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The Effects of Spot Lighting on Broiler Performance and Welfare

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Abstract: In this study, the effects of spot lighting on performance and welfare in broiler production were investigated. The base performance criterions as body weight, feed conversion and mortality ratio organ weights were determined and also some visceral organ weights (bursa of Fabricius, spleen and liver), Tonic Immobility (TI) and gait score have been evaluated as welfare indicators. Day old chicks from a commercial hatchery divided into three group (n = 174) randomly one of them as a control and each experimental group separated into three subgroup (n = 58) make replications. In control groups 40 W filament bulbs were used as light source to provide approximately 10 lux light intensity on the bottom of the poultry house. In the each treatment groups, two halogen spot lamps were used to supply at different light intensities (10+10 vs. 10+5 lux) over two circular bottom spot of 1 m^2 diameter. Spot light (10+5 lux) has shown better (2297.07 g) live weight than the control groups. Similarly this group shown significantly ($p<0.05$) higher weight or relative weight in bursa of fabricius than the other experimental groups. As a conclusion, spotlights might be useful tool for the dim light applications without negatively affecting the performance and welfare of broilers.

Key words: Broiler, illumination, light source, performance, welfare, spot light

INTRODUCTION

Lighting is an important management tool and widely used in broiler production. Although, vision is important to birds, lighting does not matter alone. It can be manipulated in four areas that may be helpful including source intensity, wavelength and photoperiod (Manser, 1996). Because altering all these factors may play a part on the performance and welfare of poultry. The incandescent bulbs have been common light source in poultry houses up to the last decade. There has recently been a trend towards, many poultry producers have changed from incandescent lamps to more energy efficient, longer lasting light sources (Lewis and Morris, 2006). These new light sources give more opportunities to the producer technologies in control of the light environment in poultry houses. Hence, luminous efficiency initial cost, running cost and working life could be changed differ by the light source.

Because of the light can be used to improve broiler welfare without affecting broiler production, the effects of photoperiod and light intensity on broiler production and welfare were intensively studied (Classen and Riddell, 1989; Classen *et al.*, 1991; Sorensen *et al.*, 1999; Classen, 2004) in the past. Especially, manipulation of the light intensity is a widely adopted management tool affecting broiler production, behavior and welfare. In the most management guides recommend a reduction in intensity after the early brooding period but there is some debate as to the appropriate level that should be used. A usual recommendation is for light intensity to be 5-10 lux during the grow-out period but many producers use levels as low as 1-2 lux (Lewis and Morris, 2006). Comments from industry indicate that the rationale for using very low light intensity is improved feed efficiency, reduced mortality due to sudden death syndrome and reduced carcass damage (scratches, bruises) because of decreased activity. However, these advantages are not confirmed by scientific investigation. Examination of the literature reveals that broiler performance was unaffected by light intensity within the range of 1-150 lux but the use of low to very low light intensity has negative effects on broiler processing characteristics and welfare. There is a significant depression of growth and reduction in feed intake when broilers are given brighter light intensity. However, in practical terms, light between 1-200 lux has a very small effect on broiler performance. There is also a tendency for feed intake to decrease linearly with increasing illuminance but by only 30 g between 1 and 100 lux. Hester *et al.* (1983) reported that various high-illuminance (20 lux) step up and low-illuminance (2.5 lux) step-down lighting regimes have been used to improve leg integrity in turkeys. Alternating between 5 and 100 lux at 2 h intervals without darkness alters the activity patterns in broilers but neither regime regime appears to benefit bird welfare or reduce the incidence of

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leg abnormalities (Kristensen *et al*., 2004). Light intensity has also been shown to affect the incidence of foot pad disorders. It has been suggested that decreased activity and increased resting associated with dim light resulted in an increased incidence of foot pad erosions (Blatchford *et al*., 2009). They suggested that decreased activity with dim light results in increased contact time between the foot and litter, leading to greater foot pad erosions. Alternatively, light intensity might have affected litter quality, thereby resulting in differences in foot pad health. In conclusion, the impact of light intensity on broiler skeletal health is inconsistent but it is clear that dim light (<5 lux) is related to increased incidence of foot pad lesions.

