Turkish Journal of Veterinary & Animal Sciences

Volume 34 | Number 5 Article 3

1-1-2010

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Turk. J. Vet. Anim. Sci.
2010; 34(5): 433-439
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doi:10.3906/vet-0901-25

Research Article

Responses to abrupt changes in feeding and illumination in laying hens

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Received: 26.01.2009

Abstract: This study aimed to investigate the responses to abrupt changes in feeding and illumination during the egg-laying period. Six hens were housed individually in cages under constant environmental conditions, with a photoperiod of 15 h (0400-1900) and ad libitum access to food for 10 days. Then the same hens were subjected to a feed withdrawal trial (between 1200 and 0830), followed by a 5-h reduction in the photoperiod (0400-1400). The heart rate (HR), body temperature (BT), and locomotor activity (LA) of the laying hens were measured continuously using radiotelemetry, with simultaneous recording of the time of oviposition. Behavioral responses to sudden changes in the management program during the pre- and post-laying periods were also recorded.

Hens with restricted access to food had significantly lower HR, BT, and LA during the pre- and post-laying periods than hens given unrestricted access to food. In the pre-laying period the behavioral activity counts for cage pecking and preening were significantly higher, and feeding and drinking counts were significantly lower in the hens with restricted access to food than in the hens given unrestricted access to food. During the post-laying period the behavioral activity count in preening was significantly higher in the hens with restricted food access than in those given unrestricted access to food. Experimental hens subjected to a reduced photoperiod had significantly higher HR and BT during the pre-laying period than those under the normal light regime. During the pre- and post-laying periods hens subjected to light reduction had significantly lower LA than the hens subjected to the normal light regime. In the pre-laying period the behavioral activity count for circling was significantly lower and the preening count was significantly higher in the hens subjected to light reduction than in the hens subjected to the normal light regime. The post-laying period occurred during the light period and thus the behavioral activities were similar in the hens subjected to light reduction and those under the normal light regime. Mean onset of egg laying in all groups exposed to food withdrawal or darkness was delayed by 34 min in the food reduction trial and by 11 min in the light reduction trial, as compared to the hens during the control period. These results suggest that changes in the management program might lead to stress and impair the welfare of hens.

Key words: Body temperature, egg laying, heart rate, laying hens, locomotor activity

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Introduction

Housing laying hens in cages is a contentious animal welfare issue. Laying hens were once housed outdoors in free-range systems, but nowadays this system has been almost entirely replaced by the battery cage. Furthermore, the welfare of egg-laying hens is directly linked to the ability to perform motivated behaviors. Good welfare for a hen includes freedom to forage, exercise, preen, dust-bathe, take refuge on a perch whenever she feels vulnerable, and build a nest to lay eggs. These natural behaviors are denied to hens kept in a battery cage (1).

Many management practices under high-density artificial environments subject hens to stress, and can induce a state of anxiety, adversely affecting the welfare of individual birds. The inability of chickens to adapt to their social environment results in greater susceptibility to disease (2,3) and an increase in the frequency of abnormal behaviors, such as cannibalism, aggression, and feather pecking (4-7).

Battery cages are arranged in rows of 3-6 tiers inside huge, windowless sheds. These can contain up to 70,000 birds. Heating, ventilation, and lighting are all automatically controlled. Feeding and watering are also automated; however, what would happen if this system were to fail and the hens were consequently exposed to stress associated with the sudden changes that would ensue? Our previous report indicated that sudden changes in the management program had adverse effects on the daily behavioral and physiological activities of laying hens (8). However, there has been no research on the effects of sudden changes in management practices during the egg-laying period. We therefore studied the heart rate (HR), body temperature (BT), locomotor activity (LA), behavioral parameters, and delay in oviposition, as indicators of stress, in hens subjected to changes in the management factors of food availability and the photoperiod during the egg-laying period.

Materials and methods

Animals and experimental design

The study included 6 white Leghorn hens (90 weeks old) weighing 1500-2000 g. The experimental hens were housed individually in cages with a controlled temperature (20 ± 2 °C) and relative humidity (40 ± 5%). The cages were made of wire mesh and measured 41 cm (rear height) × 43 cm (front height) × 26 cm (width) × 40 cm (depth). Food and water were supplied once a day at 0830. Food was available ad libitum at all times for hens subjected to light reduction and the control hens. For hens in the food restriction trial food was removed between 1200 and 0830, and food was available ad libitum at all other times. Lights were on from 0400 to 1900; illumination of 120 lux was provided at cage level by a 40-watt cool-white fluorescent tube for hens with restricted food access and control hens. For hens subjected to a reduced photoperiod the light was on only from 0400 to 1400. All experimental procedures for the use and care of animals in the present study were approved by the Animal Care Committee of the Faculty of Agriculture of Shinshu University.

