

## PERFORMANCE, BEHAVIOUR AND WELFARE ASPECTS OF BROILERS AS AFFECTED BY DIFFERENT COLOURS OF ARTIFICIAL LIGHT

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Accepted: 28 September, 2011

### ABSTRACT

This experiment examined the effect of four colours of artificial light (ALC) on performance, behaviour, water/feed intake (WFI) and welfare of broilers. Day old broiler chicks (Cobb) were assigned into six brooders for either red (RD:650-750nm), white (WT:325-750nm), green (GR:530-545nm) or blue (BL:450-470nm) ALCs from 1- 35d (20lux,9hrs/day at growing stage). Complete Randomize Design was adopted with 6 replicates. Water and Feed provided *ad libitum*. Daily WFI; weekly weight gain (WG) and behaviour recorded. Common behaviours (21) were evaluated by scan sampling method. Welfare indicators; foot pad dermatitis, breast blisters and hock burning damage scores were determined. Lameness was assessed by gait score and latency to lie (LTL) tests. Six birds/treatment were evaluated for carcass parameters. Significantly ( $p<0.05$ ) highest WG ( $365.33\pm 12.07$ g/bd/week) was recorded in RD compared to other treatments at 21d. Also Significantly highest WI ( $102.07\pm 49.01$  g/bd/day) at 21d and FI( $226.48\pm 27.47$ ) at 28d were recorded by RD treated birds. ALC had no effect on final body weight (BW), feed conversion ratio (FCR), water feed ratio (W:F ratio), welfare indices, mortality rate, carcass parameters, gait score and LTL. Overall, the dominant behaviour was lying that showed 64.15% of the total time budget. Wing flapping (26%) and eating (6.98%) received 2<sup>nd</sup>,3<sup>rd</sup> places, respectively. ALC significantly ( $p<0.05$ ) affected sleeping behaviour (SL) where RD treated birds performed the highest ( $0.53\%\pm 0.29$ ) and GR treated birds showed lowest ( $0.31\%\pm 0.19$ ) SL. Birds were more active under RD, WT and GR compared with BL in the night as lowest eating and walking performed by BL treated birds. Highest dust bathing shown by the birds under GR during morning at the 4<sup>th</sup> week ( $0.02\%\pm 0.02$ ). Though ALC had no effect on eating, ALC\*night time interaction demonstrated increased ( $p<0.05$ ) eating in RD and WT at night. These data indicate that rearing ALC affected bird behaviour than growth. Providing RD colour light up to 21d had beneficial effects on weight gain.

**Key words:** Behaviour, Broiler, Light Colour, Performance, Welfare

### INTRODUCTION

Lighting exerts critical influences on poultry health and welfare. Birds are sensitive to light even when they are embryos (Aige-Gil and Murillo-Ferrol 1992). It is known that the pattern, colour and intensity of lighting can affect many aspects of avian physiology and behaviour, including skeletal and eye development and behavioural rhythms (Nelson and Demas 1997; Reiter 2003). Light stimulation also can impact the ability to cope with stressors (Campo *et al.* 2007), and has effects on brain organization that influence behavioural responses, including fearfulness (Dharmaretnam and Rogers 2005).

The colour of light is determined by the relative power of different wavelengths in the visible part of the light spectrum. Chickens possess normal vertebrate trichromatic vision

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(Cornsweet 1970) and can discriminate colours (Bell and Freeman 1971). Domestic fowl differ from humans in spectral sensitivity (Prescott and Wathes 1999). This difference illustrates the need to identify the light environment, which is optimal for the health, behaviour, welfare and production of broiler chickens.

Previous studies have suggested that broiler leg health as well as production can be influenced by the photoperiodic regime, colour and intensity of light. However, most studies have confounded the different aspects of light, which complicates the determination of the optimal light specifications for broilers in current production systems. The reported results vary, probably because of spectral overlap of colours, differences in spectral sensitivity with age and experience, and confusion of wavelength and light intensity (Prayitno 1997; Prescott and Wathes 1999).

The objective of this experiment was to assess the behaviour, performance, water/feed intake pattern and welfare parameters of broilers reared in deep litter system upon red (RD:650-750nm), white (WT:325-750nm), green (GR:530-545nm) and blue (BL:450-470nm) light under tropical environment. Based upon previous studies, it was hypothesized that certain colours of light would contribute to superior performance upon exposure at early stage of the life. It was also hypothesized that changes of the behaviour pattern under different colours of light would have effect on the welfare parameters of the broiler chickens.

