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COMAPARTIVE EFFECTS OF NATURAL AND ARTIFICIAL LIGHT ON BEHAVIOUR, PERFORMANCE AND WELFARE OF BROILER CHICKENS

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ABSTRACT

The present experiment was conducted to investigate the effect of the natural and artificial light on the behaviour, production and welfare of broiler chickens. Moreover, it also aimed to define the use of natural light as a way of reducing the incidence of leg disorders in broiler chickens. The experiment was conducted by using 240 chicks that were randomly distributed into four experimental rooms, two replicates for each experimental treatment. The experimental period was 5 weeks. The first light treatment included birds that had full access to natural light during day period. While the birds in the second light treatment were kept entirely under artificial light provided through LED bulbs of 20 lux light intensity. The results indicated that birds kept under natural light during day showed higher frequencies of eating, drinking and preening behaviours. While birds kept entirely under artificial light showed higher rates of sleeping behaviour. The birds kept under natural light showed heavier final body weights while the other production parameters were not affected. Moreover, birds kept under natural light showed significantly better gait score and lower incidence of tibial dyschondroplasia. Furthermore, natural light was found to significantly decrease the levels of serum corticosterone indicating lower stress levels.

INTRODUCTION

Current poultry industry is highly focusing on animal welfare challenges. Therefore, it highlights the importance of studies that are conducted to understand and investigate welfare problems related to poultry production industry. In addition, consumers concerns about poultry welfare are increasing in both meat and egg markets. Poultry producers concerning to develop a profitability programs useful to most broiler growers must consider microclimatic factors (air, temperature, humidity and light) recommendations as they are essential to optimize profitability and welfare of broiler chickens. Besides diseases, poor management is one of the main factors that compromise the poultry production and welfare. **(Edwards, 2003)**.

Light is the most critical exogenous factor in the poultry production as it regulates physiological and behavioural processes in the bird **(Manser, 1996)**. Light is important for poultry for various reasons. Vision is the predominant sense in the birds, where the largest proportion of the brain size is devoted to visual cortex and eyes **(Gunturkun, 2000)**. Sun light is the natural source of light; it is self-generated and comes in a broad spectrum of colors when compared to artificial light. The color spectrum of natural light contains the shortest wavelengths representing the ultraviolet part of the spectrum. **Edwards (2003)** reported that ultraviolet light has a beneficial effect on skeletal tissue; this could be explained by the fact that UV light increases absorption of calcium and phosphorus as it was also reported to be responsible for synthesis of vitamin D. Moreover, birds raised under UV free incandescent light had less muscle growth than birds raised under UV light. UV light also reported to increase fertility in broiler breeders, for sanitation of broiler hatching eggs **(Coufal et al., 2003)**.

It has been reported that leg disorders and gait abnormalities were caused by rapid growth rate and low locomotor activity of broiler chickens. Reducing the growth of broilers can reduce the incidence of skeletal disorders but it is not considered an economic solution. Exposure to sun light is essential for vitamin D3 (cholecalciferol) to be produced. Cholecalciferol enhances the absorption of calcium and phosphorus and therefore, it plays an important role in their utilization inside the body. Vitamin D is endogenously produced in the skin when exposed to UV light and several previous studies indicated that UV light is effective in reducing leg disorders in broiler chickens **(Ameenuddin et al., 1985; Edwards et al., 1994; Elliot and Edwards., 1997; Edwards, 2003)**.

Most humans depend on exposure to sunlight to obtain their requirements of vitamin D. Likewise in broiler chickens, vitamin D plays an important role in calcium and phosphorus metabolism and therefore, it influences the efficiency of utilization of these minerals. Some research studied the use of vitamin D for the prevention of incidence of leg disorders **(Fritts and Waldroup, 2005; Rao et al., 2008)**. Over the years, tibial dyschondroplasia was the main leg disorder affecting broiler chickens. However, the severity of it has lessened by the increase in frequent supplementation of vitamin D **(Khan et al., 2010)**. All of the previous studies investigated the effect of vitamin D as a dietary supplementation on production and skeletal health of broiler chickens **(Rao et al., 2008; Khan et al., 2010; Rostagno et al., 2011)**.While, the current study investigated the effect of sun light as a source of vitamin D on broilers production, behaviour and welfare.