HR, BT, and LA were measured by radiotelemetry. The hens were first anesthetized by an intramuscular injection of ketamine (100 mg/kg) and an intravenous injection of Nembutal (0.5 mg/kg) under sterile conditions. A telemetric transmitter (TA11CTA-F40, Data Science, St. Paul, MN, USA) was implanted intraperitoneally. The electrode leads were fixed subcutaneously to the ventral and dorsal sides of the sternum, so as to minimize contact with muscular tissue and obtain high-quality electrocardiogram (ECG) recordings, as described by Korte et al. (9). Frequency-modulated HR and BT signals were received by a single receiver board (RPC-1, Data Science) and recorded with an ECG processor (Softron, Tokyo, Japan). The transducer could be switched on or off by magnetic activation, using an AM/FM radio to detect the transmitter's signal and verify the on/off status. Locomotor activity was monitored telemetrically by measuring the movements of the hens with respect to the receiver, which provided a signal in response to horizontal movements of the hens. After surgery, the hens were returned to their cages. The experiment was performed for a minimum of 10 days after transmitter implantation. HR and BT were recorded continuously and stored at 1-min intervals, and LA data were stored at 5-min intervals.

Behavioral observations

Behavioral patterns were recorded using an infrared camera (CCD-TR 180, Sony, Tokyo, Japan) and a video recorder (NV-N20, Panasonic, Tokyo, Japan) at one-third normal recording speed. Videotapes were replayed at normal speed in the laboratory. The hens were kept in constant environmental conditions for 10 days after transmitter implantation. Following this preconditioning period, behavioral and physiological data were recorded for 2 consecutive days; these became the control data. Subsequently, the same hens were subjected to food withdrawal between 1200 and 0830, and behavioral and physiological data were recorded for 2 days. After the food restriction trial, the same hens were kept in constant environmental conditions for 10 days before the next trial started. Behavioral and physiological data were then recorded for 2 consecutive days; these became the control data. Thereafter, the hens were exposed to a change in the photoperiod. This consisted of changing the time of lights-off from 1900 to 1400 hours. Behavioral and physiological data were then recorded for 2 days. Behavioral observation data were divided into 120 min pre-laying, the moment of laying, and 120 min post-laying. Counts of 7 activities (cage pecking, preening, crouching, circling movement, sitting, feeding, and drinking) were recorded, as defined in the Table. The behavioral activity counts of each hen during the control and trial periods (food restriction period and light reduction period) were measured by continuous visual sampling during the observation periods. Furthermore, when the videotapes were replayed at normal speed in the laboratory the oviposition time was recorded for each hen under control period and trial conditions (food restriction period and light reduction period).

Statistical analysis

Results are expressed as the mean ± SE for each parameter. HR, BT, LA, and behavioral parameter values for the pre- and post-laying periods, and the time difference in oviposition between the control and trial periods were compared using the paired t-test. A probability level of $P < 0.05$ was considered significant.

Results

Food restriction

Figure 1 shows the minute variation in HR, BT, and LA in hens fed ad libitum and in hens with restricted access to food during the 120-min pre- and post-laying periods. The latter had significantly lower HR, BT, and LA during the pre- and post-laying periods ($P < 0.01$) than hens given unrestricted access to food. In the pre-laying period the behavioral activity counts (cage pecking and preening) were significantly higher in the hens with restricted food access than in those given unrestricted access to food ($P < 0.01$). On the other hand, hens with restricted food access exhibited less significant feeding and drinking than the hens given unrestricted access to food ($P < 0.01$). During the post-laying period the behavioral activity count (preening) was significantly higher in the hens with restricted food access than in the hens given unrestricted access to food ($P < 0.01$), as shown in Figure 2.

Table. Description of recorded behavioral activities

Behavior	*Description*
Cage pecking	Pecking at the wire of the cage roof, wall or floor, feed or water trough.
Preening	Beak brought into contact with own feathers or skin and one or more different movement performed: pecking, combing, stroking, and nibbling.
Crouching	Hens legs were bent and the back sloped downwards towards the tail.
Circling	Hens moved frequently around the axial plane inside the cage (i.e. moving from front to back cross the cage and back again).
Sitting	Sitting without doing anything else.
Feeding	Pecking at food-particles in troughs at cage front.
Drinking	Intake of water from drinking troughs at cage front.