However, these advantages of dim light have not been confirmed by scientific investigation and in some cases are contrary to published data. Dim light was found to induce buphthalmia, altered retina (peripheral darkened areas and non-pigmented white bands), choroiditis, lens damage inflammation and increased eye size and weight (Harrison *et al*., 1968; Jenkins *et al*., 1979; Siopes *et al*., 1984; Thompson and Forbes, 1999; Blatchford *et al*., 2009).

Light intensity effects on broiler welfare are noted for physical health and behavior. In terms of physical health, light intensity has been suggested to affect ocular, foot pad and skeletal health. Also, light allows the bird to establish rhythmicity and synchronize many essential functions including body temperature and various metabolic steps that facilitate feeding and digestion. Of equal importance, light stimulates secretory patterns of several hormones that control in large part, growth, maturation and reproduction (Olanrewaju *et al*., 2006). In regard to behavior, expression of comfort behaviors and alteration of circadian behavioral rhythms are noted to be affected by light intensity and are considered indicators of reduced welfare. Higher light intensity has been shown to increase bird activity and aggressive behavior (Hester *et al*., 1987; Newberry *et al*., 1988; Kjaer and Vestergaard, 1999) but a specific negative effect of higher light intensity within the range of 1-100 lux has not been scientifically demonstrated in broiler chickens. Despite published negative effects on broiler production and welfare, the broiler industry still uses and recommends dim (<5 lux) lighting. These recommendations are based on the perception that very low light intensities improve feed efficiency, reduce mortality due to Sudden Death Syndrome (SDS) and reduce carcass damage (scratches, bruises) because of reduced activity (Lewis and Morris, 2006). In general, light intensity ranging from 1-150 lux has been found to not affect body weight, feed consumption and feed to gain ratio (Skoglund and Palmer, 1962; Newberry *et al*., 1988; Kristensen *et al*., 2006; Lien *et al*., 2007; Blatchford *et al*., 2009). Researchers have hypothesized that increasing light intensity would increase activity and thereby exercise and that the increased exercise would improve skeletal health. Light intensity can affect skeletal health of broilers by affecting their activity level (Lewis and Morris, 2006).

The purpose of the present study was to determine the effects of two different light intensities (10+10 vs. 10+5 lux) provided by halogen spot lamps on live performance and welfare of broilers. In the experiment the effects of two different spot lighting applications on broiler performance walking ability (gait score), duration of induced Tonic Immobility (TI) reactions, some blood variables and lymphoid organ weights were investigated.

MATERIALS AND METHODS

Flock management: A total of 522 Ross 208 male and female day old broilers were obtained from a commercial hatchery for trials and reared in nine light tight indoor pens (58 birds each) of semi controlled poultry house for 42 days experimental period. At the beginning of the experiment, chicks were individually tagged and weighed. The lighting program was constant at 23L:1D for rest of the experiment. In control, a photoperiod of 23 h was provided with a light intensity of approximately 10 lux at bird height with two incandescent bulbs (40 W, Osram AG, Munich, Germany). In each treatment groups, two halogen spot lamps (20 or 10 W, Phillips) were used to supply at different light intensities (10+10 lux vs. 10+5 lux) over two circular areas of 1 m^2 diameter in the experimental groups In this way only one-third of the bottom area (two separate spot) was illuminated (Fig. 1). The room temperature was 33-35°C at the 1st day and gradually decreased until it was 21-23°C by day 21st. All chicks were fed a standard broiler starter diet (3050 kcal ME^{-1} kg and 23% CP) from 1-14 days and a standard grower diet (3100 kcal ME^{-1} kg, 22% CP) from 15-35 days and then a finisher diet with 3200 kcal ME^{-1} kg, 20% CP. Water was available for *ad libitum* consumption from bell

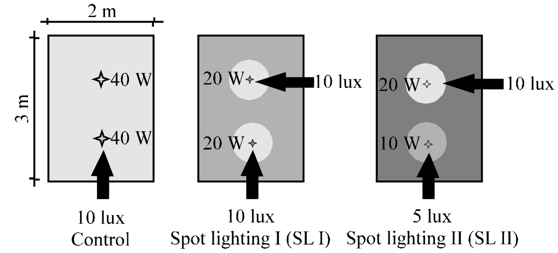

Fig. 1: Design of the experiments with power of lamps and light intensities

drinkers. Feeder and drinker spaces were identical in each pen. Approximately 3 kg m^{-2} of wood shavings litter were supplied to each pen at the start of the trial.

