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Behavioral and Production Responses of W-36 Chicks to Supplementary UVA Light

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ABSTRACT. *UVA (315-400 nm) light perception is an essential part of poultry vision, which may be used to modify behavioral traits of birds such as feeding, peer recognition, and social encounters. The objectives of this study were to assess behavioral and production responses of W-36 chicks reared under LED light with or without various levels of UVA supplementation (0%, 5%, 10%, and 15%), i.e., LED+UVA vs. LED. For behavioral response, a total of 108 chicks (day-old) in 18 groups were assessed for their lighting preference. Each group of chicks was involved an 8-d preference test, during which the birds could move freely between two inter-connected compartments that contained LED and LED+UVA, respectively. For production response, a total of 180 chicks (day-old) in 12 groups were used to assess the effects of the UVA supplementation (5%) on growth performance of chicks. For each batch, two groups were randomly assigned to two compartments, one with LED and the other with LED+UVA. In the scenario of 0% vs. 5% UVA, the chicks spent significantly lower amount of time under LED+UVA than under LED (45.6% vs. 54.4%), but had comparable feed use under both light conditions. In the scenario of 0% vs. 10% UVA, the chicks showed similar amount of time spent and feed use. In the scenario of 0% vs. 15% UVA, the chicks spent significantly higher proportion of time (61.3% vs. 38.7%) and consumed significantly more feed (60.5% vs. 39.5%) under LED+UVA than under LED. Chicks had comparable growing performance under LED and LED+UVA (5%) and no eye pathology was detected at 5% UVA supplementation level. The study demonstrates the attracting effect of UVA light at 15% inclusion rate under LED illumination on chicks in terms of time spent and feed use. A large-scale and long-term study to further verify the positive effects of UVA inclusion seems warranted.*

Keywords. *Computer vision, Growing performance, Light preference, Poultry lighting, UVA light*

Introduction

Ultraviolet (UV) light perception may play important functions in navigation, foraging, interspecies communication, and control of circadian rhythms in various animal species from insects to mammals (Tovee, 1995). Poultry have a fourth retinal cone that allows them to see in the ultraviolet A (UVA) wavelength (315-400 nm) (Prescott & Wathes, 1999;

Cuthill et al., 2000). As such, poultry may use UVA perception to modify various behavioral functions such as feeding, peer recognition, mate selection, mating activity, and social encounters (Lewis & Gous, 2009). As UVA perception is an essential part of poultry vision, it may be of socio-economic significance to provide a certain amount of UVA light in modern poultry production facilities, particularly where artificial lighting is the only light source for the animals.

Previous research has reported beneficial or non-detrimental effects of UVA lights on poultry. On the one hand, UVA light could greatly influence poultry physiology and behavior, thus enhancing poultry well-being and production. For example, UVA light has been reported to minimize injurious pecking in intact male turkeys (Lewis et al., 2000), reduce basal corticosterone levels of broiler chicks (Maddocks et al., 2001), increase both the number of mating and the amount of locomotor activity performed by broiler breeder males (Jones et al., 2001), prolong laying cycle (Lewis et al., 2007), increase critical flicker frequency values for chickens (Rubene et al., 2010), and have no effect on eye pathology (Hogsette et al., 1997). On the other hand, UVA light may not be efficient in improving poultry production performance as it did not show significant differences in egg production, fertility, hatchability of fertile eggs, or total hatchability for W-36 laying hens (Hogsette et al., 1997); nor was there significant difference in mortality, weight gain, feed consumption, or feed conversion for broilers and turkeys (Hogsette & Wilson, 1999; Lewis et al., 2000). Recently, there have been some anecdotal claims by industry people that UVA lights attract turkeys to feed when the feeders are illuminated with UVA lights. However, few published scientific studies could be found that prove or disprove the validity of such claims. A previous study on young laying hens found that UVA light had a suppressing effect on feed intake (Lewis et al., 2000). However, young turkeys chose white fluorescent light supplemented with UVA light over white fluorescent light on its own in preference tests, irrespective of whether they had been reared with or without supplementary UVA light (Moinard & Sherwin, 1999).

If UVA light can indeed be used to attract the birds to feed, it would be a powerful tool for poultry producers to get the young birds a quicker start in feeding once introduced to an unfamiliar environment. Getting birds to feed as quickly as possible in an unfamiliar environment is very critical to ensuring good subsequent health and production performance. This is particularly true with day-old birds. Past research experiences with the PI's group clearly showed that delayed start in feeding will cause markedly higher mortality within the first week, even though, in theory, the day-old birds can live on the yolk for two to three days. The problems lie in the fact that when birds do not learn how to feed quickly they will suffer from the "starve-out" syndrome four to five days after the placement. Furthermore, those that did survive are believed to have subpar subsequent production performance.

