EFFECTS OF EWE BREED AND RAM EXPOSURE ON
ESTROUS BEHAVIOR IN MAY AND JUNE

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ABSTRACT
Two groups of purebred ewes (A and B), each consisting of 25 Dorsets and 25 Hampshires,
were used to study effects of ewe breed and ram exposure on ovulation and estrus in May and
June. Ewes lambed in January and February and were isolated from mature rams for at least 5 mo.
From May 8 to June 11 (Period 1), Group A ewes were penned with vasectomized rams fitted with
marking harnesses and Group B ewes were isolated from rams. From June 11 to July 13 (Period 2),
rams were placed with Group B ewes and Group A ewes were isolated from rams. Ovulation was
monitored by biweekly serum progesterone assays and crayon marks were used to detect es-
trus. For Group A ewes in Period 1, more Dorsets ovulated (96%) than did Hampshires (72%), and
of ewes that ovulated, more Donets mated (83 vs 28%). Fifty-five percent of Dorsets, but only
20% of Hampshires, appeared to have been spontaneously cycling at the start of the experiment.
Of ewes mated in Period 1, more Dorsets than Hampshires continued to cycle during Period 2 (65
vs 0%). For Group B ewes in Period 1, 44% of Dorsets, but only 8% of Hampshires, ovulated in the
absence of rams. In Period 2, 92% of Dorsets and 84% of Hampshires ovulated. Of ewes that
ovulated, more Dorset ewes mated (78 vs 52%). Of ewes that mated, more Dorsets appeared
to be cycling spontaneously at ram introduction (39 vs 0%). Throughout the study, 24% of Dorsets,
but no Hampshires, cycled continuously. Thus, Dorsets had higher levels of spontaneous ovarian
activity in May and June, but Hampshires were capable of responding to ram introduction, especial-
ly in June.
(Key Words: Sheep, Breeds, Rams, Ovulation, Estrus, Progesterone.)

Introduction
Domestic ewes generally exhibit estrus from
late summer through mid-winter. During spring,
most, if not all, ewes have an anestrous period
when ovulation and behavioral estrus do not
occur. This period of sexual inactivity sharply
limits the annual reproductive rate of the ewe.
Ewes that are exposed continuously to rams
exhibit a characteristic breeding season and an-
estrus (Dufour et al., 1982; Fahmy and Dufour,
1986). However, if ewes are preconditioned by
a period of isolation from rams (Oldham, 1980),
subsequent reintroduction of males can stimu-
late ovulation and estrus at times when ewes
that have been continuously exposed to rams
are still anestrous (Watson and Radford, 1960;
Knight et al., 1978; Oldham, 1980). This phe-
nomenon has been termed the ram effect.
The ram effect is a useful tool, but it has
limitations. Although ewes generally ovulate in
response to ram introduction within 54 h (Old-
ham et al., 1978), the first ovulation following
introduction of rams (teasing) usually is not ac-
companied by behavioral estrus (Oldham and
Martin, 1978; Knight et al., 1981). Also, a size-
able proportion of ewes may not respond to
teasing or may return to anestrus after one or
two ovulations and without mating (Oldham
and Cognie, 1980). The response to the ram
effect also depends on the time of ram introd-
uction relative to the normal breeding season (Old-
ham and Cognie, 1980). Dorset (D) ewes have
been shown to have an extended breeding sea-
son (Dufour, 1974; Hall et al., 1986) and to be
superior to Hampshire (H) ewes in breeding
ability in late July and early August (Christen-
son, 1983). Thus, the objective of this study
was to compare the ability of D and H ewes to
cycle spontaneously or after ram introduction
in May and June, and to continue cycling after
ram removal in June.
Materials and Methods

Animals. Fifty purebred H and 50 purebred D ewes were used. Ewes were chosen at random from the first 54 (of 86) D and from the first 56 (of 70) H that lambed in the Virginia Polytechnic Institute (VP1) purebred flocks. Lambing dates ranged from January 1 to February 18 and averaged January 26 ± 2 d for D and January 18 ± 1 d for H. Thus, H ewes lambed earlier (P < .01) than D ewes. Ewes averaged 4.0 yr of age, and the two breeds did not differ in mean age of ewe. Dorset ewes were sired by nine rams. Five of the rams had been produced within the VPI flock, and four had been purchased from other flocks. Hampshire ewes were sired by five rams; all but one of these rams were produced outside the VPI flock.

