HORMONAL CONTROL OF REPRODUCTIVE ACTIVITY IN KARAKUL EWES

N. SEFIDBAKHT, M. MAKARECHIAN AND K. GHORBAN

Pahlavi University, Shiraz, Iran

CONSIDERABLE work to increase efficiency of production in sheep has been done through the development of hormonal control of the estrous cycle and in induction of fertile estrus in the anestrous ewe. Two injections of pregnant mare serum (PMS) at one estrous cycle interval either or both preceded by progestogen priming have been shown to increase fertility in the lactating and dry anestrous ewes (Gordon, 1963; Brunner, Hansel and Houge, 1964; Wagner, 1964; Roberts and Edgar, 1966; Hulet and Foote, 1967).

The first part of this paper presents data concerning the effects of 6-Chloro-6-17 acetoxyprogesterone (CAP) with and without estradiol 17-β on estrus and fertility in cycling Karakul ewes. The second part presents studies which were designed to investigate the interaction between three hormone progesterone, estradiol 17-β and PMS on estrus and fertility in lactating, anestrous ewes.

Materials and Methods

Trial I. One-hundred-ninety-six 2- to 7-year-old Karakul dry ewes from the flock of Animal Experiment station, Ministry of Agriculture were randomly selected on August 6, 1967. These animals had lambed during 44 days from December 5, 1966 to January 20, 1967. The lambs had been weaned at about 100 days of age.

Selected ewes were divided at random into three groups and received the following treatment:

Group 1. Seventy-three ewes treated with 1 mg CAP daily for 15 days.

Group 2. Seventy-three ewes treated the same as group 1 plus an injection of 2 mg estradiol 17-β on the first day of feeding CAP.

Group 3. Fifty ewes used as control.

Treatments started on September 23, 1967 (day 0) and all the animals received 400 g of ground feed (75% barley and 25% alfalfa) after daily pasture grazing. The CAP was mixed with the ground feed and fed to the ewes.

Breeding Karakul rams at the ratio of one ram per 10 ewes were introduced on October 10 and remained until November 16 (day 54). The rams were then reduced to two head until December 2 (day 70). Ewes showing estrus during daytime were recorded by their ear tag numbers.

The animals were maintained on natural pasture and, in addition, were given about 1 kg of corn silage per head daily. The lambing period started on March 7 and ended on April 24. Each lamb was identified within a few hours of birth.

Trial II. In April 1968, a supplementary experiment was conducted. At an average of 20 days (ranging from 6 to 29 days) post-partum, 171 head of mature lactating Karakul ewes from trial I, were divided randomly into five groups so that the average postpartum interval was approximately equal for all the groups and treated as summarized in table 1.

The progesterone and estradiol were injected intramuscularly. Two injections of 1,000 IU PMS were given subcutaneously. The first one was on the average 36 hr. after last injection of progesterone, and the second one followed 18 days later. Karakul rams at the ratio of one ram per 10 ewes were placed with the ewes within 12 hr. after the first PMS injection. Ewes showing estrus were observed during day time and were recorded by their ear tag numbers. Ewes had access to the rams until June 29.

Results and Discussion

Trial I. The effects of hormonal treatments on estrus are shown in table 2. Eighty-eight percent of ewes treated with CAP and 79%
of those treated with CAP+estradiol showed estrus during 4 days after adding rams to the flock as compared to 38% in the control group. Occurrence of estrus during 4 days in groups receiving CAP and CAP+estradiol were increased as compared to control group (P<.005). Percentage of treated ewes lambing to mating at first synchronous estrus were 55%, 40% and 20%, for CAP, CAP+estradiol and control groups, respectively. There was no significant difference between different treatments.