Therefore, the overarching goal of this study was to better understand the impact of UVA light on poultry with regards to behavior, well-being and production performance; and to provide data for the establishment of guidelines on UVA light application in commercial poultry operations. As the first step toward attaining the goal, the specific objectives of this study were: 1) to investigate the behavioral responses of poultry to supplementary UVA light through preference test, emphasizing its impact on feeding behavior of young chicks, and 2) to assess the effects of the supplementary UVA light on mortality, feed intake, body weight gain, feed conversion ratio, and eye condition (e.g., pathology) of young chicks. The guiding hypothesis of this project was that the poultry-specific LED light supplemented with certain amount of UVA light (i.e., LED+UVA) will have an attracting effect on chicks compared to the same LED light without supplementary UVA light (LED only); and the UVA lighting will not cause detriments to birds' eyes.

Materials and Methods

This study was conducted in an environmentally controlled animal research laboratory located at Iowa State University, Ames, Iowa. Two separate experiments were conducted to fulfil the stated objectives. The procedures and methodologies for each experiment are described below. Before the onset of the experiments, the experimental protocol was approved by the Iowa State University Institutional Animal Care and Use Committee (Log #: 12-16-8408-G).

Experimental Lights

Light Sources Used in the Study

A poultry-specific Dim-to-Blue LED light (Agrishift JLP LED, 8W, Once, Inc., Plymouth, MN, USA[1]) and a HL-UVA LED light (Agrishift HL-UVA LED, 385 nm, 3W, Once, Inc.) were used in the study. Two light environments were investigated in the experiments, i.e., Dim-to-Blue LED light supplemented with or without HL-UVA LED light, designated as LED+UVA and LED, respectively. The spectral profiles (Fig. 1) of the LED light supplemented with or without the UVA light were determined using a spectrometer (GL Spectis 1.0 Touch, GL Optic Inc., Germany) coupled with a software for measuring poultry-perceived light intensity in p-lux (SpectraShift 2.0, Once, Inc.). As shown in the Fig. 1, the LED+UVA has substantial amount of UVA light at 385 nm wavelength, while the LED light does not contain any UVA light.

[1] *Mention of trademark, proprietary product, or vendor is for information purposes only. No endorsement implied.*

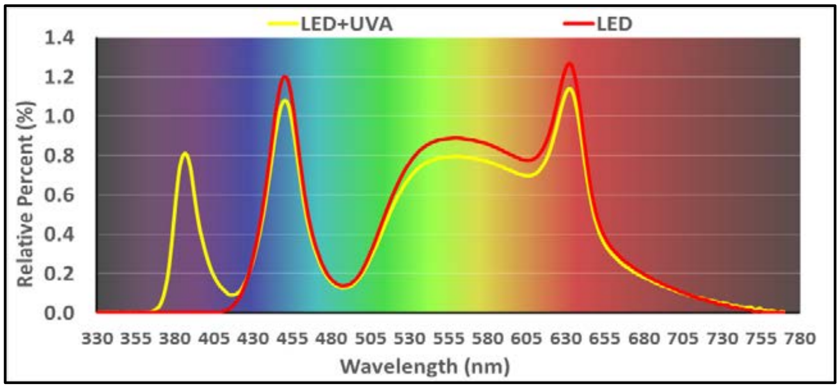


Figure 1. Spectral characteristics of the Dim-to-Blue LED light with or without supplementary UVA light used in the study, designated as LED+UVA and LED, respectively.

Light Treatments Used in the Study

Four levels of UVA light supplementation were achieved in the study, including 0% (LED light only), 5%, 10%, and 15% UVA light. Three comparisons were conducted with regards to the UVA levels, namely, 0% *vs.* 5%, 0% *vs.* 10%, and 0% *vs.* 15%. For the experiment assessing behavioral responses of chicks under the LED+UVA *vs*. LED, all the three comparisons were conducted and completed, but only the comparison of 0% *vs*. 5% UVA was completed in the experiment assessing production responses of chicks. The lighting program (Table 1) used in the study was determined according to the genetic breed and age of the experimental birds (i.e., Hy-Line W-36, day-old chicks at the onset of the experiment, Fig. 2) and used for both experiments.

Table 1. Lighting program used for Hy-Line W-36 chicks (from 0 to 8-day old) in the study.

Age (day)	Light Schedule (h)	Light Period (hh:mm)	Recommended Light Intensity (lux) [1]	Light Intensity (lux/p-lux [2])
0	22	00:00-22:00	30-50	40/60
1	22	00:00-22:00	30-50	40/60
2	22	00:00-22:00	30-50	40/60
3	22	00:00-22:00	30-50	40/60
4	21	00:00-21:00	30-50	40/60
5	21	00:00-21:00	30-50	40/60
6	21	00:00-21:00	30-50	40/60
7	21	00:00-21:00	30-50	40/60
8	20	00:00-20:00	25	40/60

[1] Light intensity measured using human light meter; intensity levels for each age are recommended by the Hy-Line W-36 Commercial Layers Management Guideline.
[2] Light intensity measured using spectrometer as poultry-perceived light.

