance			126	128	157	168

[a]In brackets: the reference level from which deviations were taken.

[b]NS = nonsignificant.

*P< 05.

survival considering both birth types. Dorset ewes were intermediate and, in both classes, not better than Rambouillet crosses. The average number of lambs weaned by litter size is presented in table 9. Differences in survival between singles and twins agree closely with a general estimate based on differences between these two birth types in birth weight (Bradford, 1985). A low average survival for triplets, as well as a poor performance of lambs from Finn dams, is also evident in table 9.

Total weight of lambs weaned per ewe exposed is a measure of the overall performance of ewes. Breed differences were not significant in either group I or group II (table 8).

Year effects in this study are confounded with age of ewe effects. Years did not influence the number of lambs weaned (P>.05). A nonsignificant influence of years and age on the number of lambs weaned was also reported by Hohenboken et al. (1976) for spring lambing conditions in Oregon. Contrastingly, year effects contributed to differences (P<.05) in the total weight of lamb weaned per ewe lambed and, among group II ewes, per ewe exposed.

Lamb survival was higher earlier in the year than later. The difference was significant for ewes with singles. The reason for this might be poorer environmental conditions (wetter weather, mud and competition in the barn) to which late lambs are exposed. The trend was less clear for ewes with multiples, but there were few early multiples.

The results in table 8 show that fewer lambs and less total lamb weight are weaned by ewes failing to lamb in the previous year.

Individual Lamb Weaning Weights. Results of the analyses of individual lamb weaning weights adjusted to a 70-d basis, are included in table 10. These results were obtained by the model in table 2 that does not contain breed of the sire, a factor that was not completely crossclassified with years.

Breed of the dam was an important source of differences (P<.05) among lambs born to group I ewes. Finnsheep ewes weaned lambs that were 9 to 12% lighter than lambs weaned by other breed groups. Thus total weight of lambs weaned per ewe exposed in Finnsheep is not only a reflection of poor fertility, as discussed before, but also of a lower preweaning lamb growth rate.

Individual weaning weights were influenced by years, lambing seasons, sex of the lamb and birth-rearing type (P<.05). Year effects were significant for lambs born to group II ewes (table 10), a trend that was not evident in group I. Consistent with results presented earlier, lambs born before January 1 grew 4 to 12% faster than those born later.

Male lambs were 6 to 8% heavier at 70 d than female lambs; lambs born and raised as singles were 12 to 21% heavier than those born as multiples and raised as singles and 16 to 24% heavier than lambs born as multiples and raised as twins. These results agree closely with those of Notter and Copenhaver (1980) for Finnsheep under accelerated lambing.

Heterotic Effects

Heterotic effects for all analyzed traits were examined by general linear contrasts. Contrasts were obtained by deviating the performance value of the crossbred from the midparent performance value. Results of the test are presented in table 11.

Significant effects were evident only for fertility, litter size and lambs weaned per ewe

TABLE 9. LAMB SURVIVAL WITHIN LITTER SIZES

Breed	Singles No.	Singles Ratio	Twins No.	Twins Ratio	Litters ⩾ 3 No.	Litters ⩾ 3 Ratio
R	59/65	.91	31/40	.77		
D	43/51	.84	74/92	.80	2/3	.67
F	9/12	.75	69/80	.86	20/45	.44
RD	53/60	.88	64/74	.86	1/3	.33
RF	34/34	1.00	84/100	.84	12/24	.50
DF	32/39	.82	63/86	.73	15/18	.83
Average	230/261	.88	385/472	.82	50/93	.54

TABLE 10. EFFECTS OF BREED OF DAM, LAMB BIRTH YEAR, LAMBING SEASON, SEX AND TYPE OF BIRTH AND REARING OF THE LAMB ON INDIVIDUAL ADJUSTED 70-D WEANING WEIGHT

