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«Research Note»

Periodic and Local LED Light Switching Induces Broiler Locomotion

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Wooden breast myopathy and leg weakness are serious problems in the broiler chicken industry. The color and intensity of light in the chicken habitat affect behavior, including walking of chicks. The present study was conducted to determine whether periodic and local light switching induces locomotion and affects wooden breast myopathy and leg weakness in broiler chicks. Thirty five-day-old broiler chicks were assigned to two pens (4.72 m × 0.73 m each). In the control pen, chicks were reared under three white-light emitting diode (LED) lights until they were 42 days old. In the other pen, chicks were reared under a white LED light located in the center, supplemented with blue or red LED lights on either side of the pen. The color of the LED lights changed every 3 h, from blue and red to red and blue. From 21 d of age, all LED lights were changed and only one of the side lights was turned on every 3 h. From 35 d of age, all three white lights were turned on until 42 d of age. Periodic and local color switching and on-off switching significantly induced locomotion in broiler chicks. Wooden breast scores tended to improve with light-switching treatment. The tibia length, diameter, and breaking strength were not significantly affected. This is the first report showing that locomotion may be induced in broiler chicks by periodic and local lighting switching, and may be useful for improving the health status of broiler chicks.

Key words: bone, light emitting diode, myopathy, shear force, walking

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Introduction

Intensive selection of broiler chicks with desired production traits has greatly improved their growth performance and meat yield. However, such extreme situations affect bird health and raise concerns about meat quality[1] and ethics[2]. Breast muscle myopathies and leg disorders have become serious problems in the broiler industry[3,4]. Recent findings suggest that wooden breasts, a major breast muscle myopathy, are associated with leg weakness in broiler chickens[5]. Interestingly, enhanced exercise decreases the shear force of breast muscles in broiler chicks[6]. Breast muscles of chinese indigenous chickens in the highest daily step count group showed a lower shear force value of the breast muscles and higher breaking strength of the tibia than those in the lowest daily step count group[7]. Therefore, exercises such as walking and running may improve wooden breast myopathy and leg weakness in broiler chicks.

The walking ability of broiler chicks may be improved using a lighting program. For example, decreasing the lighting period improves the gait score, which is a commonly used index of leg weakness in broiler chicks[8,9]. Increasing the dark period results in higher exercise rates (walking and standing) in broiler chicks during the photoperiod[10]. Exercise is often cited as the reason shorter day lengths and longer dark periods affect the incidence of leg weakness in broilers. However, a longer dark period suppresses growth and increases the number of accidents, such as crushing deaths. Therefore, walking may be induced in broiler chicks and attenuate both wooden breast myopathy and leg weakness without affecting growth performance.

The color of light also affects chick behavior. Prayitno et al.[11] reported that red light increases the rates of walking, feeding, and stretching. Remonato Franco et al.[12] reported that chicks raised under blue light spend more time resting and suggest that blue light may improve the emotional states of fear and stress. Notably, chicks reared under blue light remain in the area, whereas those reared under red light move to the area under blue light[13]. Light intensity also affects the chick behavior. High light intensity increases the activity of broiler chicks compared to that of low light intensity[14–16]. Gait score is not improved by high light intensity[16,17]. However, the effects of periodic light and switching the light on and off on the activity and gait scores

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of broiler chicks have not been examined.

Therefore, it may be possible to leverage local and periodic switching of light color and/or intensity to induce walking without affecting growth or undesirable accidents. In the present study, the effects of periodic and local light switching on gait score, wooden breast myopathy, and physical properties of meat and bone were evaluated in broiler chicks.

Materials and Methods

Animals and light treatment

This study was approved by the Institutional Animal Care and Use Committee and performed according to the Kobe University Animal Experimentation Regulations (Permission number: 2022-10-01).

One day-old male broiler chicks (Ross 308) were purchased from a local hatchery (Yamamoto Co., Ltd. Kyoto, Japan). Water and food were provided *ad libitum* throughout the experiments. The chicks were maintained in electric battery cages until 5 days old. At 5 d of age, 30 male broilers were assigned to two pens using sawdust as the litter material (Fig. S1, 4.72 m × 0.73 m, each). The average body weights of the two groups were the same. In the control pen, the birds were reared under three white LED lights until 42 days of age. In the other pen, birds were reared under a white LED located in the center, supplemented with blue or red LED lights on either side. More than 90% of chicks reared under red light move to blue light after 3 h[13]. Therefore, the blue and red lights were changed every 3 h until 21 days of age. The wavelengths of the blue and red light were 460 nm and 640 nm, respectively. Based on a previous study[13], the light intensity of all colors was 30 lx. Wavelength and light intensity were measured using a Spectrometer C-700 (SEKONIC CORPORATION, Tokyo, Japan). At 21 days of age, the LEDs on the sides were changed to white. The LED at the center was turned off and the LEDs on the sides were alternately turned on every 3 h until 35 days of age. The light intensity under the side LED (turned on), center LED (turned off), and other side LED (turned off) was 30 lx, 6 lx, and <1 lx, respectively. Rearing density, expressed as body weight per area, increased daily in growing broiler chickens. Therefore, the risk of injury due to the high density may increase. To avoid this risk, all three LEDs were turned on after 35 days of age.