Lambs were weaned on either April 11 or April 18. Ewes had been isolated from mature rams since the previous fall breeding and were shorn 1 wk before the beginning of the study on May 8. Mean weights at the start of the study were 80 ± 1 kg for H and 64 ± 1 kg for D. Condition scores (1 = extremely thin; 9 = extremely fat) were determined by three independent scorers by palpation over vertebrae, ribs and tailhead and averaged 5.6 ± .2 for H and 5.1 ± .2 for D. Ewes were divided into two groups, A and B, each consisting of 25 D and 25 H ewes. Ewes within each breed were allocated to treatments such that lambing dates were approximately equalized between the groups. Ewes then were moved to one of two open pastures at Blacksburg, VA. The predominant forage was fescue, and the pastures were separated by approximately 4 km. Water was provided ad libitum, and no supplemental feed was given.

On May 8, three vasectomized teaser rams were placed with the Group A ewes in Pasture 1. Teaser males were mature crossbred rams possessing varying percentages of D, Finnsheep, Rambouillet, Coopworth and Barbados Blackbelly breeding. Rams were fitted with crayon-equipped marking harnesses to allow detection of mating activity. On May 8, Group B ewes were placed in Pasture 2 without rams. No rams were housed within 4 km of Pasture 2 during the study, and no rams had been on Pasture 2 since the previous fall.

Ewes remained at these locations until June 11. Every Tuesday and Friday throughout the period ewes in both groups were bled via jugular venipuncture, and Group A ewes were checked for evidence of mating. Ewes in Pasture 2 (isolated from rams) were handled before ewes in Pasture 1 to prevent isolated ewes from being exposed to the scent of rams (Knight and Lynch, 1980a, b) carried via clothing or hands. The color of the crayons worn by the rams with the Group A ewes was changed on May 21 and June 7 to detect repeated matings. The original three vasectomized rams were replaced with three comparable rams on May 24 to counter decreasing physical condition to the rams and to provide additional potential mating stimulus from the introduction of new males.

On June 11, Group A ewes were removed from the vasectomized rams and transported to Pasture 2, and Group B ewes were brought to Pasture 1 and exposed to vasectomized rams. All ewes were bled, and Group B ewes were checked biweekly for evidence of mating until July 13. Again, isolated ewes were handled first. The color of the marking crayons worn by the rams was changed on June 25, and the original vasectomized rams were replaced on June 28 with three different rams.

Ewes that first mated before 17 d of ram exposure were considered to have cycled spontaneously, whereas ewes that first mated after 17 d of ram exposure were considered to have been induced to cycle by the ram effect. Two peaks of estrous activity generally are seen in flocks of teased ewes (Oldham and Martin, 1978). The first occurs approximately 18 d after ram introduction, and the second occurs about 6 d later. This pattern occurs because expression of behavioral estrus appears to require preconditioning of the neuroendocrine system by a period of elevated circulating progesterone. In the cycling ewe, this preconditioning is provided by the corpus luteum (CL) from the previous ovulation, but is absent at the first ovulation following anestrus (Oldham et al., 1978). Hence, following ram-induced ovulation, some ewes develop a CL with a normal life span (14 d) but do not exhibit estrus. These ewes subsequently exhibit estrus at their second ovulation. The second peak of estrous activity occurs around d 24 and is made up of ewes that experienced premature regression of the initial CL at about d 6 (Oldham and Martin, 1978; Legan et al., 1985). After premature regression of this CL, these ewes ovulate a second time (again without estrus) and then develop a CL with a normal life span, which provides progesterone priming sufficient to allow estrus at the subsequent (third) ovulation.
Blood Handling and Hormone Assay. Immediately after collection, blood samples were stored together at room temperature out of direct sunlight for approximately 1 h to allow samples to clot. Samples then were centrifuged at 1,972 \( \times g \) for 20 min at 4°C, and plasma was decanted and frozen at -20°C. After all samples had been collected, plasma was assayed for progesterone (P4) content using radioimmunoassay techniques described by Beal et al. (1986). All samples were randomized before beginning the assays, were assayed in duplicate and were reevaluated if P4 concentrations of the duplicates differed by more than 25% and .1 ng/ml. The intraassay and interassay coefficients of variation were 11.4% and 13.7%, respectively.

