2950 Niles Road, St. Joseph, MI 49085-9659, USA
269.429.0300 fax 269.429.3852 hq@asabe.org www.asabe.org

An ASABE Meeting Presentation
DOI: https://doi.org/10.13031/aim.201800193
Paper Number: 1800193

Computer Vision-Based Animal Preference Assessment – Do Laying Hen Chicks Prefer Light with UVA Radiation?

*Kai Liu [1, 3], Kailao Wang [1, 4], Tao Fei [2], Lilong Chai [1], Hongwei Xin [1, *]*

[1] *Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA 50011, USA*

[2] *Department of Food Science and Human Nutrient, Iowa State University, Ames, IA 50011, USA*

[3] *Department of Clinical Studies, University of Pennsylvania, Kennett Square, PA, 19348, USA*

[4] *Department of Biosystems Engineering, Zhejiang University, Hangzhou, Zhejiang, 310058, China*

** Corresponding author: hxin@iastate.edu*

Written for presentation at the
2018 ASABE Annual International Meeting
Sponsored by ASABE
Detroit, Michigan
July 29-August 1, 2018

ABSTRACT. ***Poultry have a fourth retinal cone that allows them to see in the ultraviolet A (UVA) wavelength (315-400 nm) and may use UVA perception to modify various behavioral functions such as feeding, peer recognition, mate selection, and social encounters. As UVA perception is an essential part of poultry vision, it may be of socio-economic significance to provide certain amount of UVA light in poultry production facilities, particularly in most of modern facilities where artificial lighting is the only light source for the birds. However, there is limited scientific information regarding how to provide the UVA supplementation to birds as well as the behavioral responses of birds to UVA radiation. The objective of this study was to assess preference of W-36 chicks (day-old) for light-emitting diode (LED) light supplemented with or without various levels of UVA radiation (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. For each group (six chicks), each bird was individually identified with one of the six colored marks (yellow, green, blue, purple, pink, and orange) on the head. Each group of chicks involved an 8-day preference test, during which the birds could move freely between two inter-connected compartments that contained LED and LED+UVA, respectively. A real-time monitoring system was employed to record behaviors of chicks at a capture rate of 5 frames per second. Trajectory of each bird was tracked using automated computer vision based on color detection algorithms. Time spent and feed intake by the birds under each light condition were measured daily and analyzed with generalized linear mixed models. 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. 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, Feeding behavior, 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 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 certain amount of UVA light in poultry production facilities, particularly in most of modern facilities 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 induce well-being friendly behaviors, thus enhancing poultry well-being and production. For example, UVA light has been reported to minimize injurious pecking in intact turkey males (Lewis et al., 2000), reduce basal corticosterone levels of broiler chicks (Maddocks et al., 2001), increase both the number of mattings 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 radiation over white fluorescent light on its own in preference tests, irrespective of whether they had been reared with or without supplementary UVA radiation (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 the 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.

This study was conducted as a part of a comprehensive project to pursue the overarching goal of better understanding the impact of UVA radiation (385 nm) on poultry with regards to behavior, well-being and production performance; and providing data for the establishment of guidelines on UVA light application in commercial poultry operations. As the first step toward attaining the goal, the specific objective of this study was to investigate the behavioral responses of poultry to supplementary UVA radiation through preference test, emphasizing its impact on feeding behavior of young laying hen chicks. The guiding hypothesis of this study was that the poultry-specific LED light supplemented with certain amount of UVA radiation (i.e., LED+UVA) will have an attracting effect on chicks than the same LED light without supplementary UVA light (LED).

Materials and Methods

This study was conducted in an environment-controlled animal research laboratory located at Iowa State University, Ames, Iowa. The procedures and methodologies for the experiment are described below. Before the onset of the experiment, 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) and a HL-UVA LED light (Agrishift HL-UVA LED, 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 radiation 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 radiation at 385 nm wavelength.