Experiment 1 - Behavior Responses of Chicks to LED+UVA *vs*. LED

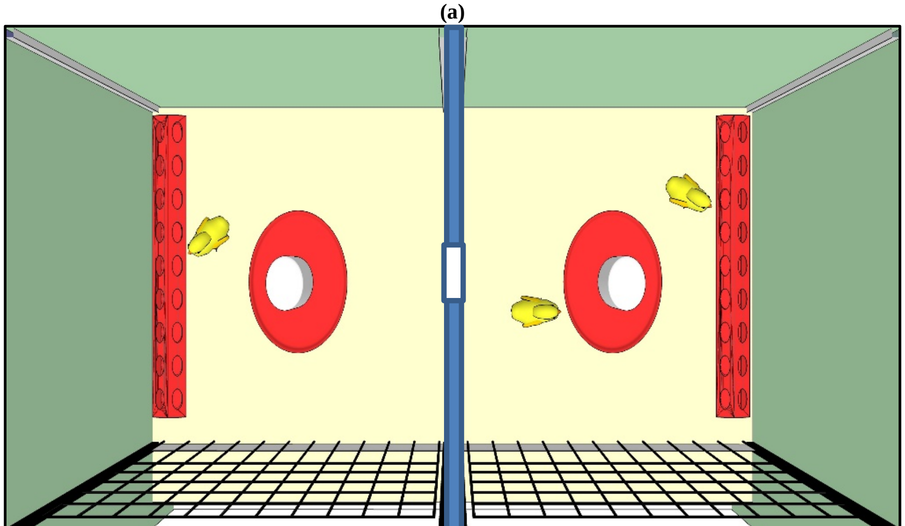
Animals and housing

Behvioral responses of chicks to the supplementary UVA light was assessed via a preference test. A total of 108 day-old W-36 chicks (Fig. 2) in nine successive batches (12 chicks per batch and three batches for each comparsion) were used in this preference test. These day-old chicks were procured from a local commercial hatchery (Hy-Line International) in Dallas Center, Iowa. For each batch of chicks, birds were randomly selected from the hatchery and were randomly assigned to two groups with six chicks per group upon arrival at our lab facility. For each group, the six chicks were individually marked on their heads with one of the six colored paints (animal-specific) – yellow, blue, green, purple, pink, and orange. Thus all the chicks within each group were individually identified by color. The two groups of chicks were then placed inside two sets of free-choice preference-test compartments (Fig. 3) for an eight-day preference test. In this experiment, for each comparsion (i.e., 0% *vs.* 5%, 0% *vs.* 10%, and 0% *vs.* 15%), six groups of chicks were tested.

Figure 2. W-36 chicks (day-old) used in the study.

Each of the two sets of free-choice preference-test compartments (Fig. 3) used in the experiment had two identical compartments (60 cm L × 90 cm W × 180 cm H) with free access to each other through a recutanglar passageway (10 cm W × 12 cm H). A round drinker and a rectangular feeder were provided in each compartment. Feed and water were available ad-lib during the test. The preference-test compartments were conditioned (warmed) to the desired environment (e.g., 33-35°C, 50% RH) at least 24 hours prior to the arrival of the experimental birds. Temperature and relative humidity (RH) were maintained essentially identical in all compartments at the desired levels according to the Hy-Line W-36 Commercial Layers Management Guideline, i.e., 33-35ºC from day-old to three days old; 31-33ºC from four to seven days old; and 29-31ºC at eight days old. The compartments are light-proof and each is equipped with a Dim-to-Blue LED light. Light intensity within each compartment was maintained constantly throughout the experiment at similar intensity level as indicated in Table 1. For each comparison (i.e., 0% *vs.* 5%, 0% *vs.* 10%, and 0% *vs.* 15%, respectively), UVA light was alternately applied to one of the two compartments within each set of free-choice preference-test compartments on a daily basis (Table 2) during the eight-day test (LED+UVA *vs*. LED).

(a)



(b)

Figure 3. A schematic representation of the free-choice preference-test compartments, (a) side-view and (b) top-view.

Table 2. Light treatment arrangements in the free-choice preference-test compartments.

age	Set 1		Set 2	
	Left	Right	Left	Right
0	LED+UVA	LED	LED+UVA	LED
1	LED	LED+UVA	LED	LED+UVA
2	LED+UVA	LED	LED+UVA	LED
3	LED	LED+UVA	LED	LED+UVA
4	LED+UVA	LED	LED+UVA	LED
5	LED	LED+UVA	LED	LED+UVA
6	LED+UVA	LED	LED+UVA	LED
7	LED	LED+UVA	LED	LED+UVA
8	LED+UVA	LED	LED+UVA	LED

"LED+UVA" and "LED" stand for LED light with and without supplemented UVA light, respectively.

Data acquisition and processing

Daily feed use in each compartment was manually weighed and recorded on a group basis. The proportion of daily feed use under each light environment (LED+UVA *vs*. LED) or compartment (left or right) was calculated. Distribution and locations of the birds in each set of free-choice preference-test compartments were recorded at 1 frame per second (FPS) using a top-view camera system (720P HD, night vision, backstreet Surveillance Inc., Salt Lake City, UT, USA) over the eight days. Algorithms for image processing (color detection) were developed using MATLAB (MATLAB R2014b, The MathWorks, Inc., Natick, MA, USA) and validated by comparing with the golden standard (human observation). Locations of individual birds or their choices of light environment/compartment were analyzed using the developed image processing algorithms (Fig. 4), and the time-series data of choices for lights or compartments were summarized using VBA program using Microsoft Excel (Fig. 5). The proportion of time spent by the chicks under each light environment (LED+UVA *vs*. LED) or compartment during the light period was analyzed.

