SEXUAL ACTIVITY AND SEMEN PRODUCTION OF RAMS AT HIGH TEMPERATURES

D. R. LINDSAY*

Department of Animal Husbandry, University of Sydney, Sydney, Australia

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Summary. The sexual activity of groups of Merino, Dorset Horn and Border Leicester rams, from which weekly semen collections were made by artificial vagina, was studied at controlled temperatures from 27 to 43°C. Only Merino rams maintained sexual activity at the highest temperature (43°C). Dorset Horns recovered activity after the temperature was lowered but Border Leicesters did not. Semen motility was poor at high temperatures in all but two rams, both Dorset Horns. The Merino rams had shorter reaction times than the other breeds. There was no significant correlation between reaction time and number of ejaculates. The rectal temperatures of the Dorset Horn rams were 0.3 to 0.4°C lower than those of the Border Leicesters; Merinos were intermediate.

At a given ambient temperature, rams had lower rectal temperatures after severe heating than before, apparently owing to increased thermo-regulatory ability. Mounting and ejaculation resulted in virtually no rise in rectal temperature.

INTRODUCTION

Rams are said to exhibit little or no sexual interest in ewes for several weeks during the summer (McKenzie & Berliner, 1937; Ahmed, 1955; Hafez & Scott, 1962), though Pepelko & Clegg (1965a), with different techniques, found less marked seasonal variation than previous workers. Merino rams in the field in Australia maintain sexual interest during the summer, although there may be diminution in sexual activity (Dun & Restall, 1961). Moule (1950) obtained a marked increase in sexual activity of Merino rams during the spring after he had subjected them to rapidly decreasing hours of daylight. Shukla & Bhattacharya (1952a, b), on the other hand, found that, although the quality of semen collected by artificial vagina was higher in the spring than in the autumn in Indian breeds of sheep and goats, there was no variation in sexual activity, as measured by reaction time. Reaction time was defined as the interval between first contact with the teaser and ejaculation.

High temperatures depress the testicular activity and semen quality of the

* Present address: Institute of Agriculture, University of Western Australia, Nedlands, Western Australia.
ram (Phillips & McKenzie, 1934; McKenzie & Berliner, 1937; Gunn, Sanders & Granger, 1942; Bogart & Mayer, 1946).

The sexual behaviour of rams presents two problems. First, under natural conditions it is considerably influenced by the responsiveness of ewes. Since this varies seasonally, there is difficulty in providing a standard stimulus for the rams. Secondly, the measurement of sexual behaviour is itself difficult.

The experiments described here were designed to examine the effects of high temperatures on the sexual activity of rams.

MATERIALS AND METHODS

Four young rams of each of three breeds, Merino, Dorset Horn and Border Leicester, were obtained from studs in Central New South Wales in June 1962 and were put in temperature-controlled rooms, in which they had a cycle of 12 hr light and 12 hr darkness. Ten weeks were allowed for the rams to become adjusted to this regime, and for training to ejaculate into an artificial vagina after mounting an anoestrous ewe which was restrained in a crush. The rooms were kept at ambient temperature during this period but the temperature was not allowed to rise above 24° C. The crush for the ewe and all equipment for semen collection and examination were kept in the same room, so that semen collections could be carried out at experimental temperatures.

Management and feeding were kept constant as far as possible, and shearing was carried out monthly to avoid variation in the effect of wool cover on thermo-regulation (cf. Riek, Hardy, Lee & Carter, 1960). The animals were weighed fortnightly, and the quantity of available feed—good quality lucerne hay and oats—was adjusted so that they maintained a constant weight. Since air was recirculated with a minimum of exhauston, relative humidity remained consistently high throughout the experiment.

After 1 week at 21° C, during which eight collections were made from each ram to obtain some depletion of sperm reserves, the experiment was begun on 14th September 1962 with the room temperature at 27° C. This temperature was raised by 5-6° C each week to a peak of 43° C, after which the temperature was lowered by 5-6° C per week to 27° C. Experimental collections of semen were carried out over an 8-hr period on the last day of each week. During this day each ram was brought to the ewe eight times. If he had not mounted the ewe within 5 min and showed no inclination to do so he was returned to the other rams. In this way each ram was given an opportunity to ejaculate at hourly intervals.