MATERIALS AND METHODS

1. Birds and Housing

The study was conducted using 240 newly hatched and unsexed Indian River (IR) broiler chicks that were obtained from a commercial hatchery (El-fayoumi Institution for Poultry, Damietta governorate) and raised to 35 d of age. The birds were weighted on arrival, randomly and evenly distributed into four experimental rooms, two replicates for each experimental treatment. Each room had a floor area of 9 m^2 (3m width x 3m depth), with 60 bird in each room. Chicks were vaccinated for Marek's, Newcastle and Infectious bronchitis diseases at the hatchery. The study was conducted during mid-summer (august 2016). Therefore, the floor of each room was bedded with wood shaving litter to a depth of approximately 3-4 cm.

The rooms temperature was set at 34ºC at chicks placement and gradually decreased until it reached 22ºC by day 28. Relative humidity was set at 50 % throughout the study. Birds were provided a 3-phase feeding program (Starter: 1 to 14 d; Grower: 15 to 28 d and Finisher: 29-35 d). Diets were formulated to meet NCR nutrient recommendations. The starter food was provided as a mash while the subsequent feeds were provided as a crumbles and whole pellets respectively.

2. Experimental treatments

During the first week, all birds were kept completely under artificial light (LED bulbs) with light intensity of 30 lux and 24 L photoperiod. At the 7th day of age, two different light treatments were applied, with two replicates for each treatment. The first light treatment included birds that had full access to natural light during day period, and this was provided through two windows in each room, starting from 8:00 to 17:00 h. while, during the night period, light was provided through artificial LED bulbs of 20 lux light intensity. The birds in the second light treatment were kept entirely under artificial light provided through LED bulbs of 20 lux light intensity. Windows were covered to prevent any access of natural day light. The ventilation in the closed rooms (artificial light rooms) was operated through 2 centrally placed exhaust fans (25 x 25 cm) in each experimental room. These fans were controlled by a thermostat and a timer for periodic air removal.

3. Experimental measurements

Behaviour was assessed by recording behavioural patterns of 15 focal birds in each room. Recordings were taken for 4 days each week between week 2 and week 5 of the rearing cycle. All behavioural observations were taken for one hour during four distinct periods of the day including 9:00 h, 12:00 h, 16:00 h and 19:00 h. Instantaneous scan sampling was used with 30-second sample interval. A well-defined ethogram was developed to decrease chances of errors in diagnosis of a particular behaviour. Sleeping and lying down were categorized as inactive behaviours; walking and standing as locomotor behaviours; eating and drinking as ingestive behaviours; preening, dustbathing, wing flapping, feather pecking, floor pecking, running and flying as comfort behaviours (Table 1).

Individual body weight (g) was determined at 0, 7, 14, 21, 28 and 35 day old chicks. Feed intake (g) was calculated as the difference between the weight of offered food at the morning and the weight of remaining food at the next morning. Feed conversion ratio (FCR) was calculated by diving the amount of feed consumed (g) during the week by the gain in the weight (g) during the same week.

Fifteen bird were randomly selected from each experimental room and observed while moving from one part of the room toward other parts without a walking stimulus and assessed for gait score according to **Garner et al. (2002)** technique. After slaughtering, the footpad of the right and left foot of five random birds were examined using the technique of **Mcward and Taylor, (2000)**. The tibia bones were removed and dissected from both legs of five random birds, the tibia was held nearly parallel to the surface and the upper head of the bone was cut and evaluated for macroscopic scores as described by **Edwards (1984)**. The hock bone was dissected from right and left legs of five random birds and they were evaluated for hock burns according to a technique described by **Mcward and Taylor, (2000)**. Their femur heads were examined for macroscopic examination for necrosis. The femur was dislocated, proximal femoral epiphysis was examined and assessed on the basis of a 0 to 2 score as described by **Almeida Paz et al. (2009)**.