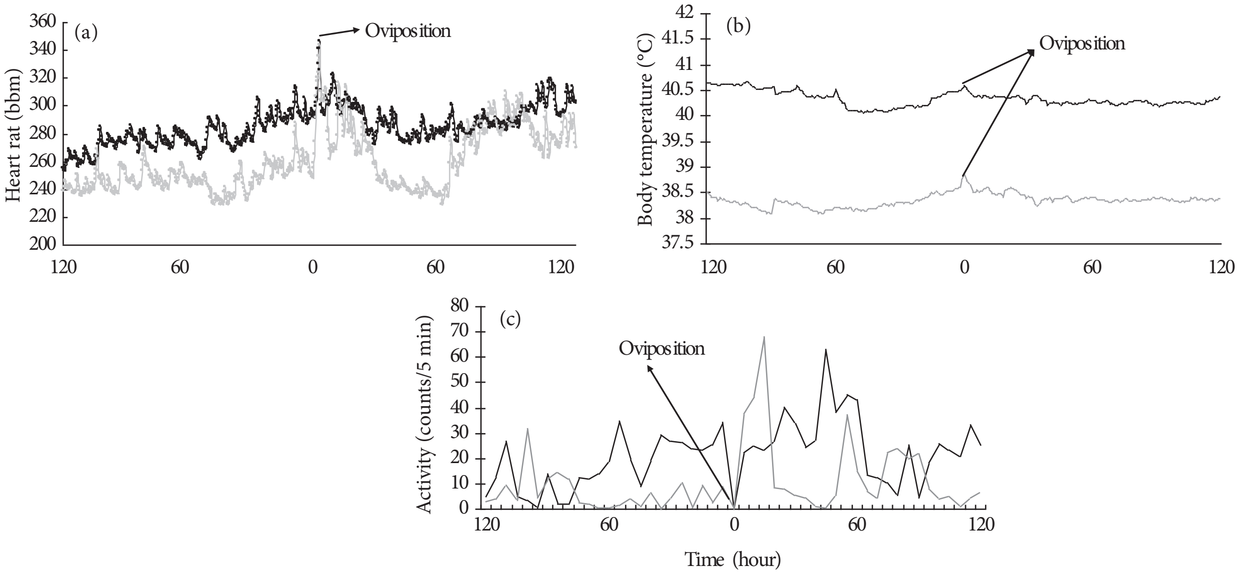

Figure 1. (a) Mean heart rate; (b), body temperature; and (c), locomotor activity changes under the food restriction trial. (■) Control fed hens; (□), hens with restricted food access.

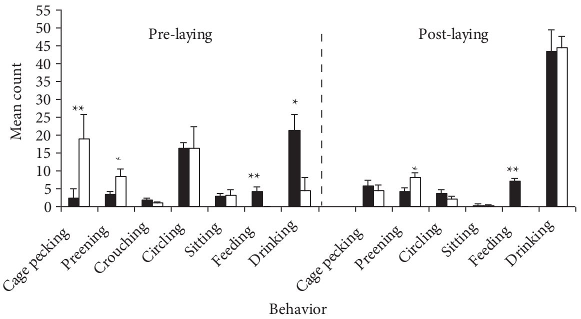

Figure 2. Mean (± SE) number of times per hour of different activities per hen under the food restriction trial. (■) Control fed hens; (□), hens with restricted food access. [a,b] P < 0.01.

Light reduction

Figure 3 shows the HR, BT, and LA during the 120-min pre- and post-laying periods in the hens subjected to the normal light regime and in hens exposed to a reduced photoperiod. Hens subjected to light reduction had a significantly higher HR and BT during the 120-min pre-laying period ($P < 0.01$) than those subjected to the normal light regime; however, during the post-laying period, HR and BT were similar between the groups of hens (hens subjected to a normal light regime and hens subjected to light reduction). On the other hand, hens subjected to light reduction had significantly lower LA during the 120-min pre- and post-laying periods than those subjected to the normal light regime ($P < 0.01$). In the pre-laying period behavioral activity counts (preening, feeding, and drinking) were significantly higher, whereas the circling movement count was significantly lower in the hens subjected to light reduction ($P < 0.01$) than in those subjected to the normal light regime. In the post-laying period behavioral activity was similar in the hens subjected to the normal light regime and in those subjected to light reduction (Figure 4). Mean onset of egg laying in all hens exposed to the light reduction trial and food restriction trial was delayed 34 min and 11 min, respectively, as compared to the hens given unrestricted access to food and hens subjected to the normal light regime (Figure 5).

