Changes of Body Temperature Related to Oviposition and Ovulation Induced by LH in the Domestic Hen

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ABSTRACT. The deep body temperature of the unrestrained laying hen was measured continuously by the telemetry system with the simultaneous recording of the time of oviposition. The photoregimen was 14L:10D. The body temperature increased during either the natural oviposition or the oviposition induced by LH. Premature ovipositions were induced by the intravenous injection of vasopressin or prostaglandin $F_{2\alpha}$ after the induction of ovulation by LH. The peak time of body temperature was not advanced by the prematurely induced oviposition. A small rise in body temperature was observed 6.2 hr after the injection of LH. This can be considered due to the occurrence of ovulation. One of the causes of a rise in body temperature at oviposition may be secretion of prostaglandin.—**KEY WORDS:** body temperature, hen, oviposition, ovulation.

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An obvious but temporary increase in body temperature at the time of oviposition has been recognized in the domestic hen [1, 2, 11, 12, 20] and Japanese quail [21]. Similar increase in body temperature has been observed at the predicted time of oviposition in the case of premature, delayed oviposition or internal laying (ovulation without subsequent oviposition) [1, 12]. Thus, this rise in body temperature is considered to be of hormonal origin or related to the function of the endocrine system [1, 2, 12, 14].

In the present study ovine luteinizing hormone (LH), posterior pituitary hormone and prostaglandin were used to induce premature by either ovulation or oviposition under a continuous monitoring of body temperature.

MATERIALS AND METHODS

Animals: Laying Single Comb White Leghorn hens (n=20) were used and most hens showed a regular 4-day clutch cycle with one skip (pause) day. Other several non-laying hens were used for a comparison. A calibrated transmitter was surgically implanted under the tip of the sternum of each bird using a local anesthetic. They were individually

caged in a controlled-environmental room (14 hr light and 10 hr dark) for 30 days before the start of the experiment. Food and water were available *ad libitum*.

Cage: The cage was made of 1.27 cm thick plywood and the size was 55 cm long, 43 cm wide and 60 cm high. Wooden dowels (0.6 cm in diameter and 18 cm in length) were placed vertically and 7 cm apart in the front of the cage to which food and water containers were attached. The wire rod cage floor sloped toward the rear of the cage so that the egg struck a trip-bar attached to a micro-switch for the recording of oviposition time.

Telemetry system: The frequency modulated (FM) radio transmitter used to measure body temperature of hens continuously has been described elsewhere [13]. This telemetry system will tell body temperature of hens with an accuracy of $\pm 0.05^\circ\text{C}$. Each transmitter was calibrated prior to the implantation and after each experiment.

Chemicals: LH (NIH S-22) for the premature ovulation was injected intravenously ($40\mu\text{g}/\text{bird}$) at 16:00 hr on the day of last oviposition in a clutch. Vasopressin (Pitressin, Sankyo

Fig. 1. A typical record of body temperature during a clutch of normal laying hen. Test chicken was kept under 14L: 10D photoperiod. Chicken showed four-egg cycle. The first day of this figure is a skip day. C₁-C₄ represent 4 ovipositions in a clutch. ► indicates the time of oviposition. A characteristic rise of body temperature is observed in each oviposition time.

Co.) for the premature oviposition was injected intravenously (2 unit/bird) 12 hours before the predicted oviposition time. Prostaglandin F_{2α} (Prostalmon-F, Ono Yakuhin Co., 1.5 μg/bird) was similarly used for the same purpose as vasopressin.

Data collection: Body temperature was recorded as number of pulses every 15 sec. on a digital printer (Matsushita Tsushin Kogyo Co., VP-491 B) through an FM radio and an electronic counter (Matsushita Tsushin Kogyo Co., VP-4761). Oviposition time was recorded on the same digital printer. Based on these data figures were prepared.

RESULTS

Fig. 1 shows typical pattern of daily changes in the body temperature and oviposition time in a normal hen during four-egg cycle. The first day is a skip day in a clutch. The time of oviposition delayed from C₁ to C₄ in order and terminal oviposition occurred

Fig. 2. A typical record of body temperature by the administration of LH. After C₄ oviposition, LH was injected at 16:05 hr. Induced oviposition was observed at 01:14 hr on the 3rd day in this figure. Arrows indicate the time of LH injection, and IOV shows induced oviposition by LH.

in the afternoon. The body temperature started to increase about 1 hour before each oviposition and decreased gradually after oviposition. After about 30 minutes the body temperature returned to the previous level. This peak of body temperature related to oviposition has been called as the "oviposition peak" [12]. In the present study the oviposition peak height was $0.47 \pm 0.12^\circ\text{C}$ ($n=21$).

