EFFECTS OF ENVIRONMENTAL TEMPERATURE, RELATIVE HUMIDITY, FASTING AND FEEDING ON THE BODY TEMPERATURE OF LAYING HENS

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Summary
The separate effects of air temperature, relative humidity, fasting and heat increment of food utilization on the body temperature of laying hens were studied. Hens acclimatized to 35°C showed a smaller diurnal variation in body temperature than hens at 20°C and the variation was further decreased when relative humidity was increased from a range of 20-35% to constant 45%. The effect of daytime activity (diurnal variation) was greater than that of fasting and heat increment of food utilization.

I. INTRODUCTION
Robinson and Lee (1947) showed that hens introduced to a hot atmosphere had a greater increase in body temperature when fed a high energy diet than a low energy diet. However, data on the extent of influence of the heat increment of food utilization on body temperature are lacking. Standard deep body temperatures (King and Farner 1960) are measured at resting metabolic rate. The effect of heat increment of food utilization on body temperature must be based on the increase in temperature above that at fasting metabolic rate (FMR).

The experiments reported here were part of a study of the effect of heat stress on egg production in the domestic fowl.

II. MATERIALS AND METHODS
(a) Stock and Housing
White leghorn-type hens, 12-15 months of age, with persistent laying ability were obtained from the closed flock of the Poultry Research Foundation. They were housed in temperature and light controlled psychrometric rooms (±1°C, 14 h:10 h light:dark ratio). The relative humidity was recorded continuously during the three experiments. In Experiments 1, 2 and 3 the relative humidities at the stated temperatures were as follows:

Experiment 1, 20°C, 40 — 70%; 35°C, 20 — 35%
Experiment 2, 20°C, 50 — 60%
Experiment 3, 20°C, 60 — 80%; 35°C, 45% ± 2% (controlled).

Food and water were available ad libitum; a commercial laying ration was given in Experiments 1 and 2 and a diet containing 15% protein and 2860 kcal M.E./kg in Experiment 3.

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Experiment 1
Six laying hens were housed at 20°C for seven days. Air temperature ($T_a$) was then increased to 35°C after a 30 h transition period and continued for 16 days.

Experiment 2
Six laying hens were housed at 20°C for six days and fasted for 72 h.

Experiment 3
Eighteen laying hens were housed at 20°C for 42 days. Twelve of these hens, after a 30 h transition period, were introduced to 35°C, and acclimatization of both groups continued for a further 34 days. Temperature recordings began on 12 hens at 35°C and the 6 at 20°C. After the initial night body-temperature ($T_N$) recording at 35°C, 6 of the 12 hens were transferred back to 20°C. After six days, the groups acclimatized to 20°C and 35°C were fasted for 72 h, and then fed 4h before the final $T_N$ recording.

Methods
Body temperatures were measured with a 30 sec clinical thermometer inserted 5 cm into the rectum for 1 min. Day body-temperatures ($T_D$) were measured between 1600 and 1800 h, and $T_N$ at least 1½ h after darkness. Hens were fasted for 72 h to obtain $T_D$ and $T_N$ values at FMR. In Experiment 3, they were given 40 g of food 2 h before dark and $T_N$ readings were measured 2 h after dark.

In all experiments, the hens became accustomed to handling after two days and results obtained before this time were omitted from the analyses.

III. RESULTS
(a) Experiment 1
The results are presented in Figure 1 and show the change in $T_D$ and $T_N$ after introduction to 35°C. There appeared to be a definite period of acute heat
stress followed by gradual acclimatization after which $T_D$ returned to pre-stress level and $T_N$ increased, resulting in a reduction in the difference between $T_D$ and $T_N$.

(b) Experiment 2

The mean $T_D$'s and $T_N$'s for fed and fasted hens are shown in Table 1. The results were analysed as a 2 x 2 factorial in which Day v. Night, and Fed v. Fast were treatments. The diurnal and fasting effects were significant ($P<0.005$) but the interaction was not, indicating that fasting had the same effect on $T_D$ as on $T_N$.

