RELATIONSHIP BETWEEN OVULATION RATE AND REPRODUCTIVE PERFORMANCE IN SHEEP

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AN index or criterion for predicting the future reproductive performance of yearling ewes could be most useful in developing a more efficient sheep industry. It has long been assumed that there is an important relationship between ovulation rate and lamb production, but the repeatability of ovulation rate within a breeding season and between breeding seasons is unknown.

Until recently, surgical procedures have been time-consuming and have discouraged the study of these relationships. However, use of the laparotomy cradle as developed by Lamond (1963) and use of local anesthesia have made practical the examination of reproductive organs in large numbers of live animals.

The objective of this study was to determine the relationship between two ovulation rates measured at a 35-day interval during the peak of the breeding season and the relationship between the mean of these ovulations and previous lifetime lamb production. The relationship between the number of corpora lutea (CL) at the first and second observation periods to the number of embryos resulting from matings at the second observation period was also studied.

Materials and Methods

Three hundred forty-two mature Rambouillet, Targhee and Columbia range ewes [5] (156 in October 1964 and 186 in October 1965) were synchronized for estrus by 13 days of feeding 60 mg. of 6-methyl-17-acetoxyprogesterone (MAP) per head per day in alfalfa pellets. These ewes came from a group which had been unselected for fertility except that ewes dry for 2 consecutive years were culled. Also only ewes which had lambed the previous year were included. The ewes were laparotomized and CL counted 4 or 5 days after the last MAP feeding. They were bred to fertile rams at the third estrus after the last progestogen feeding (mostly 32 to 38 days after MAP). Those which did not return to estrus were laparotomized at about 23 to 31 days of gestation. Corpora lutea and embryos (if present) were counted. Ewes which returned to estrus after breeding were laparotomized 2 to 10 days later and the new CL formed were used as an estimate of the number of CL present at breeding.

Ewes were classified into groups according to the number of CL present at the first observation period in October, and also into groups according to the number of CL formed at the second observation period in November. Comparisons where then made between the two ovulation rates and between each ovulation rate and the number of embryos.

One hundred thirty-eight of the ewes studied had opportunities to lamb 4 consecutive years for a total of 552 ewe years. The mean ovulation rate at the two laparotomies was compared with the lamb production of these ewes for the 4 previous years. The results were analyzed by chi-square (Snedecor, 1956).

Results and Discussion

The results (table 1) show a consistent relationship between the two ovulation rates observed at a 35-day interval ($r=0.38$, $P<.01$; $b=0.36$). This agrees with Dermody *et al.* (1966) who found that the ovulation rate at successive estrous cycles was significantly repeatable. Those which had one, two, three or four CL in October averaged 1.66, 1.96, 2.21 and 2.50 CL, respectively, in November (1964 and 1965 combined). There was a slight seasonal increase in ovulation rate between October and November (1.81 to 1.97 in 1964, $P<.05$ and 1.78 to 1.83 in 1965, $P>.05$).

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[5] Exclusive of 14 ewes culled after initial laparotomy for the following reasons: (a) pregnant, 1; (b) uterine tumors, 1; (c) ovarian adhesions, 1; (d) estrous cycle not in synchrony indicated by no new CL at laparotomy, 11 (ewes had either mature CL, or large follicles and/or corpora albacans).

TABLE 1. RELATIONSHIP BETWEEN NUMBER OF CORPORA LUTEA IN OCTOBER AND NUMBER OF CORPORA LUTEA IN NOVEMBER

No. of ewes observed	Ovulation rate Oct.	No. of ewes having the following no. of corpora lutea in Nov.[a]					Mean ovulation rate in Nov.
		0	1	2	3	4	
			1964				
51	1	1	18	30	2	0	1.6
88	2	1	6	67	13	1	2.1
16	3	0	0	12	4	0	2.2
2	4	0	0	1	1	0	2.5
156							
			1965				
54	1	0	20	32	2	0	1.7
119	2	1	22	88	8	0	1.9
13	3	0	1	9	3	0	2.2
0	4	..	..	..	..	..	..
186							

[a] If ewes returned to heat following breeding in November, they were laparotomized and number of CL was counted and used as a measure of the number of CL present at breeding. If the ewes did not return to heat, they were laparotomized at 23 to 31 days postbreeding, and both CL and embryos were counted.

This seasonal increase in number of CL agrees with Dermody *et al.* (1966). They also found no significant effect of progesterone on ovulation rate, which suggests this to be an effect of season rather than MAP. This increase slightly distorts the absolute, but not the relative, comparisons of mean ovulation rates at the two observation periods.

