MOTION PICTURE ANALYSIS OF EJACULATION IN THE BULL

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Summary. The following criteria, expressed as average figures, were evaluated from motion pictures of ejaculation in the bull: (1) the length of the penis extension from the entrance of the artificial vagina (AV) was 53.4 cm, (2) the time between initial contact of the penis with the AV and the initiation of semen emission was 0.97 sec, and (3) the semen emission time was 0.29 sec. Coiling of the glans penis was observed in about half of the ejaculates, ranging from a slight twist to a 360° counter-clockwise coil 6 cm in outside diameter. There was a rhythmic movement of the fore-limb dew claws during ejaculation which appears to be a characteristic of sexual behaviour in the bull. Various abnormalities were observed in thrust and semen emission patterns using a short, low temperature AV. The large amounts of semen lost on the sides of the experimental AV suggest that an AV of proper length should be used for each bull.

INTRODUCTION

Recent evidence indicates that sperm losses in the artificial vagina (AV) for bulls amount to 12 to 14% of the ejaculate (Foote & Heath, 1963; Seidel, 1968). These losses may be related to the pattern of semen emission in the AV. Bonadonna (1956) observed that emission normally occurred at the time of maximum extension of the penis. This study was initiated to obtain more information about the pattern of ejaculation in normal bulls.

MATERIALS AND METHODS

Semen was collected from eight 3-year-old Holstein-Friesian bulls at weekly intervals for 7 weeks. One ejaculate was collected per bull during the 1st week and two successive ejaculates were taken at 50-min intervals on each collection day thereafter. During the first 5 weeks, a 30-cm AV coupled to a 45-cm lucite extension tube was used at a temperature of 55°C. During the 6th and 7th weeks, this AV at 55°C and a 15-cm AV with the lucite extension at 40°C were used. The two AVs were used consecutively and in both orders for first and second ejaculates. After the 1st week of semen collection, 16-mm colour motion pictures
were taken of the penis through the transparent lucite tube. Ektachrome type B film was used at 64 frames per second (fps). During the 4th week, motion pictures were taken of the entire bull during semen collection at 24 fps.

Data obtained during Weeks 3, 4 and 5 were subjected to the analysis of variance assuming a complete factorial design comprised of the factors: bulls, weeks, and successive ejaculates. Ejaculate volume, sperm concentration, and initial progressive motility of spermatozoa were determined for each ejaculate. The following criteria were estimated by examining the film with a viewer or dissecting microscope: (1) the length of the penis extension from the AV entrance; (2) the stimulus time, defined as the time elapsing from contact of the penis with the AV until the emission of semen began, (3) the actual semen emission time, and (4) the degree of coiling of the penis. Criteria 2 and 3 were determined by counting the number of frames between events, and multiplying by the frame time of 1/64 sec. The degree of coiling of the penis was assigned numerical values as described in Table 1.

Intense sexual preparation was maintained throughout the experiment. A padded steel dummy was used exclusively for the collection of semen from one of the bulls, and similar collections were made from several of the other bulls during the first few weeks.

RESULTS AND DISCUSSION

Means for Weeks 3 to 5 are presented in Table 1. The AV at 55° C was used for semen collections during this period. The average values for the ejaculates were a volume of 6.4 ml, a sperm concentration of 1.58×10⁹ spermatozoa/ml and an initial motility of 58%. Bull differences in length of penis extension were not large (P<0.1), but were substantial considering that bulls were of similar age (33 to 41 months). Bull differences are likely to be greater in the general population, indicating the desirability of providing AVs of appropriate length for different bulls. Bulls also differed in stimulus time (P<0.05) and the amount of coiling of the penis (P<0.005). There was more coiling with first than with second ejaculates (P<0.05). Subjectively, the coiling appeared to be associated with the more vigorous thrusts. All bulls showed coiling to some extent (Table 1), suggesting it is a normal occurrence. Coiling previously recorded (Carroll, Ball & Scott, 1963; Ashdown & Coombs, 1967) was usually observed before mating or during electro-ejaculation and, under these conditions, may have been an abnormality.

An increase in length of penis extension and semen emission time occurred in the course of the experimental period and means of 8.2, 9.9 and 10.9×10⁹ total spermatozoa per ejaculate for Weeks 3, 4 and 5, respectively, also reflect an increase, suggesting a more effective removal of spermatozoa from the epididymis. These increases may have resulted from incomplete adjustment to the experimental regimen, although the first 2 weeks' data were discarded.

Significant (P<0.05) correlation coefficients obtained were r = −0.33 between stimulus time and ejaculate volume, r = −0.30 between stimulus time and total spermatozoa per ejaculate, and r = −0.30 between stimulus time and length of penis extension. Since a long stimulus time represented a slow thrust,
these correlations suggest that improper preparation or stimulation leads to a less vigorous thrust and fewer spermatozoa per ejaculate.

From the data obtained, an approximate diagram of the position and rate of movement of the tip of the penis during a typical ejaculation was prepared (Text-fig. 1). Semen emission normally occurred when the penis was fully extended or slightly earlier. The relative position and rate of movement of the penis just before the thrust, and especially after emission, depended in part upon the collection technique. Ejaculations with the AV at 55° C did not involve multiple thrusts or emissions. However, many of the ejaculations using the AV at 40° C did not fit the normal pattern of Text-fig. 1. Evaluation of these was more subjective and, therefore, trends rather than numerical values are presented for Weeks 6 and 7.

