FACTORS AFFECTING LITTER-SIZE IN THE SCOTCH HALF-BRED EWE

I. TREATMENT WITH PMS AND PROGESTERONE

J. E. NEWTON AND J. E. BETTS

The Grassland Research Institute, Hurley

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Summary. Seventy-eight ewes were injected with pregnant mare serum (PMS) during the normal breeding season. Injections of 500, 750, 1000, 1250 or 1500 i.u. of PMS were given on the 12th or 13th day of the oestrous cycle. The number of lambs born per ewe was significantly increased with increasing levels of PMS.

Progesterone injections were given to sixty-three ewes to synchronize oestrus within the flock during the normal breeding season. Injections of 500, 750, 1000, 1250 or 1500 i.u. of PMS were given 1 day after the last progesterone injection. The fertility of mating at the first synchronized oestrus was high. There was a marked increase in the number of lambs born per ewe using 1500 i.u. of PMS.

INTRODUCTION

The ultimate value of herbage within an animal production system is largely determined by the efficiency with which animals can convert it into products of agricultural value. Since a high proportion of the total food consumed by a flock is eaten by the ewe, the relevant index of food conversion efficiency has to be based on a ewe and her progeny for at least an entire year. Recent work (Large, 1965) has demonstrated very large effects of litter size on this index. Scotch Half-bred ewes with twins convert their annual food intake to meat with an efficiency some 50% higher than that of similar ewes with singles. It is of considerable importance to extend the range of litter sizes used in such studies and to explore the possibilities of increasing the mean litter size of the flock. This may be achieved in the long term by breeding but the injection of exogenous hormones has already shown great promise.

The work of Robinson (1951) confirmed that between the levels of 500 and 2000 i.u. of PMS there is a dose-response relationship in the number of ova shed by sheep. Wallace, Lambourne & Sinclair (1954), Wallace (1955), Gordon (1958) and Pálsson (1962) all reported increases in the fertility of various breeds of sheep during the natural breeding season following injection of PMS on the 12th or 13th day of the oestrous cycle. These authors were primarily concerned with ensuring that each ewe produced two lambs. In contrast, the object of the work described here was to produce the maximum number of viable lambs

per ewe and to determine the level of freeze-dried commercial PMS that would consistently produce large litters in the Scotch Half-bred ewe. Research into the artificial rearing of lambs was proceeding simultaneously so that all lambs could be reared independently of the ewe if required (Large, unpublished data).

Dutt & Casida (1948) and O'Mary, Pope & Casida (1950) showed that the length of the oestrous cycle and the onset of oestrus in ewes, during their normal breeding season, could be controlled by administering progesterone. Cullen & Shearer (1964) injected PMS on the same day as the last injection of progesterone and found that the conception rate, following mating at the synchronous oestrus, was low. In the present work it was hoped to overcome this low conception rate, and also to ensure effective superovulation before the onset of oestrus, by injecting PMS 24 hr after the last injection of progesterone.

MATERIALS AND METHODS

Experiment 1

Two flocks of Scotch Half-bred ewes were employed: Flock 1 consisted of forty-eight and Flock 2 of thirty ewes. Ages ranged from 2½ to 7½ years; only ewes which were apparently healthy were included in the study. Three rams, known to be fertile, and one vasectomized (teaser) ram were used. The rams and the teaser were fitted with a Siresine harness containing a crayon so that the day of mating could be determined. Freeze-dried PMS was reconstituted with sterile distilled water immediately before injection and administered subcutaneously. In Flock 1, the dose rates used were 500, 750, 1000, 1250 and 1500 i.u. of PMS. Six sheep were allocated at random to each treatment; eighteen sheep served as controls. In Flock 2 the dose rates of PMS and the number of sheep at each level of PMS were the same as in Flock 1.

Ewes in Flock 1 were run with a teaser at pasture from 11th September 1964. The ewes were injected with PMS 12 or 13 days after they had been marked by the teaser. They were then run with two fertile Suffolk rams and inspected daily for evidence of marking. Different coloured Siresine crayons were used for the teaser and the fertile rams to avoid confusion. The ewes were at pasture until approximately 90 days of gestation when they were X-rayed to determine the number of foetuses carried. At this stage the forty-eight ewes in Flock 1 were used on a separate experiment—twenty-four ewes were brought inside and fed lucerne nuts, with water always available, until lambing time; twenty-four ewes remained outside and were fed hay and concentrates in the field. Ewes in Flock 2 were run with the teaser from 28th October 1964. Injection and mating procedure was the same as for Flock 1. The ewes were brought into yards after X-ray examination and fed silage and concentrates until lambing time.