Discussion

The present study confirms earlier reports (10,11) that HR and BT are low and relatively constant during the pre-laying period, increase sharply at the moment of laying, and then decrease gradually during the post-laying period. Our results indicate that the hens

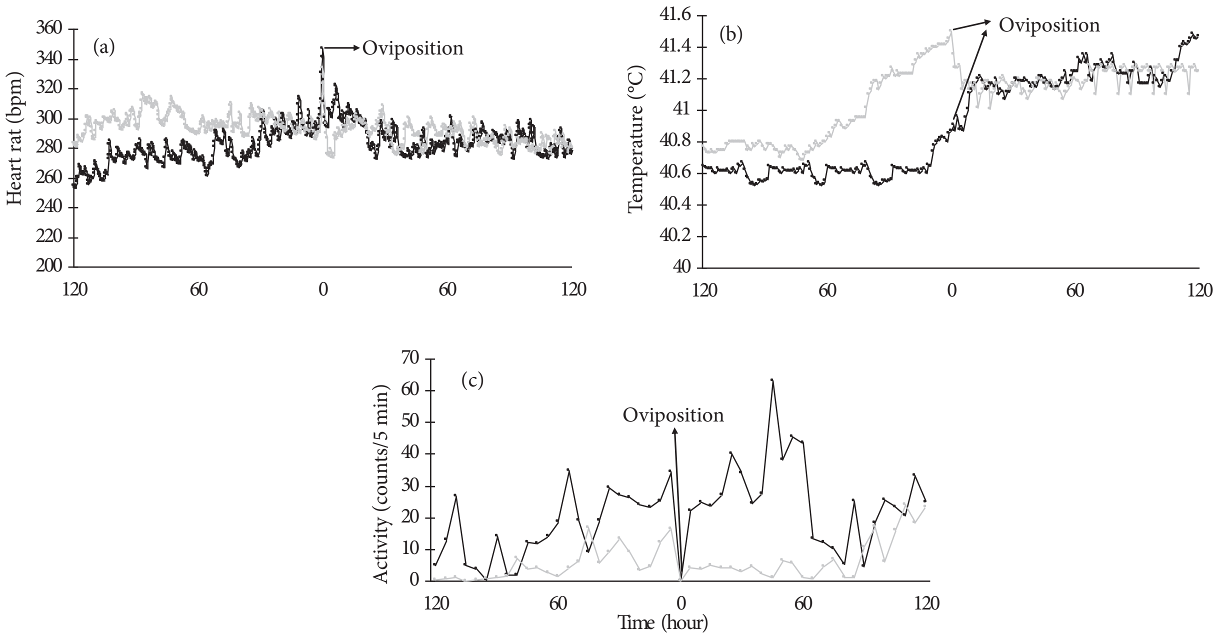

Figure 3. (a) Mean heart rate; (b), body temperature; and (c), locomotor activity under the light reduction trial. (■) Control light hens; (□), light reduction hens.

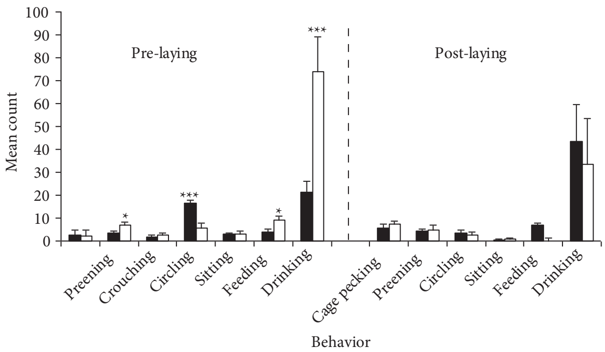

Figure 4. Mean (± SE) number of times per hour of different activities per hen under the light reduction trial. (■) Control light hens; (□), light reduction hens. ^{a,b} $P < 0.01$.