Measurements data collection: Light intensity was recorded near the floor, approximately at the bird's height and three times each room using a portable light meter (Testo Ltd. Alton, Hants., UK). All birds per pen were individually weighted at 21st and 42nd days of age. Mortality was daily recorded. Ten birds from each group, representing the average and the variability of the pen were randomly selected to be slaughtered at 42nd day of age. Before slaughter, birds were subjected to a total feed withdrawal of 8 h and brought to the slaughterhouse. The birds, previously weighed individually were killed by Cervical Subluxation Method, plucked and eviscerated (intestines, perivisceral, perineal and abdominal fat, gall bladder, esophagus, full crop and proventriculus) and then bursa of Fabricius, spleen and liver were collected. Whole carcass weight and yield (carcass weight/pre-slaughter weight) determined and bursa fabricius, spleen and liver weights were obtained, bursafFabricius/body weight, spleen/body weight and liver/body weight, ratios (%) were calculated. Feed Conversion Ratio (FCR) was calculated on the basis of unit feed consumed to unit body weight gain for each replicate separately, taking mortality into consideration.

A total of 45 birds were tested for tonic immobility responses at the treatment period (on 42nd day). TI was induced by restraining the bird on its back in a U-shaped cradle for 15 sec (Jones and Faure, 1981). The duration of TI, the time interval until the bird righted itself and the number of inductions (15 sec periods of restraint) necessary to attain TI were recorded. If TI could not be induced after 5 attempts, the bird was considered to be unsusceptible and a score of 0 was recorded. If the bird remained in TI after 5 min, the test was stopped and a maximum score of 300 sec was given for righting time. All these birds were assigned a gait score, assessed the walking ability of the birds while they were moving spontaneously in the rearing environment from a 5 point scale where 1 point for a perfectly normal bird to 5 point for the bird that could not walk at all. At the end of the experiment, environmental enrichment birds had slightly high body weight than control group.

A sample of 5 mL of blood was obtained from the wing vein of 10 birds and they were divided into two sub samples. First sub sample was used for Malondialdehyde (MDA) analysis immediately. The second sub sample was centrifuged at 4000 rpm for 10 min at 4°C to separate plasma and immediately stored at -70°C for later glucose, triglyceride analysis. Randox Cholesterol, Triglycerides and Glucose Liquid Enzymatic Colorimetric Method kits (Randox Laboratories, Ardmore, Crumlin, UK) were used which are based on the CHOD-PAP, Glycerol-Phosphate Oxidase and GOD-PAP Methods, respectively. GSH-P_x activity was determined using the commercially available enzyme kit (Ransel, RANDOX/RS-504) supplied by Randox Laboratories, Ardmore, Crumlin, UK. At 42nd day of the experiment, body weight and food intake were determined on an individual basis and food efficiency was calculated. Mortality was recorded daily in experiment groups. Tonic Immobility (TI) reactions were examined in 42 days old birds were determined bursa of fabricius, spleen and liver weights of slaughtered broilers were established. Blood was sampled 42nd day of experiment and glucose, cholesterol, triglycerides and MDA levels were analyzed which obtained all experiment groups.

Statistical analysis of data: All data one-way ANOVA as a completely randomized design using the GLM procedure of SAS Institute (1990). Significant differences among the means were determined by the Duncan's multiple range tests. Data on mortality were analyzed using Chi-square analyses. Logarithmic transformation for TI response was used prior to analyses but untransformed values are presented.