Experiment 2

A second experiment was carried out with Flock 3, consisting of thirteen mature Scotch Half-bred ewes, which had been culled from the other flocks because of bad teeth or poor udders, and fifty gimmers of the same breed. Three Suffolk rams, known to be fertile, were used. Six intramuscular injections of 25 mg progesterone, dissolved in ethyl oleate, were administered to each ewe

according to the time sequences shown in Table 1. The PMS used was similar to that described in Experiment 1 as were the dose rates of 500, 750, 1000, 1250 and 1500 i.u.

The thirty-two sheep on treatment and control A were given their first injection of progesterone on 14th October 1964. Three fertile Suffolk rams, fitted with Siresine harnesses, were introduced on 26th October, the day after the last progesterone injection. The thirty-one sheep on treatment and control B were given the first injection of progesterone on 22nd October. They were then added to the thirty-two ewes and three Suffolk rams, mentioned above, on 2nd November, the day after their last progesterone injection. All ewes were

TABLE 1
TIME SEQUENCE OF HORMONE INJECTIONS IN EXPERIMENT 2

	No. of ewes	Day												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Control A	7	×		×		×		×		×			×	
Treatment A	25	×		×		×		×		×			×	○
Control B	6	×		×		×		×		×		×		
Treatment B	25	×		×		×		×		×		×	○	

×, 25 mg progesterone; ○, various dose levels of PMS.

TABLE 2
RELATIONSHIP BETWEEN LEVEL OF PMS, LAMBS BORN/EWE
(CONCEIVED WITHIN 6 DAYS OF THE PMS INJECTION) AND LAMBS
LOST IN EXPERIMENT 1

PMS level (i.u.)	No. of ewes	Lambs born	Lambs born/ ewe	Lambs alive at 1 day/ewe	Percentage mortality
0	17	33	1.94	1.70	12
500	10	20	2.00 ^{NS}	1.80 ^{NS}	10
750	11	26	2.36 ^{NS}	2.00 ^{NS}	15
1000	12	32	2.67*	1.92 ^{NS}	28
1250	10	31	3.10**	2.70*	13
1500	10	32	3.20***	2.60 ^{NS}	18

^{NS} Not significant.

* Value significantly greater than in control group, $P < 0.05$.

** Value significantly greater than in control group, $P < 0.01$.

*** Value significantly greater than in control group, $P < 0.001$.

inspected twice daily for evidence of marking. The ewes were then brought into yards and fed silage and concentrates until lambing time.

In all three flocks, each PMS hormone treatment was equally represented and, although the feeding regime of the ewes in Flock 1 in late pregnancy was somewhat different from that imposed on Flocks 2 and 3, all ewes diagnosed as carrying more than two lambs were given additional food.

RESULTS

The results of lambing for Flocks 1 and 2 in Experiment 1 are shown in Table 2. Any ewe that was barren or was not marked by the ram within 6 days of the

PMS injection has been discarded from the results, since it was considered that the results for any ewe conceiving from a subsequent mating could not have been related directly to the PMS injection. Eight ewes were discarded for these reasons. There was a significant difference between the number of lambs born per ewe injected with 1000 or more i.u. PMS and the number of lambs born per control ewe. As the rate of PMS was increased so did the percentage of ewes bearing more than two lambs (Table 3). At 1000 i.u. PMS over 50% of the ewes had three or four lambs.

TABLE 3
LITTER SIZE IN RELATION TO DOSE OF PMS (EXPERIMENT 1)
(Percentage of ewes having litter sizes of 1, 2, 3, 4 or 5)

PMS level (i.u.)	Litter size				
	1	2	3	4	5
0	23	59	18	—	—
500	10	80	10	—	—
750	9	64	9	18	—
1000	8	33	42	17	—
1250	10	20	30	30	10
1500	—	20	40	40	—

TABLE 4
MORTALITY OF LAMBS IN RELATION TO LITTER SIZE

Experiment	Type of birth	Lambs born	Lambs alive at 1 day	Percentage deaths	Lambs alive at 1 day/ ewe lambing
I	Single	8	8	—	1.00
	Twin	66	54	18	1.64
	Triplet	51	50	2	2.95
	Quad	44	28	36	2.55
	Quin	5	5	—	5.00
II	Single	8	8	—	1.00
	Twin	52	47	10	1.81
	Triplet	36	20	44	1.54
	Quad	8	—	100	0
Both experiments	Single	16	16	—	1.00
	Twin	118	101	14	1.71
	Triplet	87	70	20	2.41
	Quad	52	28	46	2.15
	Quin	5	5	—	5.00

Table 4 shows the neonatal mortality of lambs in relation to litter-size. Only 2% of the triplets were born dead in Experiment 1 and this was encouraging: 36% of the quadruplets died, however. This latter figure is made up of four ewes which lost their complete litters, two from vaginal prolapse and two from pregnancy toxæmia. Further knowledge of the nutritional requirements of ewes carrying quadruplets should reduce such losses considerably. The remaining seven sets of quadruplets were born without loss, as was the only

litter of quintuplets. As the mean litter size per ewe increased with the rise in level of PMS, the percentage mortality increased slightly, as shown in Table 2; but the number of live lambs per ewe was still considerably greater at the higher levels of PMS.