At 35 day of age, two blood samples were collected from brachial vein of 10 birds in each experimental treatment. Plasma samples were taken in anticoagulant treated tubes **(Odunsi et al., 1999)** and labeled according to each replicate and treatment then stored at 4°C until analyzed. The hematological parameters included, red blood cells (RBC), hemoglobin concentration (HB), packed cell volume (PCV), hematocrit value (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and red blood cell distribution width (RDW). Serum samples were taken into tubes without anticoagulant and labeled according to each replicate and treatment and then the serum samples were centrifuged and stored at -20°C until analyzed. Serum corticosterone was measured using a commercially available Elisa kit, following the recommended protocol. Blood samples for corticosterone estimation were collected within one minute to minimize handling effect on hormonal response.

4. Statistical analyses

Analysis was conducted using SPSS statistical package (SPSS version 19). Data were analyzed by using one-way ANOVA. Post .hoc comparisons were done. Means were separated using Duncan's multiple range test with significance set at $P \leq 0.05$. Results were expressed as mean ± standard error.

RESULTS

Behavioural traits

Treatment x week interaction

Results showed that there was a significant treatment x week effect on some behavioural patterns of broilers including sleeping, eating, drinking, preening and leg stretching behaviours. Where sleeping behaviour was higher in birds kept entirely under artificial light in the 5th week of age (Fig 1). While birds kept under natural day light expressed more eating in the 4th week of age (Fig 2), drinking in the 2nd week of age (Fig 3), preening in the 4th week of age (Fig 4) and leg stretching in the 5th week of age (Fig 5).

Table (1): Ethogram of behavioural parameters recorded through observation of male and female broilers from 2nd to 5th week of age.

Category	Behaviour	Description of behaviour
Locomotor	Standing	The bird is motionless with no obvious movement of the legs and abdomen is not touching the ground.
	Walking	The bird is moving forward taking one or more steps.
Inactive	Lying down	The bird is resting its head on litter or anthor bird while sitting.
	Sleeping	The bird's neck is fully recumbent and the eyes are fully closed while lying.
Ingestive	Eating	The bird's head is extended towards feeder and pecking the available food resources.
	Drinking	The bird's beak is in contact with water in or above the drinker and the bird appears to be drinking.
Comfort	Preening	The beak touches the plumage of the bird itself.
	Dust bathing	The bird is bathing in the dust with the use of wings, head, neck and legs.
	Wing flapping	The bird extends both wings out from the body simultaneously and flapping wings.
	Flying	Flapping of the wings forcing the bird to be lifted from the ground.
	Floor/Feather pecking	The bird is pecking in the litter or pecking the feathers of anthor bird.
	Leg/Wing stretching	The bird extends one leg and one wing at the same side of the body.
	Leg stretching	The bird extends one leg out from the body.
	Wing stretching	The bird extends one wing out from the body.
	Out of sight	The bird cannot be seen.

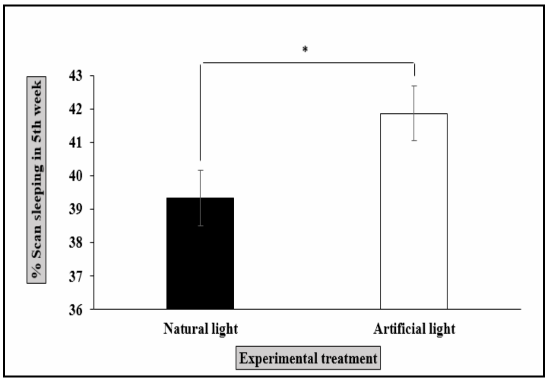

Fig. (1): Effect of natural and artificial light on sleeping behaviour of broiler in 5th week of age

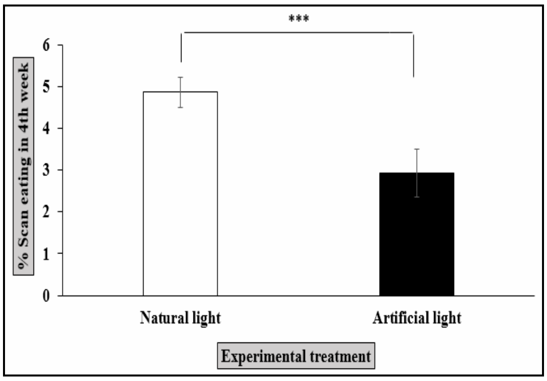

Fig. (2): Effect of natural and artificial light on eating of broiler in 4th week of age