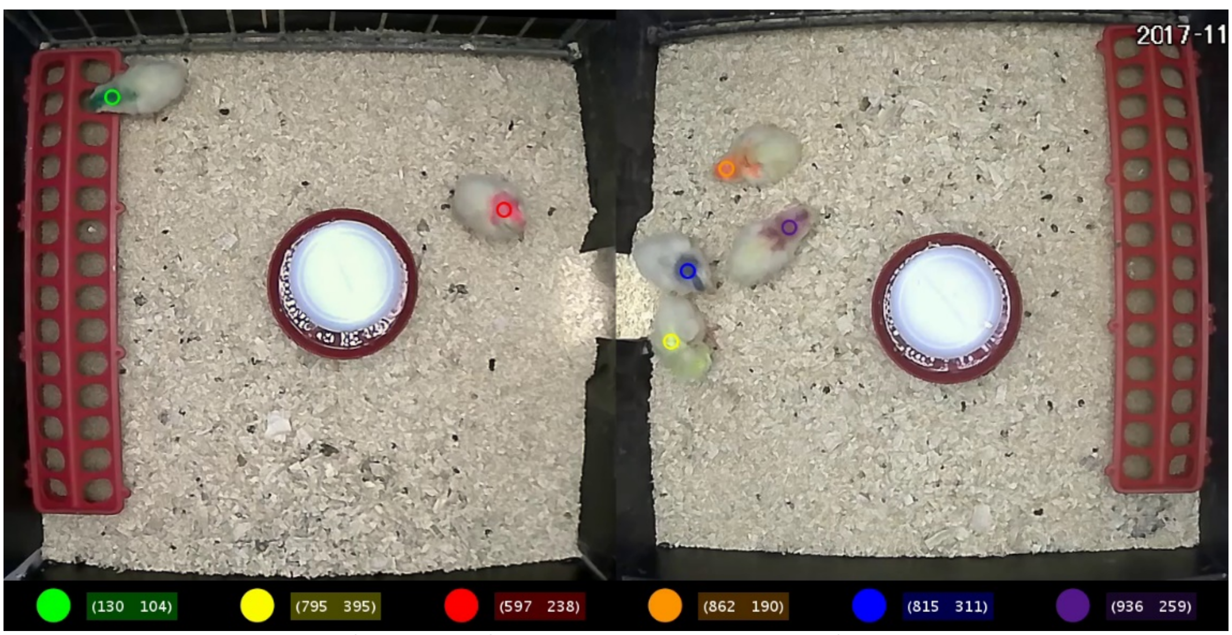


Figure 4. Individual chicks in the free-choice preference-test compartments were identified based on the color markers on their heads using an automated computer vision algorithm.

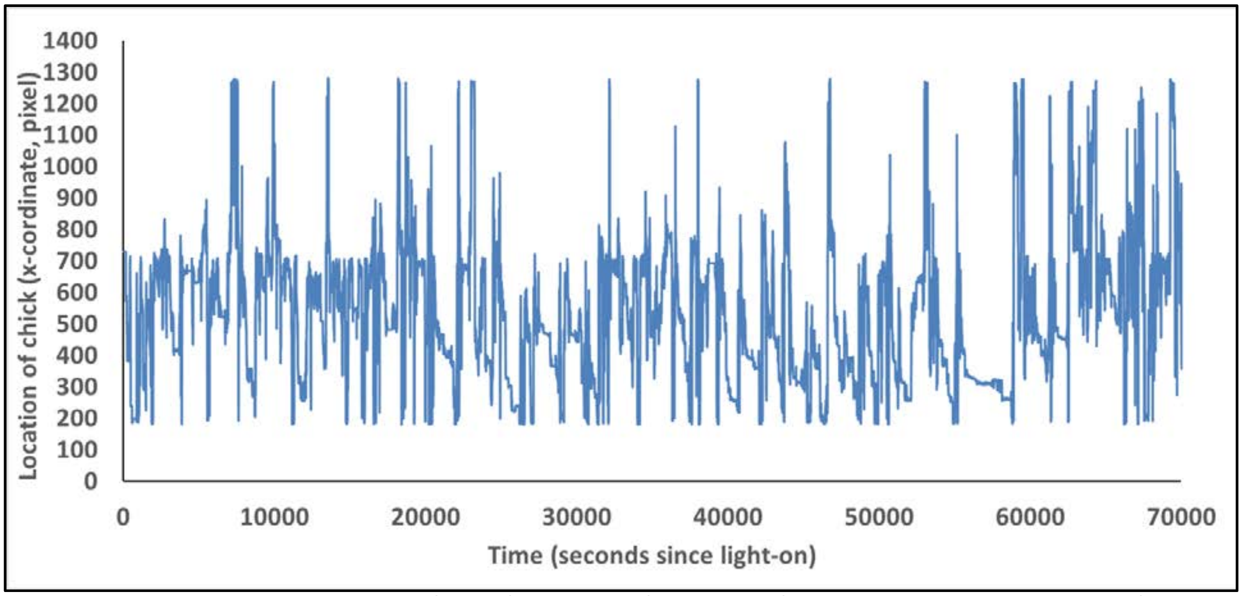


Figure 5. Time-series locations (x-coordinate) of a specific chick in the free-choice preference-test compartments. The value of 700 pixels corresponds to the partition wall and the passageway between the two compartments.