Comparison of the mean number of days from starting day of feeding CAP (day O) to induction of estrus by Tukey's method (Steel and Torrie 1960) showed a significant difference between the CAP treated group (20.5±4.0 days), the CAP+estradiol treated group (21.1±5.6 days) and the control group (24.4±5.5 days) at 5% level of probability. The mean number of days from day O to lambing were 174.3±7.2, 176.6±8.7, 179.3±8.9, for CAP, CAP+estradiol and control groups, respectively. Comparison of the means by Tukey's test, the CAP group showed a shorter period than the controls (P<.05). Comparison of the CAP treated group and the CAP+estradiol treated group for the mean interval between day O to either induction of estrus, or to lambing, showed a latent trend in both cases, i.e., the CAP+estradiol treated group. Although the latency was not statistically significant, the latent trend might be due to premature regression of corpora lutea of preceding natural ovulations in some ewes which were in the second stage of estrous cycle. Hawk and Bolt (1969) reported that ewes become susceptible to estradiol starting luteolysis by the eighth or 9th day of estrous cycle. Stormshak, Kelley and Hawk (1969) reported that estradiol injected on days 11 and 12 of estrous cycle had luteolytic effect by day 13 and caused even greater regression of corpora lutea by day 15. They also found some indication that subsequent expected estrus was delayed, and proposed that this delay in returning to estrus could be related to relatively low weight of corpora lutea in treated ewes.

A single injection of estradiol 17-β early in the estrous cycle (on day 4 or 5) is effective in inducing ovulation in ewes (Foote, 1964; Piper and Foote, 1968; Howland et al., 1968). Progesterone, however, can block the ovulatory response to estradiol (Piper and Foote, 1968). Therefore, it does not seem that injection of estradiol in those ewes which were in the first stage of estrous cycle could affect ovulation in this trial.

**Trial II.** The pattern of estrus for the five groups of lactating ewes are presented in table 3. In groups 1, 2, 3 and 4 relatively high incidence of synchronized estrus occurred from 15 to 19 days following the first PMS treatment. Two days after the first PMS injection ewes were vaccinated against foot and mouth disease which might have had a detrimental effect on the incidence of estrus. Sixty-four percent, 70%, 68%, 58% and 24% from the groups 1 to 5, respectively, were mated with rams during the period from 15 to 37 days after starting the treatment (day O). Incidence of estrus was increased in all of the treated groups as compared to the control group (P<.01).

More ewes lambed during the first 7 days in group 3 than in group 4 (P<.025) or in the controls (P<.05) as shown in table 4. The number of live lambs in group 3 was increased as compared to group 1, group 4 and control, (P<.01). The data suggest that estradiol had a stimulating effect on the lamb crop percentage when given at the beginning of progesterone administration. Reduction of postpartum interval in lactating beef cows by intramuscular injection of progesterone...
TABLE 2. SYNCHRONIZATION RESULTS AND CONCEPTION RATES AT SYNCHRONOUS AND NON-SYNCHRONOUS ESTRUS (TRIAL I)

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>No. of ewes</th>
<th>Synchronous estrus in 4 days (estrus 18 to 21)</th>
<th>Days to first mating</th>
<th>Lambing day</th>
<th>Ewes lambing from first synchronous estrus</th>
<th>Total ewes lambing</th>
<th>Total lambs born</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.</td>
<td>%</td>
<td>Mean</td>
<td>SD</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>1 mg CAP</td>
<td>73</td>
<td>64</td>
<td>88</td>
<td>20.5^</td>
<td>4.0</td>
<td>174.3*</td>
<td>7.2</td>
</tr>
<tr>
<td>1 mg CAP+2 mg estradiol</td>
<td>73</td>
<td>58</td>
<td>79</td>
<td>21.1^</td>
<td>5.6</td>
<td>176.6</td>
<td>8.7</td>
</tr>
<tr>
<td>Control</td>
<td>50</td>
<td>19</td>
<td>38</td>
<td>24.4^</td>
<td>5.5</td>
<td>179.3*</td>
<td>8.9</td>
</tr>
</tbody>
</table>

^X^2=33.928, df=2 (P<.005).
^b^ Those in estrus between days 18 and 21.
^c^ The date of conception was estimated to be 150 days before lambing date.
^d^ * Data in the same column having different subscripts are significantly different (P<.05).