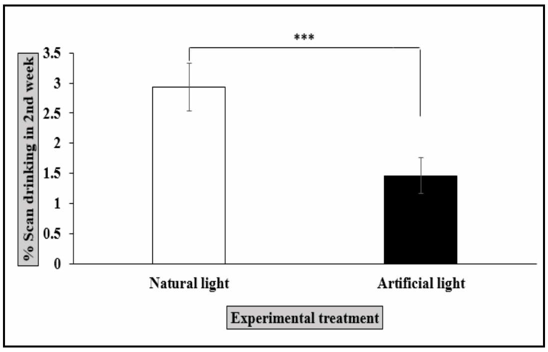

Fig. (3): Effect of natural and artificial light on drinking behaviour in 2nd week of age.

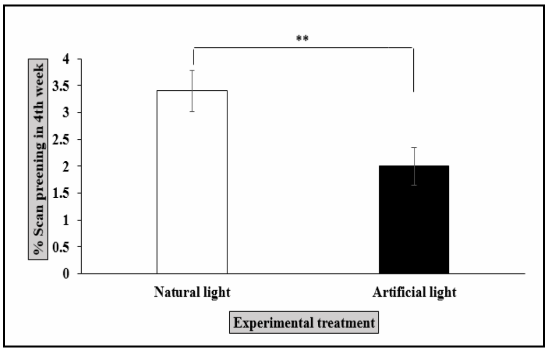

Fig. (4): Effect of natural and artificial light on preening behaviour in 4th week of age.

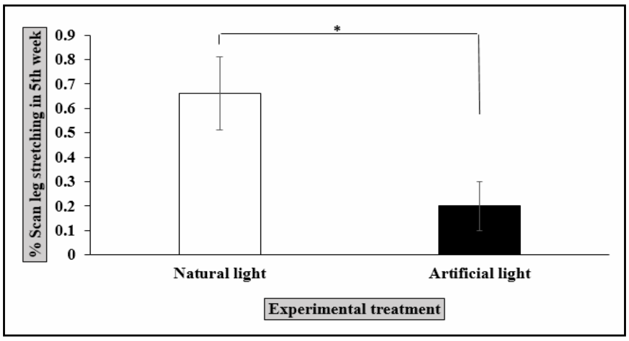

Fig. (5): Effect of natural and artificial light on leg stretching behaviour of broiler in 5th week of age.

3.1.2. Treatment x session interaction

There was also a significant treatment x session effect on sleeping, eating and drinking behaviours. Where birds kept under artificial light expressed more sleeping in the day session (Fig 6). While birds kept under natural light during the day expressed more eating in the day session (Fig 7) and more drinking in the night session (Fig 8).

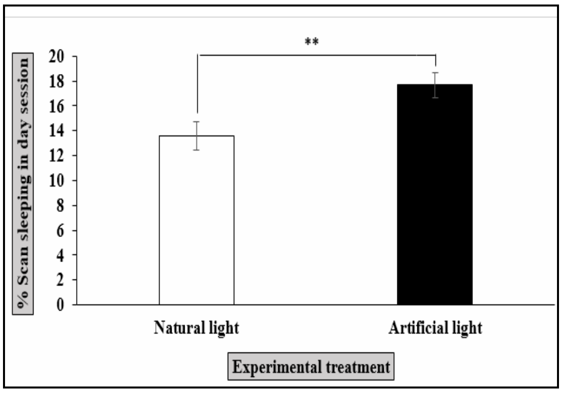

Fig. (6): Effect of natural and artificial light on sleeping behaviour of broiler in day session.

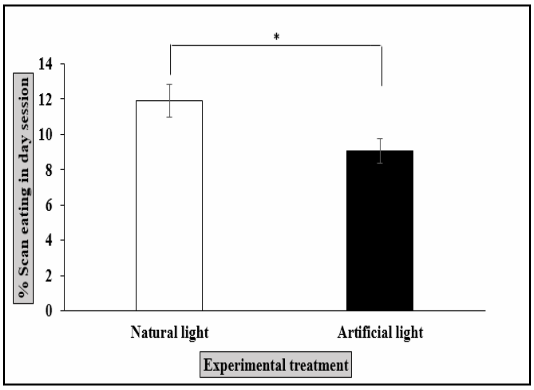

Fig. (7): Effect of natural and artificial light on eating behaviour in day session.