## METHODOLOGY

### Animals and Husbandry

Day old broiler chicks (Cobb) were obtained from a commercial supplier and distributed randomly into six replicate brooders for each colours of artificial light (ALC) treatment red (RD:650-750nm), white (WT:325-750nm), green (GN:530-545nm) and blue (BL:450-470nm) by balancing weight. Feed/water intakes (FWI), temperatures of each replicated brooder were measured daily and weight gains (WG) were measured weekly. At 14d, birds were weighed and 3 birds were placed into one experimental cage (3'x2') and continued the exposure to same ALC throughout the lifetime. Complete Randomize Design was adopted with 6 replicates. Each experimental cage was separated by double layered black polythene and those were photophically separated. Each experimental unit was provided with a feeder and a bell shaped drinker to ensure *adlib.* feed and water. Birds were remained in their allocated light treatment from 1-35d of age. Temperature and humidity were recorded daily. Chicks were fed with a commercial broiler starter (ME=2980 kCal/kg and CP = 21.5%) and finisher (ME=3050kCal/kg and CP=19.5%) diets. Vitamin C was provided at a rate of 5g/l of water to prevent from heat stress from 28d onwards.

### Light Environment

RD, WT, GN and BL colour incandescent bulbs were used. WT served as the control. During the brooding period, artificial light was provided for 24 hours using 40W coloured incandescent bulbs and the light intensity was 60 lux at bird's eye level. During growing

period it was reduced to 20 lux (5W) and provided from 22:00h to around 0700-0730 hours of the following day (9 hours and 30 minutes) until the light intensity of the poultry shed reached 150 lux by day light. The light sources were adjusted to equal intensity by changing the heights, according to the recommendations of FAWC, UK, 1997. The light bulbs were wiped weekly in order to minimize dust built-up, which would have reduced the intensity and spectra.

### Measurement of Feed/Water Intake Pattern and Production

FWI measured daily. To get an understanding of FWI pattern during 3 sessions of the day [(day time (07:30 – 18:00h), dark period (18:00 -22:00h) and night time under artificial light (22:00-07:30 h)]; FWI were measured separately 4days/week covering those sessions. The FWI were recorded by subtracting the weight of the leftover feed/water every day and the every session.

The growth of the birds was determined by weighing the birds weekly. All the birds were weighed and the average weights were recorded. Mortalities and their causes (if known) were recorded.

On 36d, 6 birds/treatment were slaughtered humanely by neck dislocation. Each de-feathered carcass was dissected into skin, shank, internal organs (gizzard, crop, liver, heart) muscle/bone (right drumstick and the thigh) and weighed them separately.

### Behaviour Recordings

The undisturbed behaviour of the chicks in the rearing room was recorded once a week in the morning [MN], evening [EV] and night [NT] for 3 consecutive hours at each session by adopting scan sampling method (Martin and Bateson, 1993) using an ethogram (Table 1). Twenty one most common behaviours performed by broilers were evaluated. Behaviours were evaluated on 3 focal birds/pen, by direct visual scans for 15 minutes intervals. Behaviours were recorded by one-zero measurements (presence or absence) of each behaviour. It was recorded the number of birds in each experimental unit engaged in each of the activity defined by the ethogram.

**Table 1: Description of each behaviour irrespective of any of the experimental factor**

Activity	Description
1. Standing (St)	The abdomen is not touching the litter and the bird is motionless with no apparent movement of legs.
2. Walking (Wk)	Moving forward taking one or more steps.
3. Lying (Ly)	Head rested on something (litter or another bird) while sitting
4. Eating (Et)	Head extended towards available feed resources while beak in or above the drinker appears to be manipulating or ingesting feed.
5. Head movement (Hm)	Immobile body apart from rapid head movements in any directions or rotations of the head around its vertical or horizontal axis.
6. Wing Flapping (Wf)	Extending both wings out from the body simultaneously and flapping of wings.
7. Scratching floor (Sf)	Scratch floor with feet usually associated with eating behaviour.
8. Dozing (Dz)	The head motionless and the eyes either half closed or slowly opening and closing while bird is sitting.
9. Sleeping (Sl)	Bird's neck is fully recumbent and the eyes permanently closed while lying.
10. Bird Interactions (Bi)	Frontal displays with raised hackles towards another bird, head pecking, jumping or kicking at another bird attacking the other birds in an aggressive manner.
11. Dust bathing (Db)	Bathing the dust with the use of wings, head, neck and legs performing vertical wing-shaking.
12. Body Shaking (Bs)	Raise feathers and shake body.
13. Drinking (Dr)	Beak in contact with water in or above the drinker and appears to be drinking water
14. Vocalization (Vc)	Making any kind of noise
15. Preening (Pr)	Beak related behaviour that beak touches the plumage of the bird itself.
16. Flying (Fl)	Flapping of the wings forcing the birds to lift from the ground or displacement.
17. Litter Eating (LE)	Pecking in the litter and ingesting litter materials.
18. Wing/ leg stretching (W/Ls)	Extending one wing and one leg at the same side of the body.
19. Idling (Id)	Lack of motion showing isolation from the flock.
20. Flying (Fy)	By forcing wings displacement from one place to another.
21. Other (Ot)	All other behaviours observed.