Group	Breed	Deviation	Year	Deviation	Lambing season	Deviation	Sex	Deviation	TBR[a]	Deviation
I		*		*		*		*		*
	[R][b]	.0	80–81	+ .9	[<Dec.]	.0	[F]	.0	[SS]	.0
	D	− .6	81–82	+ .3	Dec. 1–31	+ .5	M	+ 1.2	MS	−2.4
	F	−2.4	[82–83]	.0	>Dec. 31	− .8			MT	−3.3
	RD	.2	83–84	+3.5						
	RF	− .3								
	DF	− .6								
II		*		*		*		*		*
	[R]	.0	81–82	−1.4	[<Dec. 1]	.0	[F]	.0	[SS]	.0
	D	−1.6	[82–83]	.0	Dec. 1–31	+1.6	M	+1.6	MS	−4.2
	F	−1.0	83–84	4.5	>Dec. 31	−.1			MT	−4.8
	RD	−1.0								
	RF	−1.3								
	DF	−1.4								

[a]TBR = Type of birth and rearing: singles as singles (SS); multiples as singles (MS) and multiples as twins (MT).

[b]In brackets: Selected reference levels from which deviations were taken.

*P<.05.

TABLE 11. TEST OF LINEAR HYPOTHESIS CONCERNING HETEROTIC EFFECTS ON LAMBING AND POST-LAMBING PERFORMANCE

Contrast	Lambing date[a]		Fertility (%)		Litter size		Lamb survival		Total lamb wt/ ewe exposed (kg)	
	I	II	I	II	I	II	S[b]	M[b]	I	II
RD-1/2(D+R)	1.3	−1.8	−3.1	−1.4	−.31*	−.09	.21*	−.05	−4.5*	−.06
RF-1/2(F+R)	5.9	−.5	8.0*	3.0	.05	−.04	.21*	.02	4.5*	−.06
DF-1/2(D+F)	6.1	−3.7	−4.0	−1.0	−.23*	−.09	.03	−.05	−2.9	−.01
F (H)[c]	1.28	1.76	3.12*	.38	3.31*	.30	3.27*	.26	3.64*	.02
Denominator df	237	120	268	136	229	114	264	289	384	233

[a]Sign of estimates was changed to denote heterosis for earlier lambings.

[b]S and M = singles and multiples, respectively.

[c]F = statistic for testing significance of average heterosis.

*P<.05.

exposed, within group I; there were no significant differences for group II. Individual significant contrasts are indicated in table 11. Finn × Rambouillet cross ewes in group I exhibited positive heterosis (P<.05) for fertility, number of lambs weaned, and total weight of lamb weaned per ewe exposed. Except for some crosses involving a Rambouillet background, Sidwell and Miller (1971) found positive heterosis for the same traits. Also for Rambouillet background crosses, Hohenboken et al. (1976) documented positive heterosis (P<.05) for the traits under consideration. In contrast, Dorset × Finn ewes showed negative heterosis for litter size. Sidwell and Miller (1971) reported negative heterosis in crosses of Dorset × Columbia-Southdale and Suffolk × Dorset. Specifically with regard to lambing date, our results are consistent with those of Ricordeau et al. (1976) in showing additivity in breed crosses.

General Discussion

The trait of primary interest in this study is lambing date or, in a broader sense, factors affecting spring/summer mating success. We recognize that in some respects the study is a preliminary one, in that the design and scope of the project do not permit quantification of a number of interactions that are probably important. This is particularly true with regard to birth date, birth year and year of record; the results point out the need for much more work on identifying environmental cues that make for "early" and "late" years, and on interactions among management variables and between management and genetic effects.

Conclusions of particular interest from this experiment are: 1) the Dorset and Rambouillet breeds as represented by these samples do not differ appreciably in date of onset of the breeding season; 2) the Finnsheep breed is later in onset, and transmits this to F_1 daughters in a manner that means that 50% Finn ewes are not suitable for a fall-lambing production system in California; 3) there is not enough heterosis in lambing date to make crossbreeding an effective means of achieving earlier lambing. This suggests that, unless breeds with longer breeding season can be imported, genetic improvement in the trait will have to come from selection. The moderate repeatability of the trait found in this study is encouraging, but heritability estimates and selection experiments are needed.

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