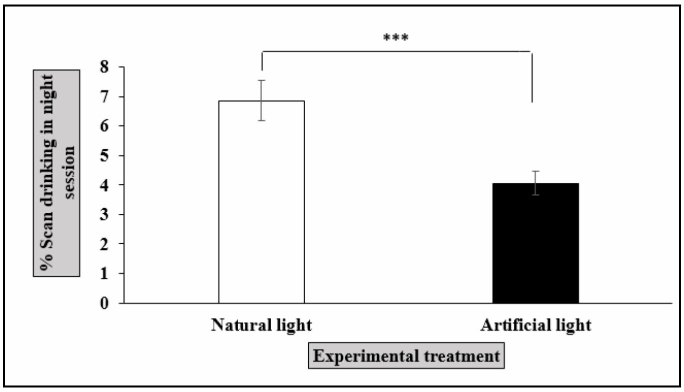

Fig. (8): Effect of natural and artificial light on drinking behaviour of broiler in night session.

3.2. Productive performance

Average body weight did not significantly differ between natural and artificial light treatments from 0-30 day of age. However, the body weight was significantly higher in birds in natural light treatment in the 5^{th} week (P=0.004) (Fig 9). Body weight gain, feed consumption and F: G from 0 to 35 day of age were not affected by natural and artificial light treatments (P=0.6, 0.8, 0.9) respectively. However food intake tended to be significantly higher in natural light treatment at the age of 4 weeks (P= 0.09).

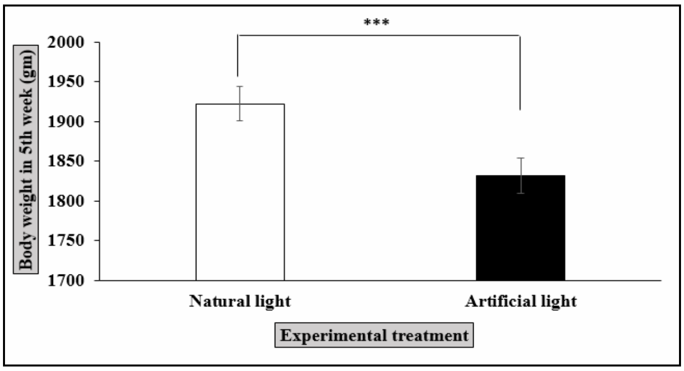

Fig. (9): Effect natural and artificial light on body weight of broiler in 5^{th} week of age.

3.3. Skeletal health

Results showed that natural light significantly affected the skeletal health of broilers as expressed by gait score. Birds kept under artificial light over the 24 hour period had a significantly higher gait score values when compared to natural light treatment (P=0.01) (Fig 10); where, in natural light treatment, 90 % of birds had 0 score and only 10 % had 1 score and no bird was found to have a gait score >1. On the other hand, 66% of birds in artificial light treatment had a gait score of 0, 13 % with 1 score, 13% had a 2 score and only 8% had 3 and 4 score. Tibial dyschondroplasia was also significantly affected by light treatments (P=0.001) (Fig 11) with a higher scores for birds in artificial light treatment; where, 40% of birds was found to have scores >1; while in natural light treatment, all birds had scores <1. On the other hand, foot pad health was not affected by light treatments; where, foot pad health and hock burns scores did not significantly differ between birds in natural and artificial light treatments (P=0.4 , 0.6) respectively.

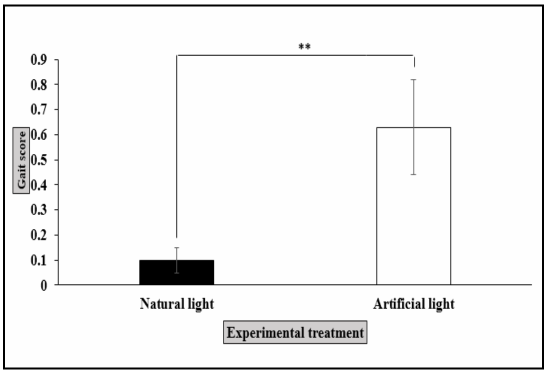

Fig. (10): Effect of natural and artificial light on gait score of broiler at 35 days of age.