On each occasion the following information was recorded: (1) whether the ram ejaculated; (2) reaction time (time in seconds from entry to the collection area until the ram ejaculated); (3) volume and (4) motility of spermatozoa (estimated subjectively from a microscopic examination of semen on a warm stage and scored 0 to 5); (5) rectal temperature at 1-hourly intervals throughout the day of collection.

RESULTS

Number of semen collections

Four hundred and seventy-six ejaculates were obtained from the twelve
Sexual activity at high temperatures

rams, out of 672 opportunities for services. The contributions of individual rams within breeds to treatment totals were found to be statistically homogeneous. There were significant differences between breeds ($\chi^2 = 111.8$; d.f. = 2; $P<0.001$). Ejaculates were obtained from the Merino rams at all temperatures, but from the Dorset Horn and Border Leicester rams less often at 43°C (Text-fig. 1). The sexual activity of Dorset Horns increased at low temperatures, but the lowered activity was more permanent in the Border Leicesters. There was a decline in the sexual activity of most rams and in semen production over the eight test periods on each day of collection. Nearly all ejaculated at the first attempt, but only the Merino rams remained consistently active throughout each day. At the higher temperatures, many rams of the other breeds needed longer than 1 hr to recover from each collection.

![Text-fig. 1. Effect of breed and temperature on number of ejaculates obtained from each group of four rams. Comparison among numbers of ejaculates at each temperature for: (a) □, Dorset Horn rams, $\chi^2 = 17.5; P<0.01$; (b) △, Border Leicester rams, $\chi^2 = 36.7$; $P<0.001$; (c) ○, Merino rams, $\chi^2 = 13.4; P<0.05$.](image)

**Characteristics of semen**

During the full series of daily collections, mean ejaculate volume decreased from about 0.40 ml from the first three to 0.23 ml by the last (eighth) collection. The Merino rams produced less semen per ejaculate, probably as a result of ejaculating more frequently.

The spermatozoa of the Merino and Border Leicester rams were less motile when the ambient temperature reached 38°C ($P<0.01$), but there was no reduction in the motility of spermatozoa from the Dorset Horn rams until after the temperature reached 43°C ($P<0.001$) (Text-fig. 2).

After the temperature was lowered, all rams displayed a delayed detrimental effect of the high temperatures on sperm motility but some recovery occurred at 27°C. This recovery was greatest among the Dorset Horn rams, and the motility
of their spermatozoa was least affected by the high temperatures. Successive hourly ejaculates during each day of collection did not differ in motility.

**Reaction times**

Mean reaction times are shown in Text-fig. 3. The Merinos had shorter
reaction times than the other rams and were generally unaffected by the high temperatures. Rams of the other breeds exhibited a delayed effect of the extreme temperatures; longest reaction times occurred 2 to 3 weeks after the severest treatment. Correlation coefficients for the number of collections made from each ram and their mean reaction times at each experimental temperature are given in Table 1. Merino rams were not included in the analysis since almost all rams of this breed ejaculated at each opportunity and the results were, therefore, not normally distributed. The correlation coefficients associated with each temperature were homogeneous, and a pooled correlation coefficient of $r = -0.27$ (Steel & Torrie, 1960, p. 190) was obtained. This was not significant.

### Table 1

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>-0.71</td>
</tr>
<tr>
<td>90</td>
<td>-0.58</td>
</tr>
<tr>
<td>100</td>
<td>-0.52</td>
</tr>
<tr>
<td>110</td>
<td>-0.12</td>
</tr>
<tr>
<td>100</td>
<td>0.24</td>
</tr>
<tr>
<td>90</td>
<td>0.23</td>
</tr>
<tr>
<td>80</td>
<td>-0.33</td>
</tr>
</tbody>
</table>

Pooled $r$, adjusted for bias (Steel & Torrie, 1960) = $-0.27$.

**Rectal temperatures**

Mean rectal temperatures are shown in Text-fig. 4, and the analysis of variance in Table 2. Dorset Horn rams had rectal temperatures from 0.3 to 0.4°C lower than Border Leicesters, with Merinos intermediate. Rectal temperatures at 27, 32 and 38°C were lower after than before rams had been subjected to an ambient temperature of 43°C. The effect of very high temperatures was presumably to promote increased thermoregulatory efficiency. Over the eight hourly collections rectal temperatures did not rise; this suggests that mounting and ejaculation involve little extra demand on thermoregulation.