To evaluate the relationship between the occurrence of oviposition and the oviposition peak, LH was injected intravenously at 16:00 hr after the last oviposition in a clutch. In the case shown in Fig. 2, the last oviposition (C₄) occurred at 14:34 hr, and LH was injected at 16:05 hr on the same day. An induced oviposition (IOV) was observed at 01:14 hr on the 3rd day or 33.15 hrs after the injection. This oviposition was associated with an increase in body temperature in the magnitude of 0.46°C . The oviposition peak for C₁ which would have been expected to appear at 06:00–07:00 hr on the 3rd day was omitted. The time of oviposition and the oviposition peaks for C₂ to C₄ were not different from that in

Table 1. Occurrence of oviposition by administration of LH

Exp.	Time between injection of LH and oviposition	Increase of body temperature at oviposition peak
1	34.95 hrs	0.37°C
2	33.15	0.46
3	32.42	0.48
4	36.75	0.55
5	36.33	0.52
Mean $\pm$ S.D.	34.72 $\pm$ 1.70	0.48 $\pm$ 0.07

Fig. 3. A typical record of body temperature in a hen treated with LH and vasopressin. After administration of LH, vasopressin was injected the next day. Premature oviposition was seen immediately after the vasopressin injection. A peak (v) comparable to the oviposition peak was observed at 00:30 hr on the 4th day in this figure. VP indicates the time of injection of vasopressin and POV shows the premature oviposition.

Fig. 4. A typical record of body temperature in a hen treated with LH and prostaglandin (PG). After administration of LH, PG was given the next day. Premature oviposition was induced 11 minutes after PG injection. A peak (v) comparable to the oviposition peak was observed at 02:28 hr on the 4th day in this figure when the egg had been expelled. PG indicates the time of injection of the prostaglandin.

intact hens without LH treatment (data for C₃ and C₄ are not shown). The same experiments of LH administration were conducted in additional 4 hens and the results are summarized in Table 1. The interval between the oviposition and LH injection was 34.72 $\pm$ 1.70 hrs and the height of the oviposition peak was 0.48 $\pm$ 0.07°C.

As shown in Figs. 2–5, obvious increases in body temperature were observed before

and after the injection of drugs, which will be attributable to the injecting procedure itself, since the birds were in an excited and frightened condition temporarily during an injection.

Vasopressin was injected to induce premature oviposition to the birds similarly treated with LH as in the previous experiment. A typical body temperature change during these treatments is shown in Fig. 3. In this case the

Fig. 5. Typical records of body temperature during 10 hours after the injection of LH in laying (A, B) and non-laying (C) hens. A slight increase in body temperature was recognized between 6 and 7 hours after LH injection in laying hens, but not in non-laying hens. IOU indicates the expected time of the ovulation induced by the administration of LH.

Fig. 6. The simple arithmetic mean values of body temperature every 3 minutes between 3 and 10 hours after the injection of LH in laying hen (A, $n=8$) and non-laying hen (B, $n=5$). A distinct increase in body temperature is recognized 6.2 hours after LH injection only in laying hens.

last oviposition (C₄) in the clutch was observed at 13:25 hr and LH was subsequently injected at 16:02 hr. Vasopressin was injected at 11:41 hr the next day. Premature oviposition was induced 4 minutes after the vasopressin injection. A rise in body temperature was recognized at 00:30 hr on the next day even though the egg had already been shed. This rise occurred 34.4 hrs after the injection of LH and the time of the occurrence coincided with the oviposition peak without the vasopressin treatment (see IVO in Fig. 2).

Fig. 4 shows a typical body temperature change when prostaglandin was administered instead of vasopressin. The last oviposition of a clutch in this hen was observed at 14:14 hr and LH was injected at 16:03 hr and prostaglandin was injected at 11:19 hr the next day. Premature oviposition was induced 11 minutes after the injection. Again, an obvious body temperature rise (0.51°) was

recognized at 02:28 hr on the 4th day, or 34.95 hours after the administration of LH coinciding with the oviposition peak in the birds treated with only LH.

Fig. 5 shows the body temperature curves before and after the injection of LH. A small but distinct increase of body temperature was recognized 6–7 hours after the injection of LH (A and B). Mean interval between the LH administration and this type of body temperature rise in 9 hens was 6.37 ± 0.44 hours and the magnitude of the rise was $0.28 \pm 0.03^{\circ}$. C in Fig. 5 shows an example of body temperature curves of non-laying hens treated with LH and no characteristic rise of body temperature around 6–7 hours after the injection of LH was observed. A simple arithmetic mean of body temperature in LH-treated laying ($n=8$) or non-laying hens ($n=5$) was calculated for every 3 minutes between 3 and 10 hours after LH injection to eliminate the

random variation. The result shows a distinct peak in laying hens 6.2 hours after LH injection (Fig. 6, A) and no peak in non-laying hens (Fig. 6, B).