TABLE 3. SUMMARY OF INDUCTION OF ESTRUS AFTER THE FIRST AND THE SECOND INJECTION OF PMS (TRIAL II)

<table>
<thead>
<tr>
<th>Group no.</th>
<th>Treatment</th>
<th>No. of ewes per group</th>
<th>Days* 15 to 19</th>
<th>No.</th>
<th>%</th>
<th>New</th>
<th>33 to 37</th>
<th>Return</th>
<th>Days 15 to 37</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Progesterone^b</td>
<td>33</td>
<td>11</td>
<td>10</td>
<td>30</td>
<td>1</td>
<td>21</td>
<td>3</td>
<td>23</td>
<td>89</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>Progesterone^b+2 mg estradiol</td>
<td>37</td>
<td>7</td>
<td>19</td>
<td>19</td>
<td>51</td>
<td>24</td>
<td>3</td>
<td>23</td>
<td>89</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>Progesterone^b+4 mg estradiol</td>
<td>34</td>
<td>6</td>
<td>18</td>
<td>17</td>
<td>50</td>
<td>24</td>
<td>3</td>
<td>23</td>
<td>89</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>Progesterone^b+2 (2mg estradiol)</td>
<td>33</td>
<td>13</td>
<td>39</td>
<td>6</td>
<td>18</td>
<td>24</td>
<td>3</td>
<td>23</td>
<td>89</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>Control</td>
<td>33</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>21</td>
<td>24</td>
<td>3</td>
<td>23</td>
<td>89</td>
<td>24</td>
</tr>
</tbody>
</table>

^X^2=19.23, df=4 (P<.005).
^b^ Two days after first PMS injection ewes were vaccinated against foot and mouth disease, which perhaps decreased the incidence of estrus.
^c^ Two days after first PMS injection ewes were vaccinated against foot and mouth disease, which perhaps decreased the incidence of estrus.
^d^ X^2=10.38 (P<.01).
^e^ X^2=14.76 (P<.005).
^f^ X^2=7.88 (P<.01).
<table>
<thead>
<tr>
<th>Group no.</th>
<th>Treatment</th>
<th>No. of ewes treated</th>
<th>No. of ewes at lambing time</th>
<th>Ewes lambing&lt;sup&gt;a&lt;/sup&gt; during 7 days</th>
<th>Total ewes lambed</th>
<th>Live lambs</th>
<th>Average lambing date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Treated No.</td>
<td>%</td>
<td>Bred %</td>
<td>Treated No.</td>
</tr>
<tr>
<td>1</td>
<td>Progesterone&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34</td>
<td>33</td>
<td>Treated 8</td>
<td>24</td>
<td>38</td>
<td>Treated 8</td>
</tr>
<tr>
<td></td>
<td>Progesterone&lt;sup&gt;a&lt;/sup&gt; + 2 mg estradiol</td>
<td>37</td>
<td>35</td>
<td>Treated 13</td>
<td>42</td>
<td>70</td>
<td>Treated 13</td>
</tr>
<tr>
<td>2</td>
<td>Progesterone&lt;sup&gt;a&lt;/sup&gt; + 4 mg estradiol</td>
<td>34</td>
<td>33</td>
<td>Treated 14</td>
<td>51</td>
<td>25</td>
<td>Treated 6</td>
</tr>
<tr>
<td>4</td>
<td>Progesterone&lt;sup&gt;a&lt;/sup&gt; + 2 (2 mg estradiol)</td>
<td>33</td>
<td>33</td>
<td>Treated 5</td>
<td>15</td>
<td>25</td>
<td>Treated 6</td>
</tr>
<tr>
<td>5</td>
<td>Control</td>
<td>33</td>
<td>33</td>
<td>Treated 6</td>
<td>18</td>
<td>75</td>
<td>Treated 9</td>
</tr>
</tbody>
</table>