Experiment 2 - Production Responses of Chicks to LED+UVA vs. LED

Animals and housing

A total of 180 day-old W-36 chicks (Fig. 2) in six successive batches (30 chicks per batch) were used in the experiment assessing their growing performance under LED+UVA *vs.* LED. These day-old chicks were also procured from the hatchery of Hy-Line International. For each batch of chicks, the birds were randomly selected from the hatchery and were assigned to two groups with 15 chicks per group. All the chicks were individually weighed before assigning to a specific group as we maintained comparable average body weight for the two groups at the onset of the experiement. For each group, the 15 chicks were individually identified using two colored leg bands that included yellow, blue, green, purple, pink, and orange (one colored band for each leg). The two groups of chicks were then randomly placed inside two environmental compartments for an eight-day performance test. The two environmental compartments were similar to the free-choice preference-test compartments as described in Experiment 1, but these two environmental compartments had no passageway between them, thus birds were not allowed to move between compartments. Both compartments were equipped with a Dim-to-Blue LED light, but only one of them had supplementary UVA light, which was not alternated between the compartments for the eight-day test (although the LED+UVA and LED treatments were swapped between the compartments for different batches of chicks). In this experiment, all six batches of chicks were tested for the comparsion of 0% *vs*. 5% UVA. The comparsions for 0% *vs.* 10% and 0% *vs.* 15% UVA were not tested due to time limitations.

Data acquisition and processing

Chicks were individually weighed before the placement and at the end of performance test (eight-day old). Average body weight and average body weight gain were then calculated. The feeder in each compartment was manually weighed during the dark period (no more feeding behavior), thus daily feed consumption and the feed conversion ratio were also calculated on a group basis. At the end of each test, the birds were examined for any pathological signs in the eyes. This examination (Fig. 6) was performed to assess if the exposure of the birds to the UVA light for the eight-day period causes any adverse effect to the birds' eyes. Specifically, all birds were subjected to an ophthalmic examination by a board-certified veterinary ophthalmologist utilizing slit-lamp bio-microscopy.

Figure 6. Ophthalmic examination by a board-certified veterinary ophthalmologist utilizing slit-lamp bio-microscopy.

Data Analysis

Statistical analyses were performed using SAS Studio 3.5 (SAS Institute, Inc., Cary, N.C.). For variables derived from the preference test, the proportions of daily feed intake and time spent by the chicks under both light conditions were analyzed to determine light preference. These two variables were analyzed with generalized linear mixed model by implementing PROC GLIMMIX procedure. A beta distribution was specified for the analyses. Data from the three comparisons (0% *vs.* 5%, 0% *vs.* 10%, and 0% *vs.* 15%) were analyzed separately using a same model, in which the bird age (0, 1, 2, 3, 4, 5, 6, and 7-d old) was considered fixed effect and the bird group (1, 2, 3, 4, 5, and 6) was the random effect. The interaction effect of the bird age and bird group was also included in the model as random effect. Evaluation of the light preference was accomplished by testing the null hypothesis that the proportion of daily feed intake or the proportion of time spent under each light condition equals 0.5. As the beta distribution used a logit link function, the evaluation was actually testing if the intercept equals zero [logit(0.5) = 0]. For variables derived from the performance test, overall feed intake, body weight gain, and feed conversion ratio of chicks under both light treatments were analyzed with a linear mixed model by implementing Proc MIXED procedure. In this model, light treatment (LED+UVA *vs.* LED) was considered fixed effect, and the bird group was the random effect. Differences were considered significant at $p < 0.05$. Normality and homogeneity of variance of the data were examined by residual diagnostics. Unless otherwise specified, data are presented as least squares means along with the standard error of the mean (SEM).