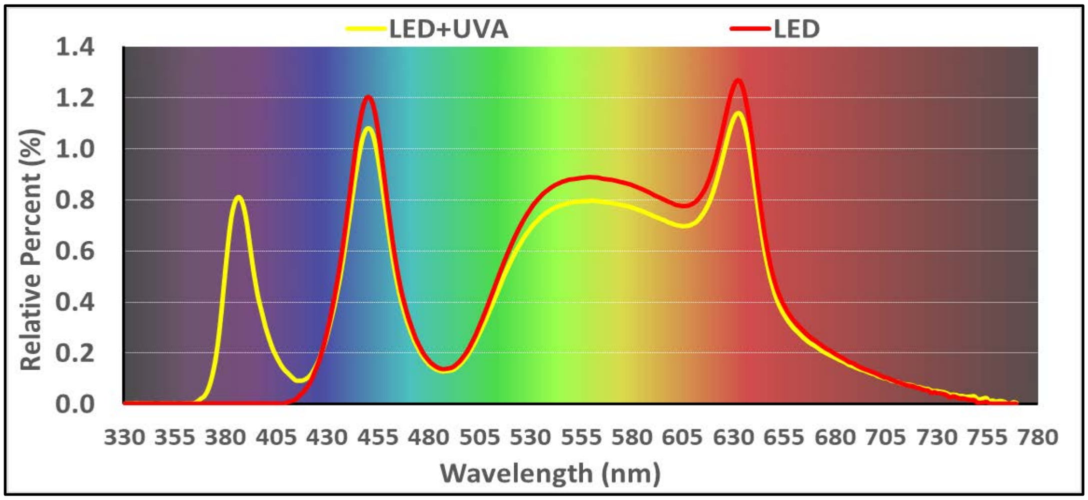


Figure 1. Spectral characteristics of the Dim-to-Blue LED light with or without supplementary UVA radiation used in the study, designated as LED+UVA and LED, respectively.

Light Treatments Used in the Study

Four levels of UVA radiation supplementation were achieved in the study, including 0% (LED light only), 5%, 10%, and 15% UVA radiation. Three comparisons were conducted with regards to the UVA levels, namely, 0% *vs.* 5%, 0% *vs.* 10%, and 0% *vs.* 15%. Light 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**).

Table 1. Light 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 Procedures

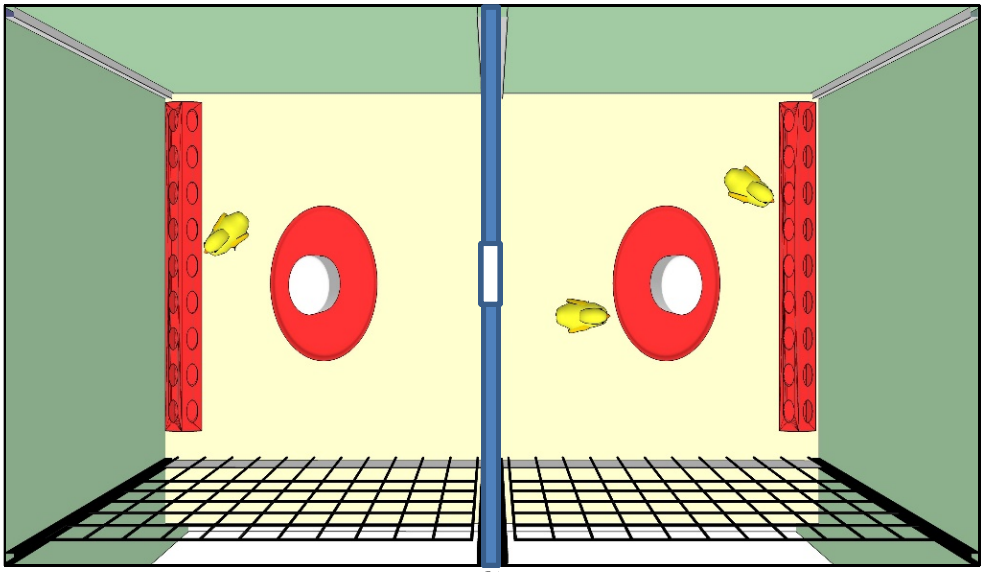
Animals and housing

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, they 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 for an eight-day preference test. In this experiment, six groups of chicks were tested for each comparsion (i.e., 0% *vs.* 5%, 0% *vs.* 10%, and 0% *vs.* 15%).