**Table 1**

**Means of Main Effects**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor level</th>
<th>Length of penis extension (cm)</th>
<th>Stimulus time (sec)</th>
<th>Semen emission time (sec)</th>
<th>Frequency distribution of coiling&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mean coiling&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeks</td>
<td>3</td>
<td>49.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.05</td>
<td>0.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8 3 1 4</td>
<td>1.06</td>
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<tr>
<td></td>
<td>4</td>
<td>54.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00</td>
<td>0.30</td>
<td>9 2 3 2</td>
<td>0.88</td>
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<td></td>
<td>5</td>
<td>56.0</td>
<td>0.85</td>
<td>0.32</td>
<td>6 1 6 3</td>
<td>1.38</td>
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<tr>
<td>Ejaculates</td>
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<td>0.90</td>
<td>0.30</td>
<td>8 3 6 7</td>
<td>1.50&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>52.0</td>
<td>1.06</td>
<td>0.29</td>
<td>15 3 4 2</td>
<td>0.71</td>
</tr>
<tr>
<td>Bulls</td>
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<td>1.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.29</td>
<td>2 1 0 3</td>
<td>1.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>49.9</td>
<td>1.29</td>
<td>0.33</td>
<td>3 0 2 1</td>
<td>1.17</td>
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<td>50.6</td>
<td>0.98</td>
<td>0.31</td>
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<td>1.50</td>
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<td>0.86</td>
<td>0.27</td>
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<td>0.30</td>
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<td>0.87</td>
<td>0.27</td>
<td>3 3 0 0</td>
<td>0.50</td>
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<td>Grand mean or total</td>
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<td>53.4</td>
<td>0.97</td>
<td>0.29</td>
<td>23 6 10 9</td>
<td>1.10</td>
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</table>

<sup>a</sup> = Statistical significance within the array, P<0.005; <sup>b</sup> P<0.05; <sup>c</sup> P<0.10. <sup>d</sup> = 0 = no coiling; 1 = slight coiling; 2 = moderate coiling; 3 = extensive coiling (~360°). <sup>e</sup> = Non-parametric techniques were used for statistical tests of coiling.

Greater coiling of the penis appeared to be positively related to the length of penis extension and negatively related to stimulus time. There was much less coiling associated with the shorter AV at the lower temperature used in sequence with the standard AV during Weeks 6 and 7. This low level stimulus treatment also resulted in slightly less extension of the penis and a longer semen emission time. With this treatment, semen emission sometimes lasted longer than a second and often there were multiple emissions. Such ejaculates were high in volume and low in sperm concentration. The penis was often extended and retracted several times.

Plate 1 depicts a coiling sequence enlarged from the motion pictures of semen ejaculation. Emission of semen continued for a number of frames beyond
Pl. 1, Fig. 3 and lasted for 0.29 sec. If the sequence shown in Pl. 1 is taken as representing maximum coiling, the amount of coiling shown in Pl. 1, Fig. 2 would be coded as 2 and that shown in Pl. 1, Fig. 3 as 3 (Table 1). The coil was retained, in part, for a total of 0.51 sec. The pattern and duration of coiling and the relationship between coiling, semen emission and maximum penis extension varied with ejaculates. An ejaculate without coiling of the penis appeared essentially as an extension of Pl. 1, Fig. 1.

![Time-motion study of approximate movements of the penis during semen collection with an artificial vagina (AV).](image)

**TEXT-FIG. 1.** Time-motion study of approximate movements of the penis during semen collection with an artificial vagina (AV). The solid line represents observations made through the lucite extension of the AV and the dashed lines represent extrapolations. The ordinate is an indication of penis extension.

The potential semen loss from spermatozoa adhering to the side of the AV is shown well in Pl. 1, Figs. 2 and 3. Much of this loss could be avoided with a shorter AV which would allow emission to occur nearer the collecting cone, though the optimum length of AV would vary for individual bulls (Table 1). It appears that the photographic method can be used to determine this optimum for any set of conditions.

A rhythmic wiggling of the fore-limb dew claws was observed in the motion pictures during semen collection. These dew claws represent vestigial second and fifth digits. The significance of this phenomenon is unclear; it may be associated with sexual excitement.

The study of feet and leg movements during Week 4 showed both rear feet leaving the ground during thrusting in thirteen of fifteen collections and one rear foot left the ground in the other two cases. In this behaviour pattern, the bulls studied appeared to be normal (Hafs, Knisely & Desjardins, 1962).

Additional features can best be observed in the motion picture film. A 7-min 16-mm colour film was prepared highlighting several of the features seen in the experimental film (Seidel & Foote, 1967).
Sequence showing ejaculation in the bull, omitting several of the consecutive frames. Lines on the artificial vagina (AV) were 5 cm apart.

Fig. 1. This picture, showing the first drop of semen emitted, was taken approximately 0-45 sec after the initiation of thrust into the AV.

Fig. 2. Formation of the coil photographed approximately 0-06 sec after Fig. 1.

Fig. 3. Complete coiling of the penis approximately 0-19 sec after Fig. 1.
ACKNOWLEDGMENTS
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REFERENCES