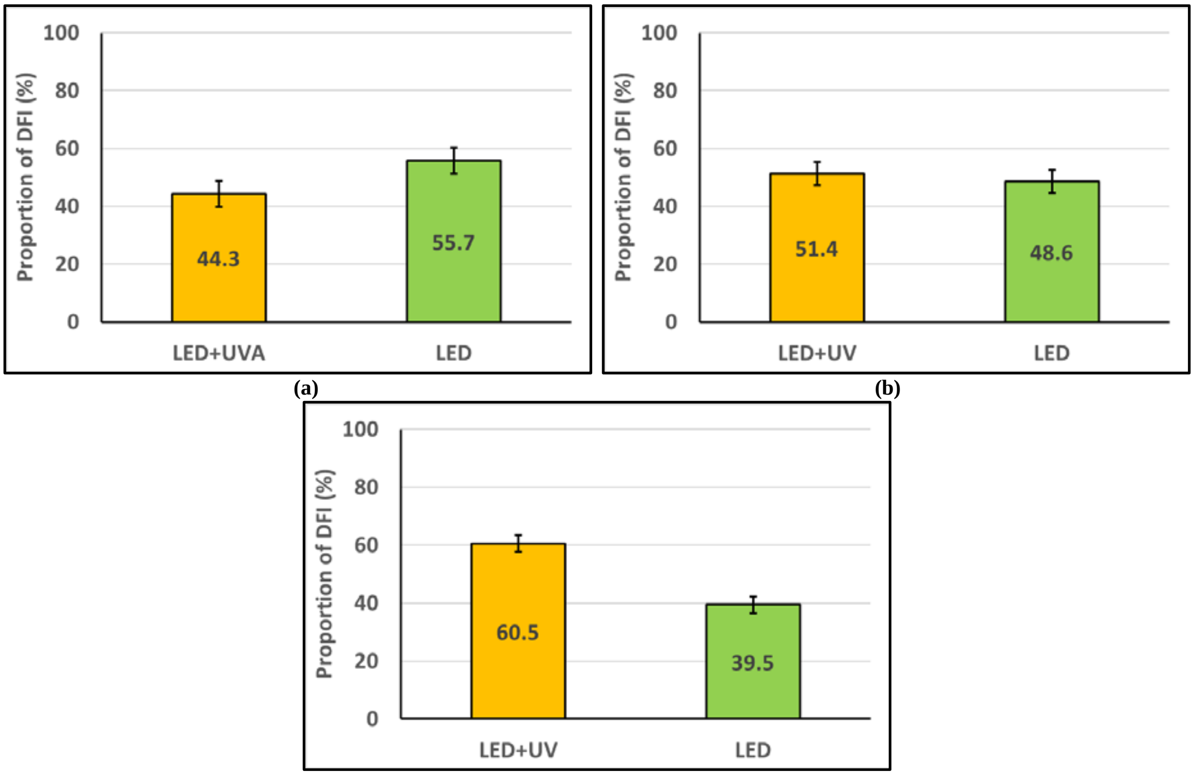
Results and Discussion

The preference tests were all finished and the performance tests on the comparison of 0 *vs.* 5% UVA were also completed by the end of December 2017. No bird mortality or system failure was found during the entire study. The following results were summarized and analyzed from the collected data. When available, results from the current study were also discussed comparatively with those from the previous studies.

Experiment 1 - Behavior Responses of Chicks to LED+UVA vs. LED

Feed use of chicks under LED+UVA vs. LED

As shown in Fig. 7, at the low (0% *vs*. 5%) and the median (0% *vs*. 10%) UVA light levels, the chicks consumed comparable amount of feed under the LED light with or without supplementary UVA light (P = 0.21 and P = 0.72, respectively), but the chicks consumed significantly more feed under the LED light supplemented with UVA light than under the LED light (60.5% *vs*. 39.5%, P < 0.01) at a higher UVA light level (0% *vs*. 15%). These results indicated that the feeding behaviors of young chicks were somehow changed by the UVA light at 15% inclusion rate under LED illumination. In the other words, UVA light at 15% inclusion rate under LED illumination showed attracting effect on chicks in terms of feed use. However, there no other studies were found in the literature regarding the impact of UVA light on feeding behavior of young chicks. A similar study on young laying hens conducted by Lewis et al. (2000) found that UVA light had a suppressing effect on feed intake on young laying hens. Consequently, it may be reasonable to guess that the impact of UVA light on birds is age-dependent, thus a study to assess impacts of UVA inclusion on birds at different ages seems warranted. Besides, it would be very interesting to continue this preference test with increased levels of UVA supplementation, such as 0% *vs.* 25% or 30%.



(a) (b) (c)

Figure 7. Proportion of daily feed intake (DFI) of chicks under LED light with or without supplemented UVA light (mean ± SE). (a) 0% *vs*. 5% UVA, (b) 0% *vs*. 10% UVA, and (c) 0% *vs*. 15% UVA. "LED+UVA" and "LED" stand for LED light with and without supplemented UVA light, respectively.

Time Spent of chicks under LED+UVA vs. LED

As shown in Fig. 8, at low UVA light (i.e., 0% *vs*. 5%), chicks spent significantly higher amount of time under the LED light without supplemented UVA light than LED light supplemented with UVA light (54.4% *vs*. 45.6%, $P < 0.01$). At the UVA light of 0% *vs*. 10%, chicks spent comparable amount of time under the LED light with or without the supplemented UVA light ($P > 0.05$). while at the high UVA light level (0% *vs*. 15%), chicks spent significantly higher amount of time under the LED light supplemented with UVA light (61.3% *vs*. 38.7%, $P < 0.01$). These results indicated that the choice of the light environment by young chicks were somehow dependent on the supplementation levels of UVA light. More specifically, UVA light at 15% inclusion rate under LED illumination showed an attracting effect on chicks in terms of time spent. A similar attracting effect was reported by another study conducted by Moinard & Sherwin (1999), who found that young turkeys chose white fluorescent light supplemented with UVA light over white fluorescent light on its own in preference tests, irrespective of whether they had been reared with or without supplementary UVA light. However, as this study only lasted for eight days for each preference test, a large-scale and long-term study to further verify the positive effects of UVA inclusion seems warranted.

