EFFECTS OF ENVIRONMENTAL TEMPERATURE, CONTROLLED FEEDING AND FASTING ON RUMEN MOTILITY

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When animals are exposed to varying environmental temperatures, numerous physiological adjustments occur. Of major importance in cattle, sheep and goats is the change in the amount of feed consumed (Johnson et al., 1963; Graham et al., 1959; Appleman and DeLouche, 1958). Davis and Merilan (1960) indicated an increase in digestibility and a decrease in ad libitum feed intake as a result of exposure to high environmental temperatures. More recent work along this same line suggests that the production of volatile fatty acids may be influenced by environmental temperature (Kelley, Martz and Johnson, 1967; Weldy et al., 1964). Since feed intake and volatile fatty acid production in the rumen are altered by environmental temperature, this study was undertaken to investigate the role that rumen motility may play in these changes. The objectives of this study were to measure the effect of temperature on rumen motility when feed intake was maintained at a constant level, and to determine if changes in rumen motility are influenced directly by environmental temperature rather than indirectly by changes in feed consumption resulting from differences in environmental temperatures. To pursue further the possible direct action of temperature on motility, the rumen contents were removed and motility measured during fasting at the higher environmental temperatures.

Experimental Procedure

Five adult Holstein cows, each fitted with a rumen cannula, were used in this experiment. These cows were housed in two controlled temperature chambers, one maintained at 18°C and the other changed to the various treatment temperatures prior to the animals' exposure. Approximately 1 week at 18°C was allowed between each exposure to the various temperatures. Following an adjustment period of 3 weeks at 18°C, the control-fed animals were exposed to environmental temperatures of 29°C and 35°C for 2 days to determine the effects of short term exposure on rumen motility. In another series of studies, the control-fed animals were exposed to 2°C and 38°C temperatures for 5-day periods prior to rumen measurements. On the last day of each of the various exposures to different temperatures, rumen motility recordings were made by the procedure of Colvin, Cupps and Cole (1958). This procedure utilized a writing lever actuated by a diaphragm which responded to pressure changes within the rumen, and a kymograph recorded the motility pattern.

Following these two series of studies in which the feed intake was maintained constant at all treatment temperatures by placing the refused feed in the rumen fistula, the animals were fasted for 14 hr. prior to exposure to the 1-day treatment temperatures of 29°C, 35°C and 38°C.

Fasting (Johnson and Yousef, 1966) was accomplished by complete removal of the rumen contents at 5 p.m. and their replacement with approximately 12 l. of water. Following exposure to the temperature treatment at 7 a.m., the animal's rumen activity was measured between 1 p.m. and 5 p.m., and the rumen contents, which upon removal had been placed in an insulated vat, were returned to the rumen at 5 p.m.

A complete ration of 50% coarsely ground hay (3.5 cm. screen), 45% grain and 5% molasses was fed. The grain ration consisted of 410 kg. corn, 162 kg. oats, 90 kg. barley, 67 kg. wheat bran, 67 kg. soybean meal (44%), 45 kg. dehydrated alfalfa (17%), 45 kg. blackstrap molasses, 11 kg. iodized, trace mineralized salt and 7 kg. dicalcium phosphate.

The data were analyzed by analysis of variance and Tukey's test, as described by Snedecor (1956).
TABLE 1. EFFECT OF EXPOSURE TO VARIOUS ENVIRONMENTAL TEMPERATURES AND FASTINGS ON RUMEN MOTILITY

<table>
<thead>
<tr>
<th>Environmental temperature °C.</th>
<th>Exposure time, days</th>
<th>Av. amplitude cm. water pressure a, b</th>
<th>Av. frequency, contractions/min a</th>
<th>Rectal temp. °C c, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fed</td>
<td>2</td>
<td>14.77±1.61 a</td>
<td>1.86±.28</td>
<td>38.4±.14</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>14.86±.20</td>
<td>2.18±.20</td>
<td>38.4±.14</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>7.52±1.16</td>
<td>1.74±.22</td>
<td>40.9±.24</td>
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<tr>
<td></td>
<td>18</td>
<td>13.41±.89</td>
<td>1.95±.08</td>
<td>38.4±.04</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>11.21±.69</td>
<td>1.88±.10</td>
<td>38.6±.04</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>12.50±0.94</td>
<td>1.88±.07</td>
<td>39.0±.14</td>
</tr>
<tr>
<td>Fasted</td>
<td>18</td>
<td>14.54±1.04</td>
<td>2.23±.20</td>
<td>38.4±.14</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>11.12±0.68</td>
<td>1.91±.10</td>
<td>38.5±.09</td>
</tr>
<tr>
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<td>35</td>
<td>12.19±0.94</td>
<td>1.88±.08</td>
<td>38.7±.07</td>
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<tr>
<td></td>
<td>1</td>
<td>4.78±.94</td>
<td>1.38±.18</td>
<td>38.3±.24</td>
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<tr>
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<td>4.17±.32</td>
<td>1.17±.18</td>
<td>38.4±.14</td>
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<tr>
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<td>1</td>
<td>4.37±.77</td>
<td>1.12±.19</td>
<td>38.6±.05</td>
</tr>
</tbody>
</table>

a Mean of five animals. Observations taken for a 30-min. period on each animal.
b P<.05 for difference between 2° and 18° C. values vs. 38° C. values.
c P<.01 for difference between 2° and 18° C. values vs. 38° C. values.