Progestosterone Profile Interpretation. Precise P4 concentrations on a particular day were not required to evaluate the ovarian state of individual ewes. Rather, relative values within each animal among sampling times gave the necessary information to determine whether a ewe was cycling or in an anestrous state. Three general types of P4 profiles were expected: uniform baseline values, short luteal phases, and normal 14-d luteal phases. Baseline P4 values were considered to be those of less than .2 ng/ml. Increases above baseline that were maintained for three consecutive bleedings were considered indicative of a normal ovarian cycle of approximately 17 d. Ewes with premature regression of the CL were expected to have a transient elevation in P4 lasting 2 to 7 d before the prolonged P4 elevation of a normal CL (Knight et al., 1981). However, the biweekly bleeding schedule may not have allowed detection of all short luteal phases.

Statistical Analysis. Differences between D and H ewes in frequency of occurrence of the various events (ovulation, mating, etc.) were tested by t-test. Binomial standard errors (SE) for each frequency were calculated as \( \sqrt{p(1-p)/n} \), where p is the frequency of occurrence of the event. The standard error of the difference (SE\(_D\)) between frequencies of Dorset and Hampshire ewes was calculated as \( \sqrt{SE_D + SE_H} \). The associated t-statistic was calculated as (p_D - p_H)/SE\(_D\) and compared to standard tabular values to determine significance.

Results and Discussion

Frequencies of Ovulation and Estrus. In Group A (Table 1), more D than H ewes ovulated (P < .01) in May, and more of the ewes that ovulated mated (P < .01). Hence, many more D ewes than H ewes mated in May (P < .01). This observation is in agreement with literature that suggests that use of D breeding increases ability to mate in spring (Thomas and Whiteman, 1979).

Of Group A ewes that mated in May, there was no significant difference between breeds in frequency of spontaneous cycling. No H ewes that mated in May continued to ovulate in June after rams were removed, but 65% of the D ewes continued cycling after ram removal. Hampshire ewes that responded to the ram effect apparently had one or two estrous cycles and then returned to anestrus.

Group B ewes exhibited similar breed differences in reproductive activity to Group A ewes, except for ovulation percentage. Compared with counterpart ewes exposed in May, H ewes exposed to rams in June ovulated and mated at a higher rate, whereas D ewes had comparable ovulation percentages in May and June (Table 2). Before rams were introduced on June 11, almost half (44%) the Group B Dorset ewes had ovulated, but only 8% of the H ewes

<table>
<thead>
<tr>
<th>Item</th>
<th>Dorset</th>
<th>Hampshire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovulated/total</td>
<td>24/25 (96%)</td>
<td>18/25 (72%)**</td>
</tr>
<tr>
<td>Mated/ovulated</td>
<td>20/24 (83%)</td>
<td>5/18 (28%)**</td>
</tr>
<tr>
<td>Mated/total</td>
<td>20/25 (80%)</td>
<td>5/25 (20%)**</td>
</tr>
<tr>
<td>Spontaneous cycle/mated(^a)</td>
<td>11/20 (55%)</td>
<td>1/5 (20%)</td>
</tr>
<tr>
<td>June ovulation/May mated</td>
<td>13/20 (65%)</td>
<td>0/5 (0%)**</td>
</tr>
</tbody>
</table>

\(^a\)Includes only those ewes that first mated before 17 d of ram exposure and were therefore assumed to have cycled without benefit of the ram effect.

**Breed differ (P < .01).
TABLE 2. OVULATION AND ESTRUS IN EWES EXPOSED TO RAMS IN JUNE

<table>
<thead>
<tr>
<th>Item</th>
<th>Dorset</th>
<th>Hampshire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovulated in May/total</td>
<td>11/25 (44%)</td>
<td>2/25 (8%)*</td>
</tr>
<tr>
<td>Ovulated in June/total</td>
<td>23/25 (92%)</td>
<td>21/25 (84%)</td>
</tr>
<tr>
<td>Mated/ovulated</td>
<td>18/23 (78%)</td>
<td>11/21 (52%)*</td>
</tr>
<tr>
<td>Mated/total</td>
<td>18/25 (72%)</td>
<td>11/25 (44%)*</td>
</tr>
<tr>
<td>Spontaneous cycle/mated(^a)</td>
<td>7/18 (39%)</td>
<td>0/11 (0%)*</td>
</tr>
</tbody>
</table>

\(^a\)Includes only those ewes that first mated before 17 d of ram exposure and were therefore assumed to have cycled without benefit of the ram effect.

\(^*\)Breeds differ (P < .05).

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Ovulated in the absence of rams. After rams were introduced, a large proportion of the ewes of each breed ovulated. The percentage of H ewes that mated of those ovulating was nearly double the percentage observed in May. Thus, compared with May, when most of the H ewes that ovulated did not show estrus, many more ewes in June had ovulations that were accompanied by estrus.