Experiment 2 - Production Responses of Chicks to LED+UVA vs. LED

Mortality, Feed Intake, Body Weight Gain, and Feed Conversion Ratio

During the performance test, no mortality was found for either light treatment. Under the comparison of 0% *vs*. 5% UVA supplementation, W-36 chicks had comparable total feed intake (89.2 g/bird *vs*. 89.1 g/bird, $P > 0.05$, Fig. 9(a)), body weight gain (49.7 g *vs*. 49.9 g, $P > 0.05$, Fig. 9(b)), and feed conversion ratio (1.79 *vs*. 1.78, $P > 0.05$, Fig. 9(c)) over the eight-day test period under the LED light supplemented with or without UVA light. These results from the current study were consistent with the results reported in some earlier studies. Hogsette & Wilson (1999) and Lewis et al. (2000) found that supplementary UVA light did not lead to significant difference in mortality, weight gain, feed consumption, or feed conversion for broilers and turkeys. On the other hand, W-36 chicks have been found to consume a significantly higher proportion of daily feed intake under LED light as compared to LED+UVA (5%) in the earlier preference test, and a previous study on young laying hens found that UVA light had a suppressing effect on feed intake (Lewis et al., 2000). The results from the current study did not agree with those findings as the total feed intakes of young chicks were comparable under the LED+UVA *vs*. LED. Considering the performance test lasted for only eight days for young chicks, and only the comparison of 0% *vs*. 5% UVA supplementation has been completed in the current study, a large-scale and long-term study to further assess the effects of UVA inclusion with higher supplementation levels (10%, 15%, or higher) seems warranted.

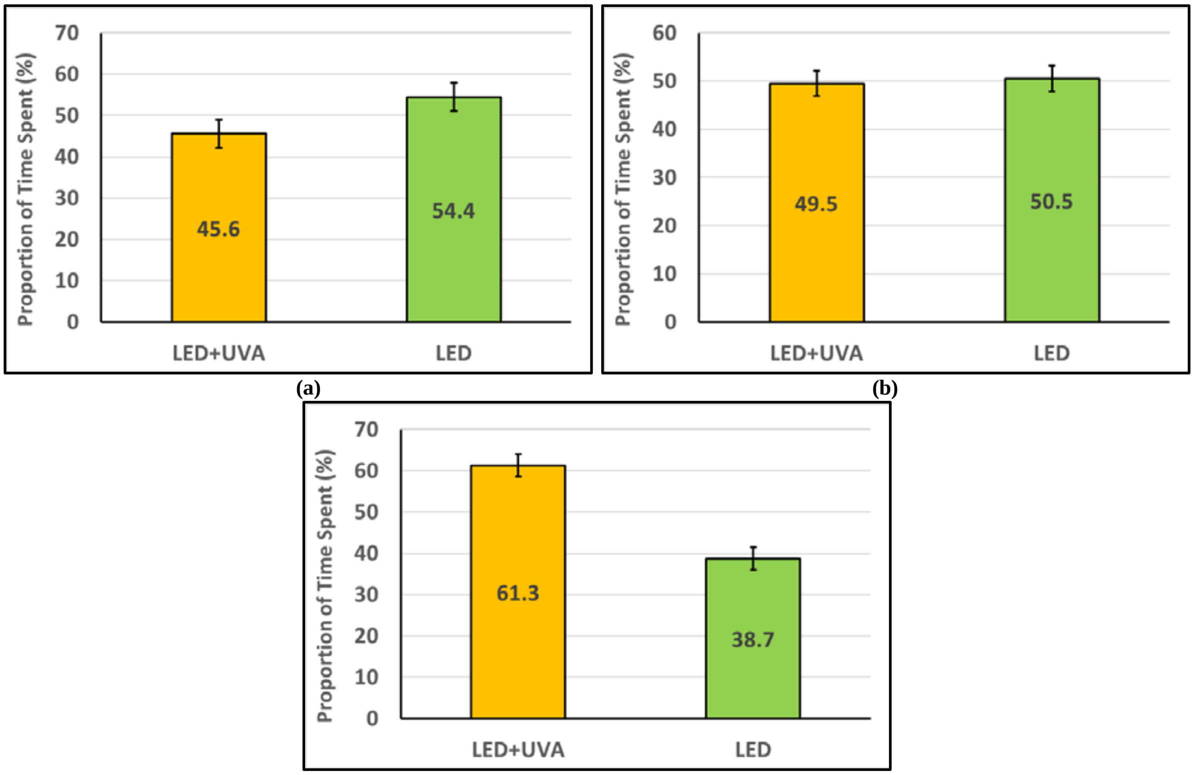


Figure 8. Proportion of light-period time spent by the chicks under LED light with or without supplemented UVA light (mean ± SE), (a) 0% *vs*. 5% UVA, (b) 0% *vs*. 10% UVA, and (c) 0% *vs*. 15% UVA. "LED+UVA" and "LED" stand for LED light with and without supplemented UVA light, respectively.