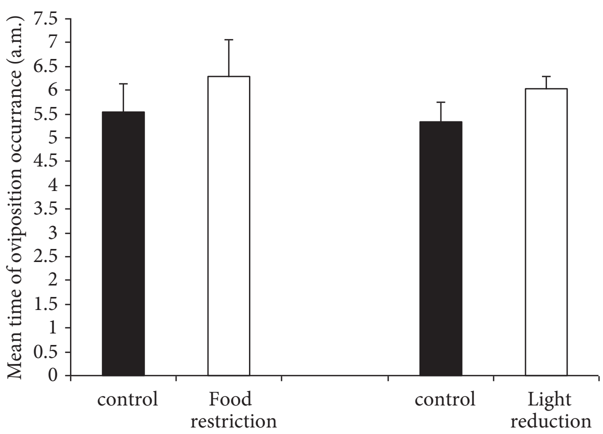

Figure 5. Time difference during the egg laying under the food restriction and lighting hour reduction trials. (■) Control hens; (□), Treated hens.

subjected to food restriction had a lower HR and BT during the pre- and post-laying periods than the hens given unrestricted access to food. Accordingly, it is a reasonable assumption that reductions in HR and BT might be associated with differences in food intake and the metabolic rate (12). This explanation is consistent with that reported by Shimada and Koide (13), who observed that food promotes eating activity in hens, which might cause an increase in the metabolic rate, and subsequent increases in the heart rate and body temperature.

Furthermore, we observed that the hens subjected to food restriction had the lowest LA (the difference was significant) during the pre- and post-laying periods as a result of the synchronized feeding activity (14). The present study shows that the frequency of cage pecking and preening was significantly higher in the hens with restricted food access than in the hens given unrestricted access to food. It is possible that these behaviors were associated with mild, short-term frustration of feeding motivation (15-18). Our observations during this period indicate that the hens subjected to food restriction spent less time crouching than those given unrestricted access to food, possibly because they had insufficient energy to perform these movements as a result of food withdrawal for more than 16 h, which delayed egg laying, as compared to the hens given unrestricted access to food. As would be expected, in the post-laying period the hens without food access performed feeding and drinking at a significantly lower level than those given unrestricted access to food.

When the light-dark cycle was changed so that the dark period was longer than the light period, mean HR and BT during the pre-laying period were significantly higher in the treated hens than in hens subjected to the normal light regime. These results confirm the hypothesis that stress might increase HR and BT, and might also impair the welfare of hens (19,20). On the other hand, sudden changes in the fixed or established routine, like suddenly changing the lights-off period, might have caused fear or discomfort, disturbing the hens' well-being and leading to lower LA during the pre- and post-laying periods in the treated hens (8). As expected, during the post-laying period more light was available and consequently the negative impact of darkness disappeared. Hence, mean HR and BT during the post-laying period were similar in the hens subjected to light reduction and in those subjected to the normal light regime.

Generally, during the pre-laying period the hens were standing quietly, but alert, and spent various amounts of time eating, drinking, or preening between bouts of restlessness. During egg laying hens enter a phase of restless activity, increasing circling movements to get themselves into the laying stance to expel the egg (21). In the present study we observed that the time for egg laying was most often in the early morning hours, between 0500 and 0600. Furthermore, the lights were on from 0400 and, consequently, at least half of the pre-laying period was in light. At the beginning of the pre-laying period (still darkness) the hens exposed to light reduction performed more preening than those subjected to the normal light regime. It is possible that the excessive preening behavior was associated with distress caused by the sudden shortening of the light period. This is in accordance with other studies in which preening behavior is considered a displacement activity in response to mildly frustrating or distressing situations (16,22). In the middle of the pre-laying period (lights on) the hens exposed to light reduction exhibited more feeding and drinking behavior than those subjected to the normal light regime, because food consumption was directly related to feeding opportunity and feeding activity was virtually absent during the dark period (23). Accordingly, the hens exposed to light reduction had lower LA, in the form of fewer circling movements, which delayed the expulsion of eggs, as compared to the hens subjected to the normal light regime. Based on these results it can be concluded that abnormal excess of certain activities may be an indicator of poor welfare (24). As expected, the post-laying period occurred during the light period and thus the behavioral activities were similar in the hens exposed to light reduction and in those subjected to the normal light regime, suggesting that light reduction did not cause differences in physiological or psychological stress during this period.

In conclusion, the present results indicate that the best strategy for ensuring the welfare of poultry is to restrict any unavoidable management disturbance. Hence, all automated or mechanical equipment that is essential for the health and well-being of the birds should be inspected at least once a day to ensure it is functioning properly. Any defects in automated or mechanical equipment that are discovered should be rectified immediately; if this is impossible steps should be taken to safeguard the health and well-being of the animals until the defects are rectified, including the use of alternative methods of feeding and watering, and methods of providing and maintaining a satisfactory environment. In addition, an alarm system should be provided to warn of any failure of the system, so that disruption of the birds' environment can be prevented and because any inappropriate changes in the environment may cause intense and prolonged distress.

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