Table 2 shows the relationship between the number of CL in October and the number of embryos in December when the embryos averaged about 26 days of age. It also shows the relationship between the number of CL in November and the number of embryos developing from ova produced at the same estrous cycle. The evidence indicates that the number of embryos is related to the number of CL occurring in October ($P<.05$). An unusually high proportion of ewes having three CL when observed in October were not pregnant in December of 1964. There is no obvious explanation for this; however, the results in 1965 suggest that this was an unusual situation which might occur when small numbers are involved.

As the number of CL per ewe (November) increased, the number of ewes with embryos resulting from matings at the same estrous cycle also increased (1 CL, 69% pregnant; 2 CL, 80% pregnant; 3 CL, 88% pregnant; $P<.01$). In other words, ewes which produced twin ovulations were more likely to be pregnant than ewes which produced single ovulations. Likewise, ewes which produce triplet ovulations were more likely to be pregnant than ewes which produce twin ovulations. However, the relationship between the number of CL in October and the number of pregnant ewes following breeding in November was low and apparently has no predictive value. The next to last column in table 2 shows a high relationship between the number of CL and the percent of embryos for ewes observed about 26 days after breeding. Those ewes having one, two and three CL averaged .62, 1.55 and 1.70 embryos per ewe, respectively, in 1964 and .72, 1.27 and 1.64 embryos per ewe, respectively, in 1965. The last column shows this same relationship when only pregnant ewes are included.

The average number of embryos per ewe and per pregnant ewe at approximately 23 to 31 days after breeding in November were 1.13, 1.35, 1.24, 2.00; and 1.45, 1.70, 1.80 and 2.00 for the groups which had one, two, three and four CL per ewe in October, respectively (1964 and 1965 combined, $P<.05$).

Combining both years 59.6% of the ewes producing twin ovulations at breeding had twin embryos whereas only 17.6% of the ewes producing triplet ovulations had triplet embryos. The pregnant ewes having twin ovulations at breeding averaged 1.77 and 1.71 embryos per ewe for 1964 and 1965, respectively. The pregnant ewes having triplet ovulations averaged 1.89 and 1.92 embryos per ewe for 1964 and 1965, respectively. This appears to indicate that the uteri of Targhee,

Columbia and Rambouillet ewes can easily accommodate two embryos but have difficulty maintaining three.

Of the ewes in the study, 138 had an opportunity to lamb during each of the 4 previous years for a total of 552 ewe years. These were used to study the relationship of ovulation rate to lifetime lamb production. The results are shown in table 3. The number of ewes in this group having an average of 1.0 CL or less, 1.5 CL, 2.0 CL and 2.5 CL or more for the two laparotomy observations were 13, 36, 72 and 17, respectively. The number of lambs born per ewe for these four groups were: 1.23, 1.33, 1.47 and 1.56 ($P<.01$). The correlation of the average number of CL at two observations with average lamb production for 4 previous years was 0.28 ($P<.01$) with a regression of 0.23. In other words for each increase of 1 CL there was an increase of 0.23 lambs born per year or an increase of almost 1 lamb in 4 years. The average numbers of lambs born per ewe lambing in these groups were 1.31, 1.40, 1.56 and 1.71, respectively, ($P<.01$).

These results clearly show that ovulation rate during the peak of the breeding season in mature ewes is related to their previous lifetime lamb production. It seems logical that a similar relationship could exist between ovulation rate in young ewes and their subsequent lamb production. If this is true, then selection for ovulation rate could have significant impact on the reproduction rate as well as a possible genetic effect on subsequent generations. These ewes were slaughtered following the study, so the effects of the laparotomy technique upon subsequent fertility are unknown. A speculum is now used to observe ovulation rate. It is hoped that this technique will have little adverse effect on subsequent fertility.

TABLE 2. RELATIONSHIP BETWEEN NUMBER OF CORPORA LUTEA IN OCTOBER OR NOVEMBER AND NORMAL EMBRYOS FOLLOWING BREEDING AT ONE ESTRUS IN NOVEMBER