Three video cameras (TLC 200 PRO, Brinno Inc., Taipei, Taiwan) were hung 1.5 m above the litter in each pen, and the positions of the birds were recorded every 30 min from 9 to 35 days of age. As video cameras were hung near each LED light, the number of chicks in each area (Fig. S1) was visually counted. The number of chicks was counted every 1 h avoiding the time when the light changed. For example, the light color changed at 7:00, and the number of chicks in the video was counted at 6:30 and 7:30. All chicks from each pen were observed throughout the experimental period.

At 42 days of age, the gait score of each bird was evaluated and their body weights were measured. Birds were euthanized by decapitation under carbon dioxide inhalation. The skin was removed and the breasts and legs were excised, weighed, and refrigerated for 48 h for aging. Shear force and breaking strength were measured after aging.

Wooden breast score

Wooden breast scoring was performed to evaluate the morphology of individual breast muscles, according to the method described by Papah et al.[18]. The wooden breast score is based on a 4-point scale from 1 to 4: 1 = no detectable increase in firmness of the breast area; 2 = breast length exhibiting localized mild firmness higher than normal; 3 = breast area is moderately firmer on palpation than normal in a focally extensive area; and 4 = >75% of the breast muscle belly is markedly firm on palpation with widespread/diffuse coverage.

Gait score

Gait scoring was scored to assess the mobility of each bird, according to the method described by Garner et al.[19]. The gait score is based on a 6-point scale from 0 to 5: 0 = fluid locomotion; 1 = slight gait defect, but unidentifiable; 2 = slight gait defect, identifiable abnormality; 3 = identifiable abnormality, impaired function; 4 = severely impaired function, but capable of walking; and 5 = complete lameness, unable to walk.

Shear force value

Meat pieces (15 mm long × 10 mm wide × 5 mm thick) were collected from the center and inside the pectoralis major muscles, with the longest side parallel to the muscle fibers. The samples were packed in a decompression package (YVC-100, Yamazen Corporation, Osaka, Japan) and heated in a water bath (SB-1200, Tokyo Rikakikai Co., Ltd., Tokyo, Japan) at 80°C for 10 min. After the samples were cooled in ice water, the shear force values were measured using a Warner-Bratzler blade with a digital force gauge (ZTS-50N, Imada Co., Ltd., Aichi, Japan) and a motorized test stand (MX2-500N, Imada Co., Ltd.). Samples were sheared perpendicular to the direction of the muscle fibers at a shear rate of 250 mm/s. The maximum value at the time of shearing for each sample was used as the shear-force value.

Tibia breaking strength

The tibias of the legs were collected, and their lengths and diameters were measured using a digital caliper (DC-150P, Mitutoyo Corporation, Kanagawa, Japan). Tibia breaking strength was measured using a digital force gauge (ZTS-500N, Imada Co., Ltd.) and a motorized test stand (MX2-500N, Imada Co., Ltd.). Samples were broken perpendicularly to the long axis of the tibia at a rate of 10 mm/s. The maximum value at the time of breaking was used as the breaking strength for each sample.

Statistical analysis

Gait and wooden breast scores were analyzed using the Mann-Whitney U test. Other data were analyzed using the Student's *t*-test.

Results and Discussion

The locomotion of broiler chicks in the light-switching pen was significantly enhanced from 12 to 20 days of age (Fig. 1 and S2): the number of chicks in the red light area was significantly lower than that in white and blue light areas during these days