c Results and Discussion

An exposure of 5 days at an environmental temperature of 38° C. significantly decreased the amplitude of the rumen contractions below the levels at 2° and 18° C. (P<.05 by Tukey's test). The treatment means are shown in table 1. At 38° C, the frequency of the contractions was reduced, although not significantly; 5 days of exposure to 2° C. did not significantly affect amplitude.

The decreased amplitude and frequency of the rumen contractions as the result of 5 days exposure at 38° C. suggested that high temperature has a direct effect on rumen motility, and is not mediated indirectly through a reduction of the feed intake (Cakata, 1965; Robinson and Klemm, 1953), since feed intake was maintained constant at the 18° C. level by forced feeding. As illustrated in figure 1, the amplitude of contractions of the animals at 38° C. were smaller and more irregular than in the same animal at 18° C.

The length of the exposure period was also important as there were no significant effects on rumen amplitude or rectal temperature at the 1- and 2-day higher temperature exposures. Regardless of the mechanism, it is apparent from a comparison of 1, 2 and 5 days of exposure to the higher environmental temperature (table 1) that considerable time is required for the depression of amplitude of contractions. Thus, one could expect a point at which the rise in body temperature was sufficient to depress rumen contractility.

Removal of the rumen contents resulted in significant declines in both amplitude and frequency of rumen contractions (P<.01 determined by analyses of variance for all temperatures). This suggests the necessity for scabrous material in the rumen to initiate normal contraction cycles (Colvin and Daniels, 1965), since fill due to water was unable to restore normal contraction cycles (Sellers et al., 1964; Stevens and Sellers, 1959). Environmental temperature did not have any effect on the rumen amplitude frequency of fasting animals (figure 1 and table 1); however, this may be due primarily to 1-day only temperature exposure.

Kelly et al. (1967), using these same control-fed animals during this experiment, found the production of volatile fatty acids influenced by high environmental temperature. They noted that at 38° C. there was a significant depression in the total volatile fatty acids present, with changes in the molar percentage of acetic, propionic and butyric acids. It is suggested that the rate of rumen motility could affect the production of the volatile fatty acids by influencing the normal mixing of the rumen contents. These results of Kelly et al. (1967) indicate that a high environmental temperature may in some way influence both the physical and metabolic activities of the
Figure 1. Temperature and feed effects on rumen motility. The upper portion of the figure shows the contraction cycle which was observed for one of the animals at 18°C. The middle section of the figure is the motility recording made on the same animal when exposed for 5 days to 38°C, with the same level of feed intake as at 18°C. The lower section is a similar recording 1 day after removal of the rumen contents at 18°C.

Rumen motility studies were conducted on five Holstein cows which were fed at a controlled level and exposed to various environmental temperatures of 2- and 5-day periods. A significant (P<.01) decrease was noted in the amplitude of the rumen contractions when the animals were exposed to 38°C for 5 days. The removal of the rumen contents and fasting for approximately 20 hr. resulted in a significant (P<.01) decrease in both the frequency and amplitude of rumen contractions at all treatment temperatures. A high environmental temperature of 38°C., with a resultant significant (P<.01) elevation in body temperature of 40.9°C., and fasting at any treatment temperature may depress the amplitude of rumen contractions? Conceivably, heat may depress the amplitude of rumen activity by depressing the ruminal fatty acid levels and thus affecting the neural receptors in the rumen, by neural depression via the central nervous system (Andersson, Gale and Sundsten, 1963), or possibly by the direct effects of a higher ruminal temperature on the rumen musculature or temperature receptors.

The depressed amplitude due to fasting, as previously discussed, is attributed to a lack of scabrous material in the rumen (Dougherty et al., 1965). It was questioned whether a common neural receptor in the rumen may be responsible for the lowered fatty acid production in the rumen during heat exposure and fasting treatments. To further clarify these responses would necessitate testing animals in very high environmental temperatures, heating and cooling of the rumen per se, or heating and cooling of the hypothalamic centers.

Summary

Rumen motility studies were conducted on five Holstein cows which were fed at a controlled level and exposed to various environmental temperatures of 2- and 5-day periods. A significant (P<.01) decrease was noted in the amplitude of the rumen contractions when the animals were exposed to 38°C for 5 days. The removal of the rumen contents and fasting for approximately 20 hr. resulted in a significant (P<.01) decrease in both the frequency and amplitude of rumen contractions at all treatment temperatures. A high
environmental temperature (38°C) depresses rumen activity directly rather than indirectly via feed intake.

**Literature Cited**