No. of ewes observed	Ovulation rate		No. ewes having the following no. of embryos 23 to 31 days postbreeding[a]				Ewes with embryos	Embryos for ewes observed	Embryos for pregnant ewes
	Oct.	Nov.	0	1	2	3			
					1964				
							%	%	%
50	1	..	10(20)[b]	19(38)	21(42)	0(00)	80	122	154
88	2	..	11(12)	21(24)	52(59)	4(4)	88	158	179
16	3	..	6(38)	3(19)	7(44)	0(00)	62	106	170
2	4	..	0(00)	0(00)	2(100)	0(00)	100	200	200
156									
24	..	1	9(38)	15(62)	..	..	62	62	100
111	..	2	14(13)	22(20)	75(68)	..	87	155	177
20	..	3	2(10)	6(30)	8(40)	4(20)	90	170	189
..	..	4	..	..	..	..	..	..	..
155									
					1965				
54	1	..	12(22)	27(50)	14(26)	1(1)	78	107	131
119	2	..	32(27)	32(27)	55(46)	0(00)	73	119	163
13	3	..	3(23)	2(15)	7(54)	1(8)	77	146	190
..	4	..	..	..	..	..	..	..	..
186									
43	..	1	12(28)	31(72)	..	..	72	72	100
129	..	2	33(26)	28(22)	68(53)	..	74	127	171
14	..	3	2(14)	3(21)	7(50)	2(14)	86	164	192
..	..	4	..	..	..	..	..	..	..
186									

[a] If ewes returned to heat following breeding in November, they were laparatomized and number of CL was counted and used as a measure of the number of CL present at breeding. If the ewes did not return to heat, they were laparotomized at 23 to 31 days postbreeding, and both CL and embryos were counted.

[b] Percent (in parentheses) of number ewes observed.

TABLE 3. RELATIONSHIP BETWEEN AVERAGE NUMBER OF CORPORA LUTEA IN OCTOBER AND NOVEMBER AND LIFETIME LAMB PRODUCTION

Av. no. CL for 2 observations[a]	No. ewes having 0 lambs	1 lambs	2 lambs	3 lambs	No. ewes appearing each year	Lambs born per ewe	Lambs born per ewe lambing
			1962				
1.0 or <	1	11	1	0	13	1.00	1.08
1.5	2	30	4	0	36	1.06	1.12
2.0	6	45	21	0	72	1.21	1.34
2.5 or >	3	7	7	0	17	1.24	1.50
			1963				
1.0 or <	0	12	1	0	13	1.08	1.08
1.5	1	22	13	0	36	1.33	1.37
2.0	1	29	42	0	72	1.57	1.59
2.5 or >	2	4	10	1	17	1.59	1.80
			1964				
1.0 or <	0	6	6	1	13	1.62	1.62
1.5	2	12	22	0	36	1.56	1.65
2.0	2	21	49	0	72	1.65	1.70
2.5 or >	0	3	14	0	17	1.82	1.82
			1965				
1.0 or <	2	6	5	0	13	1.23	1.45
1.5	3	18	14	1	36	1.36	1.48
2.0	7	25	40	0	72	1.46	1.62
2.5 or >	1	5	11	0	17	1.59	1.69
			Combined data 1962–1965				
1.0 or <	3	35	13	1	52	1.23	1.31
1.5	8	82	53	1	144	1.33	1.40
2.0	16	120	152	0	288	1.47	1.56
2.5 or >	6	19	42	1	68	1.56	1.71

[a] Observations taken during October and November.

Summary

The relationship of ovulation rate at one estrus to ovulation rate at a second estrus approximately 35 days later was studied in 342 mature ewes by means of laparotomy. Ewes which had one (105 head), two (207 head), three (29 head) and four (2 head) corpora lutea (CL) in early October, 1964 and 1965 averaged 1.65, 1.96, 2.21 and 2.50 CL, respectively, about 35 days later ($P<.01$). These same ewes were bred before the second observation. The average number of embryos per ewe and per pregnant ewe at approximately 23 to 31 days after breeding in November were 1.13, 1.35, 1.24, 2.00; and 1.45, 1.70, 1.80 and 2.00 for the groups which had one, two, three and four CL per ewe in October, respectively ($P<.05$). The percent of pregnant ewes, number of embryos per ewe and per pregnant ewe at about 23 to 31 days postbreeding were 69, 80, 88; .68, 1.40, 1.68; 1.00, 1.74 and 1.90, respectively, for the groups which had 1, 2 and 3 ovulations for the estrous cycle at which they were bred (November). One hundred thirty-eight of the ewes studied had an opportunity to lamb during each of the 4 consecutive years for a total of 552 ewe years. These ewes were used to study the relationship of ovulation rate to previous lifetime lamb production. The number of ewes in this group having an average of 1 or less, 1.5, 2.0 and 2.5 or more CL for the two observation periods were 13, 36, 72 and 17, respectively. The numbers of lambs born per ewe for these four groups were 1.23, 1.33, 1.47 and 1.56 ($P<.01$).

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