RESULTS AND DISCUSSION

Performance: Data on broiler performance are shown in Table 1. The final (42nd day) Live Weight (LW) significantly affected by spot lighting whereas Feed Conversion Ratio (FCR), Carcass Weight (CW), Carcass Yield (CY) and Mortality (M) did not. First Spot Light group (SL II) has shown better (2297.07 g) LW than the second Spot light (SP II) and the control groups. Live Weight (LW), Feed Conversion Ratio (FCR) and mortality are commonly measured indicators of broiler live production. In accordance with the findings, the majority of previous research demonstrated that broiler live production was unaffected by light intensity (Lewis and Morris, 2006). Cherry and Barwick (1962) argued that difficult management of broilers in dim light (0.2 lux) might be responsible for decreased body weight. Newberry *et al*. (1986) completed two experiments using 0.5, 10, 20, 30 and 0.1,1, 10, 100 lux. Body weight was unaffected by light intensity but feed intake and FCR increased with increased intensity in experiment 2 at 6 and 9 weeks of age.

Total mortality and mortality due to Sudden Death Syndrome (SDS) were unaffected by light intensity treatments.

Table 1: The effects of Spot Lighting (SL) on Live Weight (LW), Feed Conversion Ratio (FCR), Carcass Weight (CW), Carcass Yield (CY) and Mortality (M)

Groups	LW* at 21st day (g)	LW* at 42th day (g)	FCR*	CW* (g)	CY* (%)	M* (%)
Control (10 lux)	757.10±11.21	2272.4±20.00[a]	1.55±0.02	1784.70±33.98	75.58±0.71	4.60±1.59
SL I (10+10 lux)	681.94±7.61	2184.65±17.53[b]	1.56±0.05	1815.20±43.09	76.29±0.46	4.60±1.59
SL II (10+5 lux)	707.22±6.06	2297.07±16.96[a]	1.54±0.03	1886.70±27.78	75.96±0.57	2.87±1.27
Probability	NS	0.033	NS	NS	NS	NS

*LS Mean±SEM; NS: Not Significant; a, bLS means within columns with no common superscript differ significantly ($p<0.05$)

Table 2: The effects of Spot (SL) Lighting on Duration of tonic immobility (D), Induction Number (IN) and Gait Score (GS)

Groups	D* (s)	IN*	D/IN* (sec)	GS*
Control (10 lux)	182.00±70.56	1.46±0.19	165.52±42.33	1.40±0.28
SL I (10+10 lux)	275.90±70.56	2.10±0.41	184.23±52.33	1.13±0.09
SL II (10+5 lux)	158.60±32.97	2.10±0.38	102.33±30.23	1.00±0.15
Probability	NS	NS	NS	NS

*LS Mean±SEM; NS: Not Significant

Table 3: The effects of Spot Lighting (SL) on the levels of plasma Glucose (Gl), Cholesterol (Ch), Triglyceride (Tg) and Malondialdehyde (MDA)

Groups	Gl* (mg dL^{-1})	Ch* (mg dL^{-1})	Tg* (mg dL^{-1})	MDA* (nmol mL^{-1})
Control (10 lux)	340.00±17.72[a]	76.25±4.37	193.63±13.34	0.77±0.17
SL I (10+10 lux)	247.77±14.41[b]	91.04±6.84	153.32±16.71	0.68±0.15
SL II (10+5 lux)	235.07±7.57[b]	78.99±3.79	144.61±18.32	0.75±0.09
Probability	0.0214	NS	NS	NS

*LS Mean±SEM; NS: Not Significant; a,bLS means within columns with no common superscript differ significantly ($p<0.05$)

On the other hand, negative effects have included reduced carcass and tender yield, decreased early uniformity increased incidence of leg disorders and ocular defects, altered behavioral expression and birds being more fearful (Hughes and Black, 1974; Newberry *et al*., 1988; Lien *et al*., 2007; Blatchford *et al*., 2009; Alvino *et al*., 2009). Kristensen *et al*. (2006) compared two levels (5 and 100 lux) of light intensity and two light sources and revealed that light intensity had no effect on broiler live production (BW, FI, FCR and mortality). Lien *et al*. (2008) compared 5 and 150 lux and found that BW and FI of broilers exposed to 5 lux were higher than those given 150 lux. In conclusion, research consistently shows that light intensity from 1-150 lux does not affect broiler live production as demonstrated by BW, FI, FCR and mortality. Light intensity has no adverse effect on body weight gain or food conversion efficiency in meat type chicken.