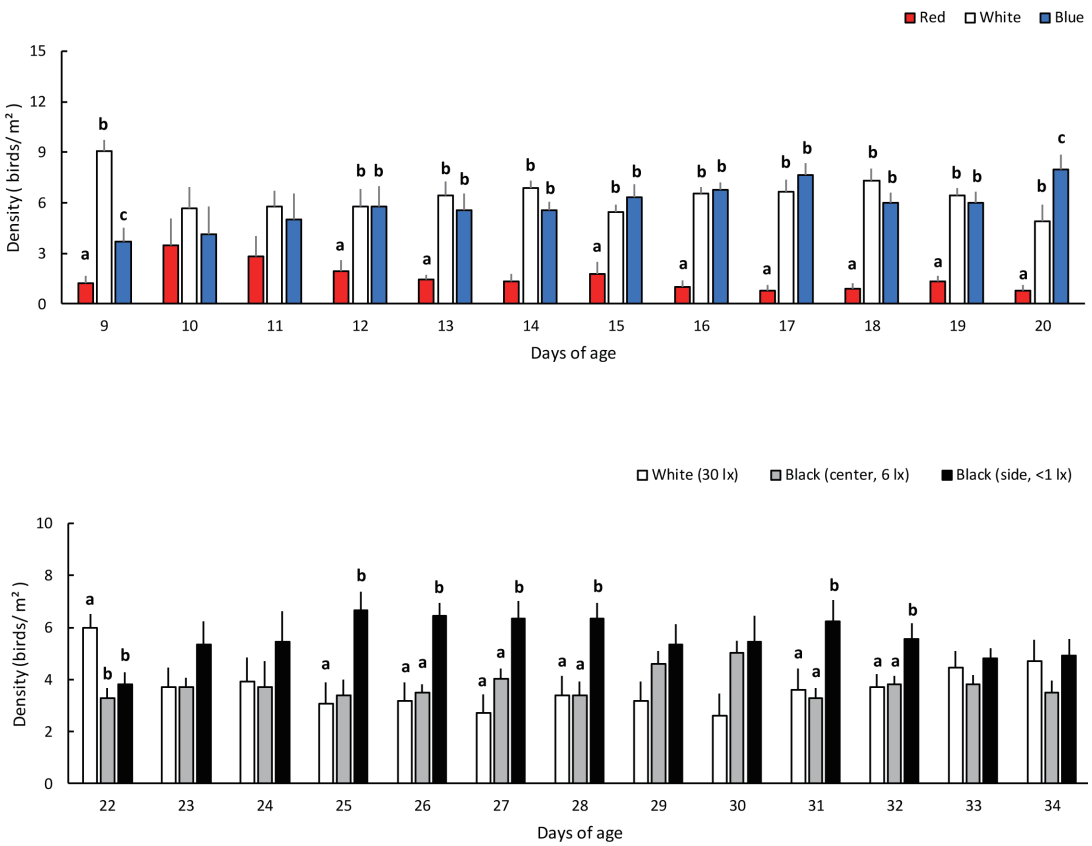

Fig. 1. **Effect of periodic and local light switching on the number of chicks in each color or light intensity area after 2.5 h of light switching.** Data are expressed as means ± SEM of eight replicates in each area. Groups with different letters are significantly different ($P < 0.05$)

of age (Fig. 1). The locomotion of broiler chicks in the light-switching pen seemed to be enhanced from 25 to 28 and 31 to 32 days of age (Fig. 1 and S3), and the number of chicks in the white light area was significantly lower than those in other areas during these days (Fig. 1). Broiler chick locomotion was not observed in the control pen (Fig. S4 and S5). Thus, the walking behavior of broiler chicks was successfully induced using the light switching system.

The number of chicks in the white 30 lx area increased significantly at 9 and 22 d of age (Fig. 1). The reason for these differences remains unclear. However, cautious behavior in chicks may be induced by major changes in the lighting patterns. That there were no significant changes in the number of chicks in each area from 10 to 11 and 23 to 24 days of age may indicate acclimatization periods.

As shown in Table 1, there is no significant difference in body weight, breast muscle weight, or leg weight between groups. The wooden breast scores tended to improve with light switching ($P = 0.067$, Table 1), whereas the shear force value, gait score, length, diameter, and breaking strength of the tibia were not affected (Table 1). As feed intake was not measured, the effects of

Table 1. **Effects of periodic and local light switching on body weight, breast weight, leg weight, wooden breast score, shear force value, gait score, and indices of the tibia in broiler chicks**

	Control	Light switching
Body weight (g)	3063 ± 49	3131 ± 51
Breast (g)	604 ± 18	613 ± 22
Legs (g)	542 ± 10	559 ± 11
Wooden breast score	2.08 ± 0.22	1.5 ± 0.19 †
Gate score	1.73 ± 0.20	1.27 ± 0.24
Shear force value (N)	6.62 ± 0.69	6.33 ± 0.42
Tibia		
Length (mm)	102.3 ± 0.8	103.2 ± 0.6
Diameter (mm)	9.7 ± 0.2	9.7 ± 0.1
Breaking strength (N)	390 ± 24	422 ± 25

Data are expressed as means ± SEM of fifteen replicates in each group.
†, $P < 0.1$.

light switching on the growth performance of chicks were not clear. However, it appears likely that the light-switching system did not cause serious adverse effects in broiler chicks.

The gait score did not improve in the present study; the gait score of 53.3% of the chicks in the control group was 2, whereas the gait score of 46.7% of the chicks in the light-switching group was 1 (data not shown). Hahn et al.[20] reported that forced locomotor activity improves the walking ability of turkeys. Their training started with a running distance of 50 m at 2 weeks of age and increased weekly by 50 m up to 300 m from 7 weeks of age. Taylor et al.[21] reported that accessing an outdoor range improves the gait score in broiler chicks. Thus, further improvements in the rearing system, including light-switching frequency and larger space to increase locomotor activity, may be needed to prevent leg weakness and wooden breasts in broiler chicks.

In conclusion, this is the first study to demonstrate that periodic and local light-switching systems induced locomotion in broiler chicks. However, further improvements in lighting systems are required to prevent wooden breast myopathy and leg weakness.

Author Contributions

Shingo Kusuda conducted the experiments and analyzed the data. Chikamitsu Oshima and Kazuhisa Honda designed the experiments. Shingo Kusuda wrote the manuscript. Takaoki Saneyasu and Kazuhisa Honda edited the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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