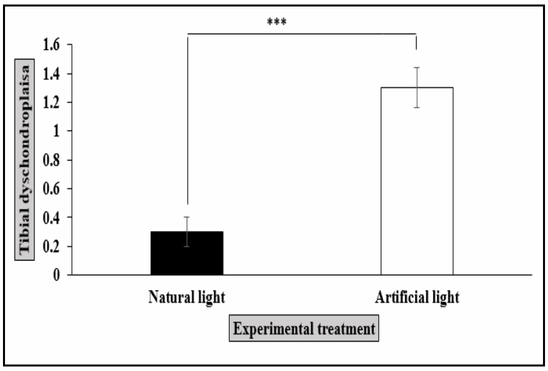

Fig. (11): Effect of natural and artificial light on tibial dyschondroplasia score of broiler.

3.4. Hematological variables

Corticosterone hormone concentrations at day 35 was significantly higher in birds of artificial light treatment (P= 0.05) (Fig 12). While, HB, RBCs count, hematocrit value, M.C.V., M.C.H., M.C.H.C. did not differ significantly between treatments (P= 0.4, 0.6, 0.4, 0.2, 0.9, 0.4) respectively.

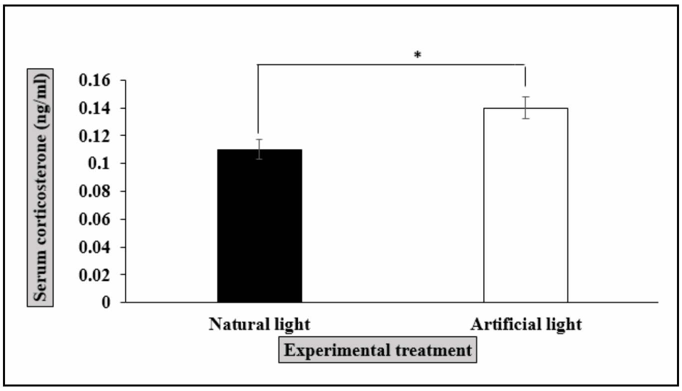

Fig. (12): Effect of natural and artificial light on serum corticosterone concentrations of broiler.

DISCUSION

Natural or artificial light is one of the most important management factors, which plays an essential role in regulating poultry production and reproduction, and this occurs by modulating several behavioural and physiological pathways of birds **(Prescott et al., 2003; Deep et al., 2010)**. The findings of the current experiment showed a non-significant effect to the access of natural day light on activity of broiler chickens, where the birds in the two different experimental treatments showed a similar rates of standing, walking and laying down behaviours over the different observation weeks and over the different periods of day. This indicates that introducing natural day light into poultry houses was a non-effective environmental modification in increasing the physical activity of broilers. However, there was a significant increase in the rates of expression of sleeping behaviour in the 5th week of age in birds kept entirely under artificial light when compared to those with access to natural light during day. These results are in agreement with those of **Ruis et al. (2004)** who reported that there was no difference in activity between birds kept under artificial light and those allowed access to an outside run with natural light.

The results of this study showed that natural day light had a strong effect on the expression of ingestive behaviours by broiler chickens. Birds that had access to natural light showed a higher rates of eating behaviour in the 4th week of age and day session and drinking behaviour in the 2nd week of age and night session. This could be explained in the light that natural light provided a better vision and a higher motivation to feeding and drinking compared to birds kept entirely under artificial light environment. Chickens are known to have a well-developed sense of vision; it is originally designed to be used in bright light environment. This suggests that the natural light is required by broiler chickens to use their sense of vision to its full potential and to maximize their ability to express natural behavioural patterns. Moreover, this data showed that birds with access to natural light showed higher rates of preening in the 4th week of age and leg stretching in the 5th week of age. This effect may be due to the greater illuminance and the broader wavelength spectrum provided by day light. This is in agreement with the result of **Khalil et al. (2016)** who found that birds kept in natural light group spent more time preening when compared to other different artificial light intensities.