DISCUSSION

It has been well known that the administration of LH to the laying hen could induce premature ovulation [4, 5, 15, 16, 19]. In the present study, when LH was injected at 16:00 hr on the day of the last oviposition in a clutch, the first oviposition of the next clutch was observed between 00:00 and 05:00 hr 2 days after LH treatment. The time of this oviposition was earlier by several hours than the normal one, because the first oviposition of the next clutch in intact hens was expected to occur at 06:00–07:00 hr.

Injection of posterior pituitary hormones leads to premature oviposition [7], and the premature oviposition in hens can also be induced by intrauterine injection of prostaglandin E₁, E₂, and F_{2 α} [8]. In the present study, vasopressin and prostaglandin F_{2 α} were given intravenously to cause the premature oviposition after LH treatment. Both drugs were effective to induce oviposition within several minutes after the injection.

Our results indicated that an increase in body temperature at the expected time of oviposition occurred even when the egg was expelled prematurely by the injection of vasopressin or prostaglandin. Therefore, it appears that the cause of body temperature rise at oviposition naturally observed is not resulted from the egg-laying behaviour itself but from some hormonal factors.

Day and Nalbandov [3] reported that the postovulatory follicle showed approximately a 100-fold increase in prostaglandin F (PGF) content about 24 hours after its own ovulation or 2 hrs prior to the next expected ovulation, and they suggested that PGF is not involved in the process of ovulation but primarily in the induction of uterine contraction for oviposition. On the other hand, the rise in body

temperature is attributed to the effect of prostaglandin E (PGE) [17]. Yang *et al.* [22] reported that both PGE and PGF increased only in those follicles which are destined to ovulate in rabbits. Hertelendy and Biellier [9] suggested that plasma concentrations of PGE in hens were higher during the period when there was an egg in the uterus. Therefore, the rise of body temperature related to the time of oviposition may be due to the action of increased PGE in the postovulatory follicle of hens. The timing of oviposition peak may solely be dependent on the time of ovulation.

Winget *et al.* [20] reported two separated temperature peaks in the diurnal variations of body temperature of the laying hen: one is associated with oviposition and one with ovulation. However, many researchers thereafter stated that the rise in body temperature associated with ovulation was not always apparent from the continuous recording of body temperature, although the oviposition peak was recognized markedly [1, 2, 12]. It is difficult to verify the change of body temperature in ovulation time under continuous temperature recording for the unrestrained hens. This may be due to the small magnitude of temperature change (about 0.2–0.3°C). The oviposition peak and food and water activity soon after oviposition will easily mask the ovulation peak naturally occurred. Furthermore, because ovulation usually occurs in the early morning when body temperature is in a rapidly increasing phase, a relatively small temperature peak by ovulation, if any, may be also masked easily.

In the present study, by the administration of LH we induced the ovulation at midnight when the body temperature change was relatively small. A definite peak 6.2 hours after LH injection was obtained and this peak may be regarded as a “ovulation peak”. This result coincides well with the reports by Furr *et al.* [6], Shodono *et al.* [18] and Johnson and van Tienhoven [10] that ovulation occurs 4–7

hours after LH surge in normal egg-laying cycle.

In our previous paper [12], the existence of an ovulation peak of body temperature was recognized by the autopsy of the anesthized chickens. It has been confirmed in the present study that there is a small rise of body temperature related to ovulation in the unrestrained laying hen and its increase was about 0.3°C.

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要 約

LHによって誘起された鶏の放卵及び排卵と体温変化: 葛野 浩・山出太陽 (岐阜大学農学部家畜生理学講座) ——無拘束産卵鶏の体内に埋込んだラジオトランスミッタで, 体温を連続的に測定するとともに放卵時刻を記録した。放卵に伴って体温は約 0.5°C 上昇し, 放卵時体温上昇は LH による人為的な排卵誘起時にも認められた。LH による排卵惹起後, vasopressin あるいは prostaglandin (PG) により未熟放卵を惹起すると, 卵放出後にもかかわらず, 予定放卵時刻における体温上昇が認められた。この事実から, 放卵時の体温上昇は, 排卵前後におけるホルモンまたは生理活性物質の分泌増加によると推察された。PGF_{2 α} 静脈内投与により未熟放卵が惹起されたが, 放卵時体温上昇には PGE が重要な役割を果している可能性が示唆された。LH surge との時間的關係から, LH 投与後 6.2 時間における体温上昇は, 排卵に伴う変化とみなされた。