About the same total percentage of D ewes mated in each group, but over twice as many H ewes mated in June as in May. All the H ewes that mated in June mated after 17 d of ram exposure and therefore were assumed to have been induced to mate by the ram effect. Thus, there appears to be a trend toward increased estrous activity in June for H ewes, whereas estrous behavior in D ewes was fairly consistent over the 2 mo. The percentage of D ewes that ovulated in May in the absence of rams (44%) was exactly equal to the proportion that apparently cycled spontaneously and mated when exposed to rams in June (39%).

The increased estrous activity exhibited by H ewes in June may indicate that these ewes were approaching the onset of their natural breeding season and were more easily stimulated by the rams, even though the frequency of spontaneous cycling was still zero in both months for the H ewes. This would provide evidence that H ewes are in a "deeper" anestrus in late spring than in early summer.

Average previous lambing dates for ewes that mated were compared to those of ewes that did not mate (Table 3). The H ewes in both groups that mated had lambed earlier than those that did not mate, but no comparable effect was found for D ewes. Hence, H ewes that lambed early were more likely to show behavioral estrus upon ram introduction 4 to 5 mo postpartum.

**Progesterone Profile Analysis.** Assessment of biweekly serum P4 concentrations throughout the study revealed five distinct P4 patterns (Table 4).

TABLE 3. AVERAGE LAMBING DATES AND STANDARD ERRORS FOR EWES THAT DID OR DID NOT MATE\(^ab\)

<table>
<thead>
<tr>
<th>Group</th>
<th>Mated</th>
<th>Did not mate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hampshire Group A</td>
<td>9.2 ± 3.4 (5)</td>
<td>19.9 ± 2.1 (20)*</td>
</tr>
<tr>
<td>Hampshire Group B</td>
<td>13.3 ± 2.4 (11)</td>
<td>21.5 ± 2.4 (14)*</td>
</tr>
<tr>
<td>Dorset Group A</td>
<td>24.0 ± 2.9 (20)</td>
<td>28.0 ± 3.3 (5)</td>
</tr>
<tr>
<td>Dorset Group B</td>
<td>24.2 ± 2.9 (18)</td>
<td>33.0 ± 4.5 (7)</td>
</tr>
</tbody>
</table>

\(^a\)Numbers in parentheses indicate number of observations.

\(^b\)Julian date.

\(^*\)Means within a row differ (P < .05).
TABLE 4. EWE BREED PROGESTERONE PROFILE TYPES

<table>
<thead>
<tr>
<th>Profile type</th>
<th>% Dorset</th>
<th>% Hampshire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Continuous</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Induced</td>
<td>44</td>
<td>76</td>
</tr>
<tr>
<td>Terminated</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Intermittent</td>
<td>22</td>
<td>0</td>
</tr>
</tbody>
</table>

*a*Defined in text.  
*b*Based on 50 ewes.

The "baseline" category encompassed ewes whose 
P_4 values remained below .2 ng/ml throughout the study. These ewes apparently were in an anestrous state and did not respond to ram introduction. Ten H ewes, but only two D ewes, remained at baseline P_4 levels throughout the 68 d of the experiment.

The "continuous" category (Figure 1) represented ewes that ovulated continuously throughout the experimental period. Twelve D, but no H, ewes were in this category. All ewes with this profile mated when ovulation occurred and rams were present. Thus, the anestrous period of these ewes did not fall within the 68 d of the experimental period. The data do not indicate when, or if, these ewes experienced anestrus. There are indications that some proportion of the D ewes within a flock will always be cycling (Phillips et al., 1984) and that some individual D ewes cycle continuously throughout the year (Hall et al., 1986).

The "induced" category encompasses a large percentage of ewes from both breeds and includes two subtypes of responses: those ewes that responded to rams in the expected manner by ovulating within 4 d of ram introduction and those that first ovulated 10 to 25 d after ram exposure.

Thirteen D and eight H ewes entered the study with baseline P_4 values and then ovulated within 4 d of ram introduction (Figure 2). The first ovulation was silent, and in all cases the first CL lasted a normal 14 d. At the second ovulation, behavioral estrus was exhibited and all ewes mated. Seven of these 21 ewes were from Group A and thus were exposed to rams in May. When rams were removed in June all of these ewes returned to an anestrous state for the remainder of the study. Hence, the ewes were anestrous, ovulated twice, mated at second ovulation and then returned to anestrus upon ram removal. The remaining 14 ewes were from Group B; no information is available for these ewes after rams were removed. Oldham and Cogemie (1980) have reported that many ewes ovulate and then return to anestrus before mating. However, in this study a large portion of ewes also mated, but still returned to baseline P_4 levels.