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 (2 ft. L × 3 ft. W x 6 ft. H) with free access to each other through a recutanglar passageway (3.7 in. W × 5.0 in. 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 simialr intensity level as indicated in **Table 1**. For each comparison (i.e., 0% *vs.* 5%, 0% *vs.* 10%, and 0% *vs.* 15%, respectively), UVA radiation was alternately applied to one of the two compartments within each set of free-choice preference-test compartments on 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 radiation, respectively.

Data acquisition and processing

Daily feed use in each compartment was manually weighed and recorded on a group basis. 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**). Proportion of time spent by the chicks under each light environment (LED+UVA *vs*. LED) or compartment during the light period was analyzed.

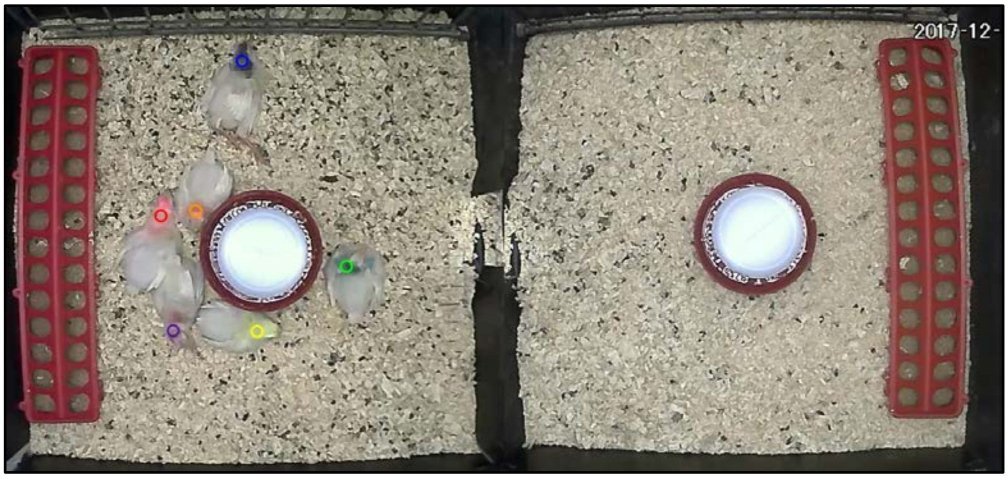


Figure 4. Individual chicks in the free-choice preference-test compartments were identified based on the color markers on their heads using an automated computer vision algorithm.