The measured production parameters were found to be unaffected by the introduction of natural day light into poultry houses. However, birds exposed to natural light recorded significantly heavier weights in the 5th week of age. Moreover, food intake tended to be significantly higher in birds in natural light groups. This indicates that there is a distinctive preference by broiler chickens for natural day light. Moreover, incorporating natural light into light regimes was more optimal for broilers performance when compared to regimes depending entirely on artificial light. However, the whole benefit of this advantage can be taken only during summer time. A previous study reported that the color of cold white light which contains wavelengths from the blue part of the spectrum resembles the color temperature of natural day light. **Riber et al. (2015)** reported that birds showed higher body weights at the slaughter age when reared under the cold white light when compared to neutral white light.

The results of the current study showed that natural light was effective in reducing leg abnormalities commonly manifested by broiler chickens. Gait score was found to be significantly lower in birds exposed to natural light, none of these birds manifested a gait score that could impair their mobility or walking ability. While some of the birds in the artificial light groups manifested a high gait score which had a large impact on their walking ability and some of them experienced a complete lameness which is considered a strong indication of inadequate welfare. It has been shown that it is possible to improve lameness in broilers with high gait score by treating them with analgesics and anti-inflammatory drugs, this has proved the assumption that leg disorders in broilers are painful **(McGeown et al., 1999; Danbury et al., 2000; Weary et al., 2006; Nääs et al., 2009)**.

There was also a significant reduction in the incidence of tibial dyschondroplasia in birds of natural light treatment. However, hock burn and foot pad dermatitis scores were nearly similar in the two treatments. It was difficult to confirm these results with previous studies because of lack of studies concerning the effect of natural light as an essential source of vitamin D3 on skeletal health of broiler chickens. However, these results were in agreement with previous studies that introduced vitamin D to birds as a feed additive. **Edwards et al. (1994)** reported that birds with ultraviolet light excluded programs showed a slower growth, higher development of rickets and low concentrations of plasma calcium. Moreover, **Naas et al. (2012)** stated that the use of vitamin D3 as a feed additive in broilers diet reduced lameness in fast growing broiler chickens and the lack of vitamin D was positively correlated with higher incidence of tibial dyschondroplasia. Furthermore, **Mitchell et al. (1997)** and **White head et al. (2004)** showed that high dietary supplementations of vitamin D3 can be effective in the prevention of tibial dyschondroplasia in broiler chickens which have a genetic tendency for this pathological condition.

The findings of the current study showed that birds in natural light groups had a significantly lower corticosterone concentrations when compared to those in artificial light groups. This indicates that keeping birds entirely under artificial light could exert some kind of stress and compromise welfare of broiler chickens. While natural light could be considered as a favorable environment that could achieve the optimal welfare requirements for the birds.

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الملخص العربي

مقارنه تأثير الضوء الطبيعي والضوء الصناعي علي سلوك وانتاجية ورفاهية دجاج التسمين

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قسم الرعاية وتنمية الثروة الحيوانية-كلية الطب البيطري-جامعة المنصورة

أجريت هذه الدراسة لتقييم تأثير استخدام الضوء الطبيعي والضوء الصناعي علي سلوك وانتاجية ورفاهية دجاج التسمين. كما أجريت بهدف تأكيد فعالية استخدام ضوء الشمس الطبيعي كوسيله لمنع او تقليل اصابات وأمراض العظام. تم اجراء التجربة باستخدام ٢٤٠ طائر من كتاكيت التسمين. تم توزيعهم بشكل عشوائي على معاملتين تجريبيتين في اربعه غرف منفصلة. كل غرفه شملت ٦٠ طائر لمدة خمسة اسابيع. المعاملة الأولي شملت تعريض الطيور لضوء الشمس الطبيعي خلال فتره النهار والضوء الصناعي خلال فترة الليل. بينما شملت المعاملة الثانية تعريض الطيور للضوء الصناعي المتوفر من خلال لمبات الليد خلال فتره النهار والليل. أوضحت النتائج أن الطيور المعرضة للضوء الطبيعي أظهرت زيادة في معدلات سلوكيات الاكل وتهيئة الريش بينما أظهرت الطيور المعرضة بشكل دائم للضوء الصناعي زيادة في معدلات سلوكيات الراحة. كما أوضحت النتائج ان الطيور المعرضة للضوء الطبيعي قد حققت زيادة في الاوزان النهائية وانخفاض في حدوث اصابات العظام وتحسن القدرة على المشي. كما انخفضت معدلات هرمون الكورتيزون في الطيور المعرضة لضوء الشمس الطبيعي.