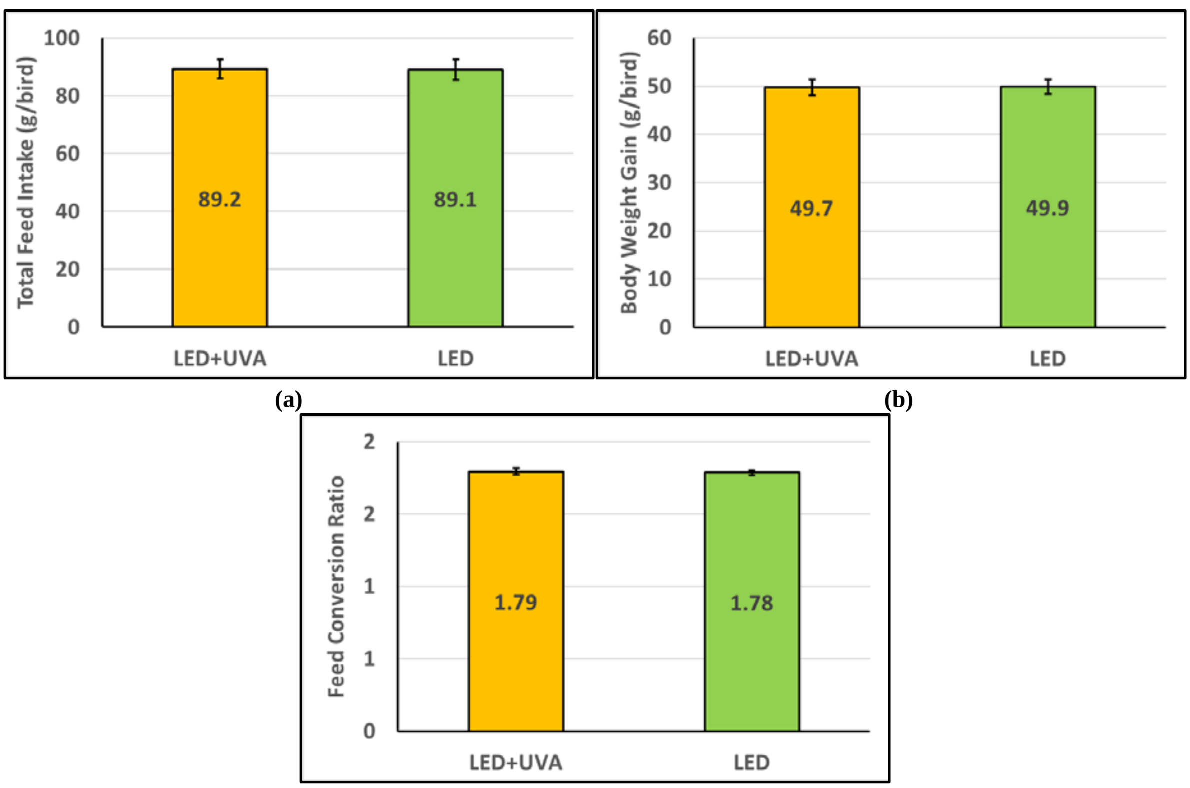


Figure 9. Growing performance of chicks over an 8-d test period under LED light with or without 5% supplementary UVA (mean ± SE). (a) Total feed intake, (b) Body weight gain, (c) Feed conversion ratio. "LED+UVA" and "LED" stand for LED light with or without supplemented UVA, respectively.

Eye Condition

Under the comparison of 0% *vs*. 5% UVA supplementation, no apparent eye pathology was detected for chicks under the both light treatments. W-36 chicks had comparable eye condition at the end of the eight-day test period under the LED light with and without supplemented UVA light. This result was consistent with an earlier finding that Hogsette et al. (1997) reported that UVA light had no effect on eye pathology.

Conclusion

This study assessed behavioral and production responses of W-36 chicks (day-old) for light-emitting diode (LED) light supplemented with or without various levels of UVA light (0%, 5%, 10%, and 15%), i.e., LED *vs*. LED+UVA. A total of 108 chicks (day-old) in 18 groups over nine successive batches were assessed for their choice via preference test, and a total of 180 chicks (day-old) in 12 groups over six successive batches were assessed for their growing performance. The following results were found. In the scenario of 0% *vs*. 5% UVA, the chicks spent significantly lower amount of time under LED+UVA than under LED (45.6% *vs*. 54.4%), but had comparable feed use under both light conditions. In the scenario of 0% *vs*. 10% UVA, the chicks showed similar amount of time spent and feed use. In the scenario of 0% *vs*. 15% UVA, the chicks spent significantly higher proportion of time (61.3% *vs*. 38.7%) and consumed significantly more feed (60.5% *vs*. 39.5%) under LED+UVA than under LED. Chicks had comparable growing performance (mortality, total feed intake, body weight gain, and feed conversion ratio) under LED and LED+UVA (5%) and no eye pathology was detected at 5% UVA supplementation level. The study demonstrates the attracting effect of UVA light at 15% inclusion rate under LED illumination on chicks in terms of time spent and feed use. A large-scale and long-term study to further verify the positive effects of UVA inclusion seems warranted.

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