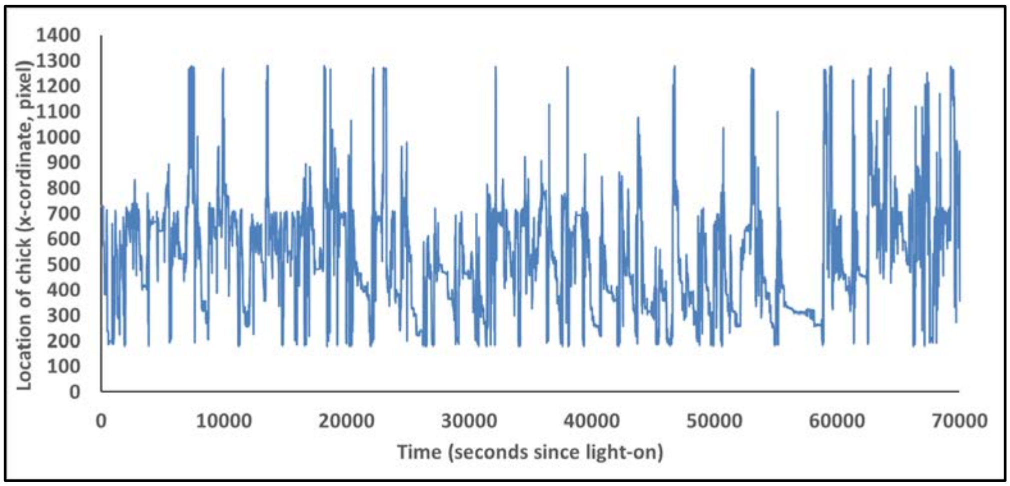


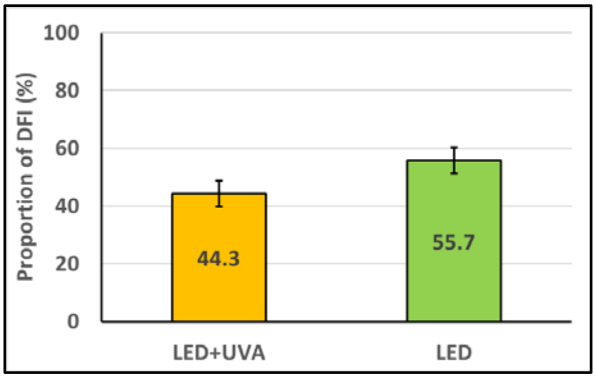
Figure 5. Time-series locations (x-coordinate) of a specific chick in the free-choice preference-test compartments. The value of 700 pixels corresponds to the partition wall and the passageway between the two compartments.

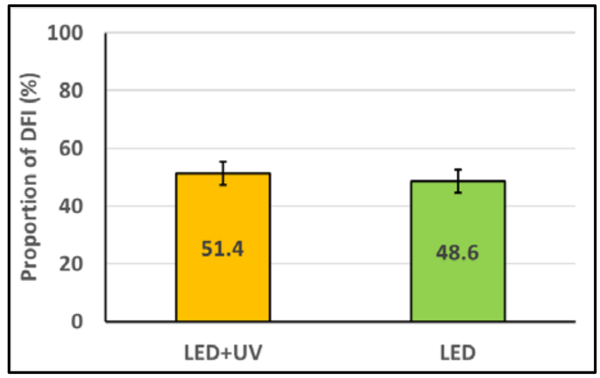
Results and Discussion

All the preference tests were finished at the end of December 2017. No bird mortality or system failure was found during the entire experiment. 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.

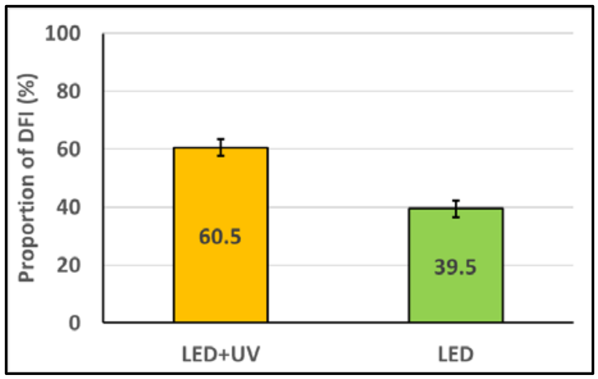
Feed use of chicks under LED+UVA *vs.* LED

As shown in **Fig. 9**, at the low (0% *vs*. 5%) and the median (0% *vs*. 10%) UVA radiation levels, the chicks consumed comparable amount of feed under the LED light with or without supplementary UVA radiation ($P = 0.21$ and $P = 0.72$, respectively), but the chicks consumed significantly more feed under the LED light supplemented with UVA radiation than under the LED light (60.5% *vs*. 39.5%, $P < 0.01$) at a higher UVA radiation 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 are no other studies that can be found during the literature search regarding the impact of UVA radiation 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 radiation on birds is age-dependent, thus a study to assess impacts of UVA inclusion on birds at different ages seems warranted. Besides, Hogsette & Wilson (1999) and Lewis et al. (2000) reported that there was no significant difference in mortality, weight gain, feed consumption, or feed conversion for broilers and turkeys between light with or without UVA supplementation. However, the effects of UVA radiation on growing performance of chicks were not assessed in this study as each preference test in this study only last for eight days. Thus a large-scale and long-term study to assess the effects of UVA radiation on growing performance of chicks seems warranted.