(c) Experiment 3

The results are shown in Figures 2 and 3. The effect of fasting on $T_D$ and $T_N$ hens acclimatized to 35°C was analysed as a 2 x 2 factorial. Fasting reduced $T_D$ significantly ($P<0.005$) and had a smaller but still significant effect on $T_N$ ($P<0.05$). The effect of fasting on $T_D$ of hens at 20°C and 35°C was compared in the same manner. Fasting significantly reduced $T_D$ at 20°C and 35°C by 0.5°C ($P<0.005$). The higher temperature increased $T_D$ significantly ($P<0.005$) by just over 0.2°C.

The rise in temperature after feeding hens at 20°C was significant ($P<0.05$) but had no effect on fasted hens at 35°C.

At 35°C, the relative humidity was 20-35% and 45% for Experiments 1 and 3 respectively, and its effect on $T_D$ and $T_N$ was analysed as a 2 x 2 factorial. The higher relative humidity significantly increased ($P<0.005$) $T_D$ and $T_N$ but did not alter the magnitude of the diurnal variation.

IV. DISCUSSION

The decreased diurnal variation after acclimatization to 35°C is a characteristic of the reaction of birds to $T_A$ above 30°C, as has been shown in the house sparrow (Passer domesticus) (Hudson and Kimzey 1966) and the Inca dove (Scardafella inca) (MacMillen and Trost 1967). When relative humidity was increased to 45% at 35°C, $T_N$ was further increased and the diurnal variation was therefore further decreased.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Day ($T_D$) and night ($T_N$) deep body temperatures for fed and fasted hens in Experiment 2. The hens were housed at 20°C.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deep body Temperatures °C ± Standard Error</td>
</tr>
<tr>
<td>Fed $T_D$</td>
<td>41.4 ± 0.02</td>
</tr>
<tr>
<td>Fed $T_N$</td>
<td>40.5 ± 0.03</td>
</tr>
<tr>
<td>Fasted $T_D$</td>
<td>40.9 ± 0.09</td>
</tr>
<tr>
<td>Fasted $T_N$</td>
<td>39.8 ± 0.10</td>
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</tbody>
</table>
The body temperatures after fasting at 20°C had a range of 1°C (39.2 to 40.2°C). From the equation relating metabolic rate (MR), body temperature (TB) and TA (Hudson and Kimzey, 1966):

\[ MR = C(T_B - T_A) \]

where C represents thermal conductance.

With TA constant, differences in fasting body temperature could be due to differences in thermal conductance or in metabolic rate. Tasaki and Sakurai (1965) have shown that crossbred cockerels have wide differences in basal metabolic rate.

Fasting reduced TB by 0.5°C and TN by 0.7°C. The non-significant interaction terms in the factorial analysis indicated that the reductions were not of different magnitude. Daytime activity was shown to have a greater effect on body temperature than fasting (Table 1).

In Figure 3, the fasting TN was extrapolated to 72 h and indicated that the temperature rise on feeding may have been as much as 0.5°C. Although the temperature did not reach normal levels, this may be a more accurate estimate of the effect of heat increment of food utilization than the difference between normal TN and fasting TN, which may include muscular activity not associated with the heat increment. The difference between the fasting TN values at 20°C and 35 °C is an indication of the heat load imposed on the hen by the higher TA.

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In contrast to the effect of food heat increment on $T_N$ at 20°C, no increase was recorded at 35 °C indicating that the increment does not appear as an increase in body temperature when body temperature is elevated above normal. Since the effect of feeding fasted hens at 35 °C, was not significant, this raises doubt on the effect of fasting on hens at 35 °C, which the analyses had shown to be significant. Figure 2 shows that from the day prior to fasting $T_N$ was unchanged and thus $T_N$ may not be influenced by fasting.

Hens which were acclimatized to 35°C (Figure 3) and then introduced to 20°C had an initial low $T_N$ and $T_D$ which gradually increased over three days. This changing body temperature may be indicative of a changing MR.

V. REFERENCES