In Experiment 2, synchronization of oestrus within the flock was more successful with treatment B than with treatment A (Text-fig. 1). On treatment A, the number of ewes marked by the rams between the 12th and the 16th day

TEXT-FIG. 1. Distribution of oestrus following hormone treatment. (a) Control A (progesterone), (b) treatment A (progesterone + PMS), (c) Control B (progesterone), (d) treatment B (progesterone + PMS). Day 0 is the day of the last progesterone injection, Day 1 is the day of the PMS injection. Black columns, fertile mating; shaded columns, infertile mating.

after the last progesterone injection (Day 0) showed that the 72-hr gap between the fifth and sixth injection of 25 mg progesterone was too long; it is probable that these ewes came into oestrus on the day before the last injection of progesterone. On treatment B over 80% of the ewes were marked by the ram within 5 days of the last progesterone injection. It is of importance to note that almost all the ewes conceived successfully at the first synchronized oestrus.

In Experiment 2, as the level of PMS was increased, there was a less marked increase in the number of lambs per ewe compared with Experiment 1 (Table 5).

TABLE 5

RELATIONSHIP BETWEEN DOSE LEVEL OF PMS, LAMBS BORN/EWE (CONCEIVED WITHIN 6 DAYS OF THE PMS INJECTION) AND LAMBS LOST, IN EXPERIMENT 2

<i>Hormone dose : 6 × 25 mg progesterone</i>	<i>No. of ewes</i>	<i>Lambs born</i>	<i>Lambs born/ ewe</i>	<i>Lambs alive at 1 day/ ewe</i>	<i>Percentage mortality</i>
+ 0	13	26	2.00	1.77	12
+ 500 i.u. PMS	7	16	2.29	1.71	25
+ 750 i.u. PMS	6	13	2.17	0.83	60
+ 1000 i.u. PMS	10	23	2.30	1.60	30
+ 1250 i.u. PMS	6	10	1.67	1.67	0
+ 1500 i.u. PMS	6	16	2.67	1.50	44

TABLE 6

LITTER SIZE IN RELATION TO DOSE OF PMS (EXPERIMENT 2)
(Percentages of ewes having litter sizes of 1, 2, 3 or 4)

<i>Hormone dose</i>	<i>Litter size</i>			
	1	2	3	4
6 × 26 mg progesterone	15	69	15	—
6 × 25 mg progesterone + 500 PMS	14	43	43	—
6 × 25 mg progesterone + 750 PMS	17	50	33	—
6 × 25 mg progesterone + 1000 PMS	10	60	20	10
6 × 25 mg progesterone + 1250 PMS	50	33	17	—
6 × 25 mg progesterone + 1500 PMS	—	50	33	17

TABLE 7

LAMBING DISORDERS

<i>Nature of ailment</i>	<i>Experiment</i>	<i>No. of ewes affected</i>	<i>No. of ewes died</i>	<i>No. of lambs died</i>
Prolapse	1	13 (33)*	6 (16)	17
	2	6 (17)	3 (7)	14
	Total	19 (50)	9 (23)	31
Pregnancy toxæmia	1	3 (10)	2 (6)	10
	2	1 (4)	0 (0)	4
	Total	4 (14)	2 (6)	14
Abortion	1	1 (2)	1 (2)	2
	2	2 (6)	0 (0)	6
	Total	3 (8)	1 (2)	8
Overall total		26 (72)	12 (31)	53

* The figure in parentheses indicates the number of lambs carried.

No. of ewes in Experiment 1 = 78

No. of lambs born in Experiment 1 = 183

No. of ewes in Experiment 2 = 63

No. of lambs born in Experiment 2 = 129

Total

141

Total

312

Only when the level of PMS reached 1500 i.u. was there a difference approaching significance between the number of lambs born per ewe and the number born per control ewe. This could either have been because of the synchronization treatment with progesterone or because the majority of the sheep in this experiment were gimmers. Table 6 shows that 50% of the ewes had more than two lambs only when the dose level of PMS reached 1500 i.u.; as in Experiment 1 there were no singles produced at this level. Lambing losses in the large litters in this second experiment were high (Table 4), 44% of the triplets and 100% of the quadruplets being lost. Eleven gimmers carried triplets; of these, two aborted and three had prolapses (Table 7). One of the two gimmers carrying quadruplets suffered from pregnancy toxæmia and the other from vaginal prolapse. From these results, one may conclude that even well-grown gimmers should not be induced to carry more than two lambs at their first lambing. No clear relationship is observable (see Table 5) between the level of PMS and the neonatal mortality of lambs. There were no losses at 1250 i.u. PMS but 50% of the ewes at this level had singles.