(a) (b)

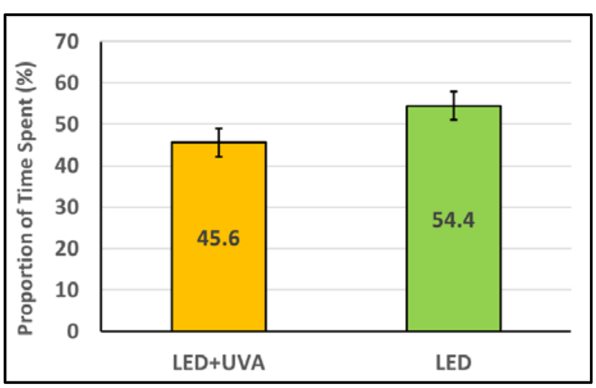


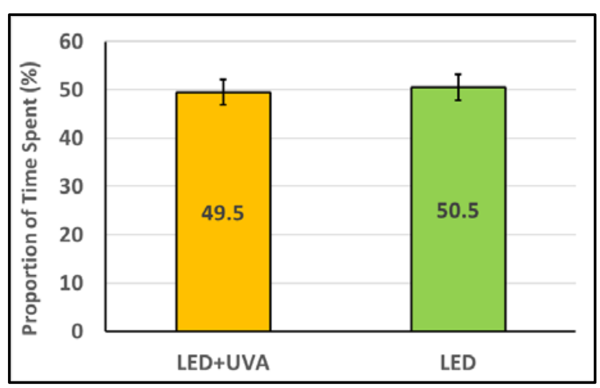
(c)

Figure 9. Proportion of daily feed intake (DFI) of chicks under LED light with or without supplemented UVA radiation (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 radiation, respectively.

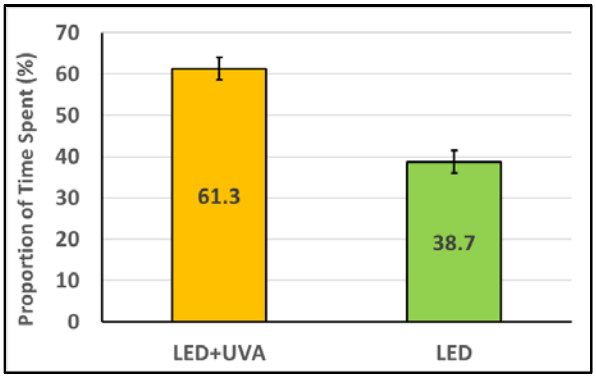
Time Spent of chicks under LED+UVA *vs.* LED

As shown in **Fig. 10**, at low UVA radiation (i.e., 0% *vs*. 5%), chicks spent significantly higher amount of time under the LED light without supplemented UVA radiation than LED light supplemented with UVA radiation (45.6% *vs*. 54.4%, P < 0.01). At the UVA radiation of 0% *vs*. 10%, chicks spent comparable amount of time under the LED light with or without the supplemented UVA radiation (P > 0.05). while at the high UVA radiation level (0% *vs*. 15%), chicks spent significantly higher amount of time under the LED light supplemented with UVA radiation (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 specific, UVA light at 15% inclusion rate under LED illumination showed 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 radiation over white fluorescent light on its own in preference tests, irrespective of whether they had been reared with or without supplementary UVA radiation. Likewise, as this study only last 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.





(a) (b)



(c)

Figure 10. Proportion of light-period time spent by the chicks under LED light with or without supplemented UVA radiation (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 radiation, respectively.

Conclusion

This study assessed preference of W-36 chicks (day-old) for light-emitting diode (LED) light supplemented with or without various levels of UVA radiations (0%, 5%, 10%, and 15%), i.e., LED *vs*. LED+UVA. A total of 108 chicks (day-old) in 18 groups over nine batches were assessed for their choice via preference test. 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. 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.

