NOTE

Ultradian Rhythm of Chicken Body Temperature under Continuous Light

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In a previous study reported by us [5], length of the circadian rhythm of body temperature of laying hens under the continuous light with common light intensity (20–50 lux) was 25.2 hours and that of the feeding activity cycle was 25.3 hours.

The circadian rhythm in mammals and birds is known to disappear or occasionally change to an ultradian rhythm under continuous illumination for over 3 months or high intensity regime [1, 2, 3].

In a series of the experiments relating to the circadian rhythm of chicken body temperature [4, 5], we found disappearance of the circadian rhythm and appearance of the ultradian rhythm in body temperature of the hen under continuous high illumination intensity. However, we did not refer to ultradian rhythm in our previous papers [4, 5] and no such data are available about the ultradian rhythm of chicken body temperature. Therefore, the purpose of the present report is to detail results of research on the ultradian rhythm of body temperature in the hen.

White Leghorn hens aging 12 to 15 months were housed in individual wooden cages placed in an environmental room (temperature, 18–22°C; humidity, 60%) and provided with a commercial ration and water *ad libitum*.

Light regimes were used in two different conditions: one was 14-hour light and 10-hour dark photoperiod (LD), then continuous 24-hour light photoperiod (LL), in which the light intensity at the front of the cage was about 50 lux, and the other was LL condition with a high light intensity (200 lux). Twenty laying hens were exposed to LD photoperiod for 2 weeks, then placed on LL condition for about one month. Furthermore, ten non-laying hens were used for the experiment of LL with a high light intensity.

The body temperature was monitored by a telemetric device. A transmitter was implanted into the abdominal cavity of the hen under pentobarbital anesthesia. Body temperature was recorded at 14 sec intervals. Food and water intake activities were also recorded simultaneously with the body temperature recording. The details on the transmitter and other parts of the device and measuring and analyzing procedures of body temperature and feeding activity were described in the previous paper [4, 5].

Correlogram, periodogram and harmonic analyses were conducted by the use of computer (FACOM 230–28, Fujitsu Kogyo Ltd.) to estimate the period length and the best fitted frequency of body temperature rhythm.

Fig. 1. Typical record of body temperature and feeding activity simultaneously measured in a laying hen during three consecutive days under LD photoperiod (14L:10D). Upper line on each day shows the fluctuation of body temperature through the day, and lower graph indicates hourly relative value (%) of the daily feeding activity. Black triangle indicates the time of oviposition on each day.

The circadian body temperature rhythm of laying hens entrained 24 hour light-dark cycle. Figure 1 illustrates a typical body temperature rhythm of a hen during consecutive 3 days under the LD photoperiod. No food and water intakes were found during the dark period. Oviposition always occurred in the early half of the light period, and a distinct body temperature rise was recognized at the time of oviposition.

When laying hens were exposed to the LL photoperiod, the fluctuation of body temperature showed a free-running rhythm. A typical example of the body

temperature and the feeding activity of a hen under the LL condition was presented in Fig. 2. The body temperature was higher when the feeding activity increased and lower when it decreased. A high rate of egg production was maintained in the hens during the LL photoperiod. The body temperature rose temporarily at the time of oviposition as found in the hens under the LD photoperiod. To eliminate this rise relating to the oviposition, non-laying hens were used in the further experiment with high light intensity condition.

When non-laying hens were housed

Fig. 2. Typical record of body temperature and feeding activity simultaneously measured in a laying hen during three consecutive days under LL photoperiod (24L:0D). See Fig. 1 for explanation of legends and symbol.

under the condition of continuous high illumination of 200 lux (i.e., four to ten times higher than ordinary light intensity), the fluctuation pattern of body temperature changed markedly as presented in Fig. 3, differing from that under the ordinary light intensity condition. As clearly shown in the figure, the body temperature change well synchronized with the pattern of the feeding activity, increasing with the initiation of feeding activity and decreasing as it ceased.

The difference in amplitude between high and low temperatures was 0.5–0.6°C. This value was considerably lower comparing with the range of body temperature variation (0.8–1.2°C) observed in laying hens.

Although we could find the disappearance of the circadian rhythm on body temperature as seen in Fig. 3, the existence of other rhythm(s) was yet uncertain. The original data were analyzed statistically by correlogram (Fig. 4A and D) and periodogram (Fig. 4B and E). The correlogram revealed a periodic variation of five to six hours in the body temperature. On the basis of analysis by the periodogram, the period length of the body temperature fluctuation on the 8th and 9th day was 5.0 and 5.4 hours, respectively. Such cyclic fluctuation is considered to be an ultradian rhythm with shorter duration compared with the circadian rhythm. The results of harmonic analysis of the fluctuation in body

Fig. 3. Typical record of body temperature and feeding activity simultaneously measured in a non-laying hen during two consecutive days (8th and 9th day) under LL photoperiod with high intensity illumination (200 lux). Feeding activity was recorded every 14 sec. and summarized each 6 min., and this count was represented directly by histogram in lower graph.

Fig. 4. Statistical analyses of the original temperature curve shown in Fig. 3. Graphs of left side show the data on the 8th day and right graphs indicate those on the 9th day. A and D: correlogram; B and E: periodogram; C and F: harmonic analysis.

temperature on each of the two consecutive days are shown in Fig. 4C and F. Each curve consisted of a large trough and three peaks.

Folk and Folk [2] found that the arctic ground squirrel exposed to continuous arctic daylight in an outdoor enclosure had a 4-hour body temperature rhythm. Shiotsuka *et al.* [6], estimating the serum corticosterone rhythm of the hamster, detected a 5-hour rhythm. Cain and Wilson [1] reported that if hens were exposed to continuous high intensity lighting (LL, 970 lux), the circadian locomotor pattern became difficult to distinguish clearly. Investigating the circadian rhythm of locomotor activity, body temperature and plasma corticosterone in rats under a continuous light of 200 lux, Honma and Hiroshige [3] demonstrated the decomposition of circadian rhythm into ultradian components and the period length of the rhythm was fairly constant in the individual within the range of 4 to 6 hours. Recently, Saito and Tsuji [5] also recognized the ultradian rhythm of 4 to 5 hours of rat body temperature under the LL condition.

There is no report on the ultradian rhythm of body temperature in the do-

mestic hen. The present data have shown the ultradian rhythm of hen body temperature, and the period length was about 5 hours. This length is not conflict with the values found in the mammals reported previously.

The ultradian rhythm should be considered as a fundamental unit component of the circadian rhythm. The results of the present experiment relating to the continuous light with high intensity could demonstrate the existence of an ultradian unit of body temperature in the hen.

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要 約

連続照明下にみられた鶏体温のウルトラデアンリズムについて(短報): 葛野 浩・宇佐見英一(岐阜大学農学部家畜生理学教室)——非産卵雌鶏を200 luxの連続照明下で飼育しラジオテレメトリ方式により体温を連続的に記録したところ、通常の50 lux照明でみられた体温のサーカデアンリズムは消失し約5時間周期のウルトラデアンリズムが出現した。この体温リズムは摂食活動と同期していた。周期解析の結果ウルトラデアンリズムの周期は200 lux条件下においた第8日目と第9日目でそれぞれ5.0と5.4時間であった。