**DISCUSSION**

The sexual activity of all rams, measured by ability to ejaculate hourly, is affected by high temperatures. The effect of temperature on Merino rams was slight compared with that on the rams of the other two breeds. In the latter, diminished activity was evident at high temperatures and persisted even after the temperature was lowered. The influence of changing day length on sexual activity in rams in the spring and early summer (Moule, 1950) may well be augmented by high temperatures. Probably, 1 or 2 hot days can lead to a...
protracted period of lowered sexual activity by the rams of at least some breeds. The reaction time of all the rams was affected by high environmental temperatures. However, only in Merinos were high temperatures reflected in immediate lengthening of mean reaction times, and these animals recovered completely at lower temperatures. Rams of the other two breeds in which heat stress was reflected in increased reaction times were most affected 2 or 3 weeks

**Text-fig. 4.** Effect of breed and ambient temperature on mean rectal temperature of groups of four rams: □, Dorset Horns; Δ, Border Leicesters; ○, Merinos.

**Table 2**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rams within breeds</td>
<td>9</td>
<td>0.5221</td>
</tr>
<tr>
<td>Breeds</td>
<td>2</td>
<td>1.9363*</td>
</tr>
<tr>
<td>Temperature</td>
<td>6</td>
<td>5.7300*</td>
</tr>
<tr>
<td>Temperature x Breed</td>
<td>12</td>
<td>0.1835*</td>
</tr>
<tr>
<td>Remainder</td>
<td>54</td>
<td>0.0782</td>
</tr>
</tbody>
</table>

*P < 0.001.

Mean squares for breed and temperature were tested against the temperature x breed interaction mean square. The interaction mean square was tested against the remainder.
after the most severe treatment. Smith (1966) similarly observed long reaction times in rams about 20 days after a short severe heat stress. No explanation can yet be given for this. In any case the relationship between reaction time and sexual activity, measured by numbers of services, was not high in these sheep \( r = -0.27 \). Pepelko & Clegg (1965b) obtained a higher figure of \( r = -0.45 \), taking the period from first ejaculate to the next mount as the reaction time. In neither case was the predictive value of the reaction time high enough to make it a reliable measure of sexual activity.

No relationship between semen quality (measured by motility) and intensity of sexual activity was found in our observations. The correlation observed by Wiggins, Terrill & Emik (1953) probably reflects long-term effects on either semen quality or behaviour, and is clearly not apparent after a brief heat treatment. The sperm motility of the Dorset Horn rams was interesting. Two rams maintained excellent motility after experiencing an environmental temperature of 43°C for 7 days. Little motility would have been evident in other breeds, after such severe treatment (Gunn et al., 1942; Bogart & Mayer, 1946).

The frequency with which rams breed with ewes under systems of free mating is high relative to that in other species (Lambourne, 1956; Hulet, Ercanbrack, Price, Blackwell & Wilson, 1963). Sustained copulation once every hour probably approaches the upper limit of sexual activity under the high temperature conditions of our experiments. Nevertheless, body temperatures did not rise during the period of intensive collection. "The sheep is not physiologically adjusted for exercise" (Lee, 1950) as far as heat regulation is concerned, so the amount of energy expended in mounting is evidently small. Hyperthermia, often associated with actively breeding rams in warm weather, is probably attributable to other activities such as fighting and chasing related to the development and maintenance of a dominance order (Lindsay, 1966). Rams joined singly with groups of 300 ewes showed little activity other than breeding, while rams joined in groups of six were very active in fighting and running (Haughey, 1959).

Acclimatization, reflected by body temperatures, appears to have occurred as a result of exposure to high temperatures. Such long-term adaptation has been demonstrated by Lee (1950) in sheep continuously held at high atmospheric temperatures for 3 weeks. The extent of this acclimatization, the duration of exposure to high temperature necessary to induce it, and the duration of exposure to lower temperatures needed to reverse it need to be examined. Exceptionally hot days in the spring and early summer would be expected to cause greater increases in body temperature than the same temperatures in late summer and autumn, owing to acclimatization during summer. For the same reason, experiments in which sheep have been alternately exposed to high and normal temperatures should be interpreted with caution.

Breed differences in heat tolerance of sheep have been demonstrated previously (Miller & Monge, 1946; Lee, 1950). Generally, Merinos have lower rectal temperatures and respiration rates than other breeds in hot environments. However, results presented here are not in agreement with those of Lee (1950), who found little difference between Border Leicesters and Merinos in their adaptability to artificially hot temperatures.
ACKNOWLEDGMENTS

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REFERENCES