Nine D and 30 H ewes made up the second subtype of response to ram induction. Instead of responding to teasing within the expected 4 d of ram introduction, these ewes first ovulated (without estrus) 10 to 25 d after ram introduction. Two D and 16 H ewes of this subtype were from Group A. Both D and 12 of these H ewes ovulated once without estrus and immediately returned to anestrus after ram removal (Figure 1).
3). Three of the remaining four H ewes mated at their second ovulation and stopped ovulating upon ram removal. The other seven D and 14 H were from Group B. These ewes first ovulated (without estrus) so late in the study that bleeding had been discontinued prior to a possible second ovulation. Three D and seven H ewes exhibited an apparent short luteal phase after the first ovulation, as indicated by a transient rise in P4 level 4 to 7 d before the sustained rise indicative of a normal CL phase (Figure 4).

The response to the ram effect appears more variable than previously reported. In some ewes, there appears to be a delayed response to teasing, which may coincide with the approaching normal breeding season. However, the majority of the Group A ewes still returned to anestrus after ram removal.

The fourth type of P4 profile was the "terminated" profile. Three D and one H ewe with this profile were in Group A and ovulated immediately at the onset of the study. These ewes continued to cycle until ram removal, at which time they ceased cycling for the remainder of the study (Figure 5). One additional H ewe in Group B ovulated at the beginning of the study but ceased cyclic activity prior to ram introduction. It is difficult to determine if these ewes were affected by the presence of the rams or were spontaneously cycling but then became anestrous.

The final type of profile was "intermittent." Eleven D ewes and no H ewes were in this category. Generally, ewes with this profile showed some ovulatory activity early in the study, followed by baseline P4 levels for about 2 wk, with a subsequent return to cyclicity. Within this type, ewes showed several different subtypes. Six of the D ewes fell into a fairly consistent subtype. All six ewes were in Group B and had one period of elevated P4 at the beginning of the study. After completion of the one cycle, P4 levels fell to baseline for 6 to 9 blood sampling periods. Then, upon the introduction of rams, ewes responded by ovulating within 3 to 7 d, presumably in association with the ram effect (Figure 6). Two of the ewes mated at their first ovulation, whereas the other four had an ovulation without estrus, followed by an ovulation with estrus. At this time all four ewes mated. Three of these ewes showed apparent short luteal phases before the first normal luteal phase. Thus, these ewes apparently had spontaneously initiated cyclic behavior by May 8, then became anestrous, but were capable of responding to ram introduction on June 11. These ewes may have been inadvert-
Figure 6. Progesterone profile of a Group B Dorset ewe that ovulated at the beginning of the study while isolated from rams, experienced a period of anestrus, and subsequently responded to the ram effect upon ram introduction. Vertical arrow indicates mating.

Conclusions

There were clear breed differences in ovarian activity throughout the study. Substantial numbers of D ewes, but no H ewes, cycled continuously, whereas 20% of H ewes, but only 4% of D ewes, were in the baseline profile type. The high level of sexual activity of D ewes was consistent with previous research, but the large number of H ewes that responded to ram introduction was unexpected. Even though many more D ewes cycled spontaneously in the study, many H ewes also were able to respond to rams by ovulating during this period.

Generally, both D and H ewes can be stimulated to ovulate in May and June. However, many H ewes ovulated without estrus and subsequently returned to anestrus, whereas many D ewes that responded to ram introduction in May continued to cycle in June after ram removal. Thus, whereas ewes of both breeds could ovulate in response to ram introduction, a larger proportion of D ewes exhibited behavioral estrus, mated and continued to cycle. Of H ewes that ovulated, more showed an accompanying behavioral estrus in June. Possibly, H ewes were beginning to terminate their anestrus toward the beginning of July.

Although breed differences in ovarian activity and response to ram introduction were expected, the amount of variation within each breed was surprising. Apparently, individual differences in timing and duration of anestrus and in ability to respond to rams accounted for these differences. Differences in depth, length and timing of anestrus within each breed are indicated. Although both breeds did respond favorably to ram introduction, the D ewes appear to be a more desirable source of genetic material for out-of-season breeding, because even those ewes that were not cycling spontaneously were able to be stimulated by rams and subsequently continued to cycle.

Literature Cited