<sup>a</sup> Seven injections of 20 mg each on alternate days.
<sup>b</sup> Conception as a result of second PMS injection, no conception as a result of first PMS injection.
<sup>c</sup> $X^2=9.676$, df=4 ($P<.05$).
<sup>d</sup> $X^2=18.919$, df=4 ($P<.005$).
<sup>e</sup> Group 2 vs. 4 $X^2=4.218$ ($P<.05$).
<sup>f</sup> Group 3 vs. 4 $X^2=5.983$ ($P<.025$).
<sup>g</sup> Group 3 vs. 5 $X^2=4.993$ ($P<.05$).
<sup>h</sup> Group 2 vs. 4 $X^2=7.316$ ($P<.01$).
<sup>i</sup> Group 3 vs. 1 $X^2=7.360$ ($P<.01$).
<sup>j</sup> Group 3 vs. 4 $X^2=14.102$ ($P<.005$).
<sup>k</sup> Group 3 vs. 5 $X^2=8.798$ ($P<.005$).
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and estradiol has been reported by Foote, Quevedo and Saiduddin (1965). Foote and Call (1969) found that the group receiving estradiol+progesterone+PMS required a shorter period for uterine involution after parturition during the anestrous season. Data in this trial also showed the same trend, because the period from treatment to lambing was shorter for treated groups than for the control group.

Additional administration of estradiol at the end of progesterone injection reduced conception rate. Wagner (1964) reported that the use of estradiol to supplement the estrogen from a PMS-induced follicle reduced the conception rate significantly in spring lambed ewes. Pursrottam, Mason and Pincus (1961) reported that progesterone can completely block and estrogen can partially block ovulation in PMS and HCG treated immature mice. It may be possible that additional estradiol at the end of progesterone treatment blocked ovulation, in this trial. However, Hulet and Foote (1967) increased conception rate by use of estrogen, 30 hr. after last progesterone treatment in fall lambed lactating ewes. This contradictory effect of estradiol in different seasons may be due to a seasonal effect. The treatment differences in conception response indicate an interaction of some or all of these hormones either in terms of inhibition or synergism, depending on season of the year.

Summary

To control the induction of estrus during the normal breeding season, 196 2- to 7-year-old Karakul ewes were randomly divided into three groups and treated as follows: 73 ewes received 1 mg CAP daily for 15 days, (group 1); 73 ewes treated the same as group 1, plus 2 mg estradiol 17-β on the first day of feeding CAP (group 2); and the remaining 50 ewes served as controls, (group 3).

The number of ewes showing estrus during the first 4 days following treatment was significantly greater than the controls (P<.01). The mean number of days from starting treatment to lambing, decreased in case of CAP group as compared to control group. Estradiol had no effect on either synchronization of first estrus or on ewes lambing to mating at first synchronized estrus as compared with CAP group. With respect to the interval from starting treatment to lambing dates, the CAP+estradiol treated group was intermediate between CAP treated and control groups. Lamb crop, based on the number of ewes per group, was 96% for the CAP group; 97% for the CAP+estradiol group; and 100% for the control group.

In a second experiment, 171 of mature Karakul lactating ewes from previous experiment were randomly divided into five groups. The average postpartum period (average 20 days, range 6 to 29 days) was approximately equal for all the groups at the time treatment was started. They were treated as follows: (1) Progesterone (seven injections of 20 mg each on alternate days, (2) same as (1) except 2 mg estradiol 17-β at the time of first injection of progesterone, (3) same as (2) except that 4 mg estradiol was injected, (4) same as (2) except an additional injection of 2 mg estradiol at the time of last injection of progesterone and (5) control. All four treated groups also received two injections of 1,000 IU PMS at 17 day intervals; the first one was injected about 36 hr. after the last progesterone treatment.

Estrous synchronization was relatively good in the treated groups, and all were significantly different as compared to the control group. The number of live lambs per group was increased in progesterone+4 mg estradiol as compared to progesterone, progesterone+2 (2 mg estradiol) and control (P<.01). Estradiol increased the lamb crop when given at the beginning of the progesterone treatment but not when given at the end.

Literature Cited