Welfare: This recent research has indicated that spot the birds of SL I slightly better Tonic Immobility (TI) response and Gait Score (GS) than control and SL II but not significantly ($p>0.05$). The Duration of tonic immobility (D) of the control, SL I and SL II birds were 182.00, 275.90 and 158.60 sec, respectively (Table 2). Even though there were no statistically significance in point of investigated characteristics, better walking scores determined in SL II group was illuminates with different illumination capacity's bulbs (10+5 lux). Newberry *et al*. (1986) reported that light intensity ranges from 0.5-100 lux had no effect on skeletal disorders of broilers. Similarly, Kristensen *et al*. (2006) studied two levels of light intensity (5 and 100 lux) and found that leg health was unaffected. Also, Olanrewaju *et al*. (2006) found that broilers exposed to light levels of 0.2-20 lux have similar skeletal health as demonstrated by gait-score. The incidence of tibial dyschondroplasia was also unaffected by light ranges from 2.2-20 lux (Hester *et al*., 1987). Recently, Blatchford *et al*. (2009) researched three levels of light intensity (5, 50 and 200 lux) and found that gait score was unaffected by light intensity.

In the study, both experimental groups have shown significantly lower blood glucose levels than the control group ($p<0.05$). Different light intensity supplied by spot lights were not affect the levels of total cholesterol, triglyceride and MDA level in plasma (Table 3).

There is no significant differences in spleen and liver weights or their relative weights, bursa of Fabricius weight and relative weight in SP I chicks were significantly ($p<0.05$) higher than other experimental groups (Table 4). It is well known that, the lymphoid organ weights are easily measured and they reflect the body's ability to provide lymphoid cells during an immune response. Bursa of fabricius weight was one of the best indicator of the stress that was related to lighting intensity and reliable indication of stress. As stress increased, bursa of fabricius weight relatively decreased significantly. Social stress induces decreasing ratio between weight of bursa of fabricius and body weight (Mohamed and Hanson, 1980). Investigating the nutritional stress on the bursa of fabricius and thymus of chickens Griffiths *et al*. (1985) point out that stress induces thymus atrophy and reduction in bursa of Fabricius weight.

Stress has generally been associated with a decline in production performance in broilers and it has significant influence on immune system andimmune organs.

Table 4: The effects of Spot Lighting (SL) on bursa of Fabricus Weight (bFW), Spleen Weight (SW) and Liver Weight (LW) and their relative (%) weights to carcass weights

Groups	bFW* (g)	bFW* (%)	SW* (g)	SW* (%)	LW* (g)	LW* (%)
Control (10 lux)	3.01±0.28[b]	0.007±0.0009[b]	2.29±0.12	0.13±0.007	44.69±1.14	2.01±0.15
SL I (10+10 lux)	2.60±0.29[b]	0.006±0.0005[b]	2.31±0.14	0.12±0.008	45.89±1.61	2.07±0.16
SL II (10+5 lux)	4.25±0.35[a]	0.009±0.0006[a]	2.83±0.28	0.15±0.015	49.02±1.82	1.85±0.15
Probability	0.0037	0.0122	NS	NS	NS	NS

*LS Mean±SEM; NS: Not Significant; [a,b]LS means within columns with no common superscript differ significantly ($p<0.05$)

CONCLUSION

This result of different lighting intensity investigations show that spot lighting in broiler chickens has significant influence on immune system and immune organs. Light intensity can also affect broiler welfare with evidence that dim light results in reduced welfare by decreasing blood glucose level and increasing size of bursa of fabricius.

Despite considerable research on light intensity, there is still a debate on the optimum level to be used for intensively housed broilers (Deep, 2010). Spot lights might be useful tool for the dim light applications without negatively affecting the expression of performance and welfare of broilers. But there are relatively few studies have shown significant effects of spot lighting on broiler production. Overall, the use of spot lighting will might combine advantages of the dim and increased illumination programs by improved the welfare of broilers if there is a sufficient contrast provided between illuminated spots.

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