DISCUSSION

In Experiment 1 there was a significant difference in the number of lambs conceived per ewe between the controls and those injected with 1000 i.u. of PMS. This difference was increased at 1250 and 1500 i.u. PMS. Both Robinson (1951) with fresh PMS, and Moore & Shelton (1962) with horse anterior pituitary extract (HAP) obtained increased superovulation with increased levels of gonadotrophin. Robinson (1951) found that at 2000 i.u. of fresh PMS ovarian abnormalities became apparent, and that at this level gross over-stimulation resulted in premature luteinization. He recommended 500 i.u. PMS as the most reliable level for two or four ovulations. Moore & Shelton (1962), using HAP found that a significantly smaller proportion of eggs was fertilized when there was an excessive ovulatory response. In the present experiments, no ewes were slaughtered for examination shortly after mating, so no evidence can be advanced as to the wastage of fertilized or unfertilized eggs at the higher rates of PMS; however, the mean number of lambs born per ewe was still increasing up to 1500 i.u. PMS. It would seem from the present investigation with the Scotch Half-bred, a cross-bred sheep of high fertility, that relatively high levels of PMS, such as 1000 i.u. and above, have to be employed to achieve significant increases in mean litter size (no assay was carried out to check the advertised potency of the commercial freeze-dried PMS). The fact that Pálsson (1962) achieved a significant increase in mean litter size with only 500 i.u. PMS using Icelandic sheep, can be explained by assuming, as does Gordon (1958), that response to low levels of PMS is greater where the natural level of fertility is low.

It was perhaps surprising that no litters larger than five were produced in the present investigations, especially at the higher rates of PMS. Wallace *et al.* (1954) using New Zealand Romneys, and Pálsson (1962) with Icelandic sheep, had ewes producing sextuplets with 1000 and 750 i.u. PMS respectively. Gordon (1958) had one Ryeland ewe which produced septuplets after receiving 750 i.u. PMS. However, Pálsson (1962) found that there was great variability in the response of the same ewes to an identical level of PMS in consecutive years. He

recorded five out of twenty ewes with three or more lambs in the first year of the experiment and ten out of eighteen with three or more in the following year.

The results of treatment B in Experiment 2 indicate that a high degree of synchronization of oestrus, within a flock of sheep, can be successfully achieved using an exogenous hormone during the normal breeding season. The large number of ewes in Experiment 2 which conceived successfully at the first synchronized oestrus, showed that the timing of ovulation in relation to oestrus was correct. This was when PMS was given 24 hr after the last injection of progesterone in a consecutive series of six equally-spaced injections. These results support the contention of Lamond (1964) and Cullen & Shearer (1964) that the timing of the PMS injection in relation to the withdrawal of progesterone is of great importance in determining subsequent fertility.

In Experiment 1, at all levels of PMS except 500 i.u., the number of lambs conceived per ewe was higher than in Experiment 2. It would be of great interest to know whether this was because a teaser was used in Experiment 1, whereas in Experiment 2 progesterone was used to synchronize oestrus. Unfortunately, a comparison between the two experiments is made invalid by the fact that the ewes in Experiment 1 were mature, whereas the majority of the ewes in Experiment 2 were gimmers.

There was a slight suggestion in Experiment 2 that the control ewes and gimmers, injected with progesterone only, had an increased litter-size; but as there was no absolute control treatment (gimmers without either progesterone or PMS), no statistical comparison can be made.

In the work reported here, the mortality of ewes and lambs associated with larger litter sizes was rather high. Vaginal prolapse was responsible for the death of more ewes and lambs than either pregnancy toxæmia or abortion. It was not possible to determine the reason for this; it is possible that increased foetal weight, associated with artificially increased litter numbers, especially with gimmers, was a predisposing cause. However, the ewes in Experiment 1 lambed fifty out of fifty-one triplet lambs successfully. This, together with the fact that in Experiment 1 just under two-thirds of the quadruplets born, and all five quintuplets were alive and capable of being reared, shows that the mature Scotch Half-bred ewe can average more than two viable lambs when treated with PMS.

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