Acknowledgements

Funding for the study was provided by the Once Innovation Inc. and is acknowledged with gratitude. Our special appreciation goes to Hy-Line International for the immense support throughout the study. Moreover, Kai Liu wishes to thank China Scholarship Council for providing part of the financial support for his PhD study at Iowa State University.

References

Cuthill, I. C., Partridge, J. C., Bennett, A. T. D., Church, S. C., Hart, N. S., & Hunt, S. (2000). Ultraviolet Vision in Birds. In *Advances in the Study of Behavior* (Vol. 29, pp. 159–214). https://doi.org/10.1016/S0065-3454(08)60105-9

Hogsette, J. A., & Wilson, H. R. (1999). Effects on commercial broiler chicks of constant exposure to ultraviolet light from insect traps. *Poultry Science*, *78*(3), 324–6. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10090256

Hogsette, J. A., Wilson, H. R., & Semple-Rowland, S. L. (1997). Effects on white Leghorn hens of constant exposure to ultraviolet light from insect traps. *Poultry Science*, *76*(8), 1134–7. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9251142

Jones, E. K. M., Prescott, N. B., Cook, P., White, R. P., & Wathes, C. M. (2001). Ultraviolet light and mating behaviour in domestic broiler breeders. *British Poultry Science*, *42*(1), 23–32. https://doi.org/10.1080/713655008

Lewis, P. D., Ghebremariam, W., & Gous, R. M. (2007). Illuminance and UV-A exposure during rearing affects egg production in broiler breeders transferred to open-sided adult housing. *British Poultry Science*, *48*(4), 424–429. https://doi.org/10.1080/00071660701543105

Lewis, P. D., & Gous, R. M. (2009). Responses of poultry to ultraviolet radiation. *World's Poultry Science Journal*, *65*(3), 499–510. https://doi.org/10.1017/S0043933909000361

Lewis, P. D., Perry, G. C., & Morris, T. R. (2000). Ultraviolet radiation and laying pullets. *British Poultry Science*, *41*(2), 131–135. https://doi.org/10.1080/713654916

Lewis, P. D., Perry, G. C., Sherwin, C. M., & Moinard, C. (2000). Effect of ultraviolet radiation on the performance of intact male turkeys. *Poultry Science*, *79*(6), 850–5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10875767

Li, D., Zhang, L., Yang, M., Yin, H., Xu, H., Trask, J. S., … Zhu, Q. (2014). The effect of monochromatic light-emitting diode light on reproductive traits of laying hens. *The Journal of Applied Poultry Research*, *23*(3), 367–375.

https://doi.org/10.3382/japr.2013-00746

Maddocks, S. A., Cuthill, I. C., Goldsmith, A. R., & Sherwin, C. M. (2001). Behavioural and physiological effects of absence of ultraviolet wavelengths for domestic chicks. *Animal Behaviour*, *62*(5), 1013–1019. https://doi.org/10.1006/anbe.2001.1842

Moinard, C., & Sherwin, C. . (1999). Turkeys prefer fluorescent light with supplementary ultraviolet radiation. *Applied Animal Behaviour Science*, *64*(4), 261–267. https://doi.org/10.1016/S0168-1591(99)00043-X

Prescott, N. B., & Wathes, C. M. (1999). Spectral sensitivity of the domestic fowl (Gallus g. domesticus). *British Poultry Science*, *40*(3), 332–339. https://doi.org/10.1080/00071669987412

Rubene, D., Hastad, O., Tauson, R., Wall, H., & Odeen, A. (2010). The presence of UV wavelengths improves the temporal resolution of the avian visual system. *Journal of Experimental Biology*, *213*(19), 3357–3363. https://doi.org/10.1242/jeb.042424

TOVEE, M. (1995). Ultra-violet photoreceptors in the animal kingdom: their distribution and function. *Trends in Ecology & Evolution*, *10*(11), 455–460. https://doi.org/10.1016/S0169-5347(00)89179-X