### Assessment of Lameness

Lameness of the birds was assessed using two different methods; gait score system and the

LTL test.

### Lameness Assessment Based on Scores of Severity

At 35d, two birds were randomly taken from each of the experimental unit and a metal mesh square (1mx1mx1m) was placed around one bird at a time. The square consisted of an opening which allow the bird to walk towards the other birds in the room. The walking ability of that bird was observed and scored as one of 6 gait-score categories (0 to 5), according to the scoring system of Kestin *et al.* (1992), where a score of 0 corresponds to normal gait, 1-intermittent detectable abnormality in gait; 2-permanent detectable abnormality in gait; 3-abnormal gait but able to walk; 4-only able to take one or two steps at a time and 5 describes a bird that is completely unable to walk even when encouraged.

### Lameness Assessment Based on Latency to Lie

“Latency to lie” test as described by Weeks *et al.* (2002) was used as an indirect measure of the leg bone strength. Two birds from each experimental cage were randomly taken for LTL test at 35d. These birds were placed in a water proof test pen which was flooded with a shallow layer (30 mm) of water. As chickens do not prefer to sit in water, flooding the pen motivates the birds to stand. The time taken for each bird to lie down was recorded.

### Assessment of the Other Welfare Parameters

Presence of foot pad dermatitis (FPD), hock burning damage (HBD) and breast blisters (BB) of the birds were assessed using an internationally accepted score system used by (Kestin *et al.* 1992). Same two birds used to assess the lameness were scored for contact dermatitis on the hocks and footpads. In addition, presence of breast blisters also assessed.

HBD was scored on a 4 point scale with 0 describing no visible damage to the skin on the hocks and 3 describing an obvious lesion or score on any of the hocks. A score of 1 was given for signs of skin deterioration without any redness; a score of 2 was given for signs of skin deterioration with the presence of redness of the skin area. Same score system was

adopted to assess the presence of breast blisters. FPD was scored on a three point scale where 0 described normal footpads without lesions, whereas a score of 2 was given for obvious scores on the footpads (Ekstrand *et al.* 1998). Once each bird had been assessed for leg health and weighed, it was marked with a tag to avoid recapture and released back into the flock before the next bird was captured and assessed. In total, 12 birds (67% ) were assessed from each of the 4 ALCs. Both legs of each bird was separately scored for the FPD and HBD.

### Statistical Analysis

Broiler behaviour and growth was tested for normal distribution before analyzing for statistical significance of treatment differences by analysis of variance, using the Statistical Analysis Software (SAS, SAS Institute Inc. Release 8.1). The difference between treatment means was examined by including treatment, age, session of the day as main effects and all two way interactions. The common model for each behaviour included all qualitative factors as well as their interactions. In order to determine the nature of the significant effect, pair wise comparison was done between significant factors.

Locomotion scores obtained by two methods; scores given for FPD, BB and HBD were tested using Kruskal-Wallis test of the statistical package Minitab (Ryan *et al.* 1985).

## RESULTS AND DISCUSSION

Providing ALCs especially up to 14d resulted a significant ( $p < 0.05$ ) effect on WG. The highest WG was recorded under the RD light while lowest WG recorded by BL colour (Table 2). But this kind of an effect could not be observed beyond 14d. At the time of slaughter (36d) there was no any significant difference in BW and growth performance among ALC treatments (Table 3).

Son and Ravindran (2009), Fawward Ahmad *et al.*; (2011) also found that ALC and intensity had no effect on WG. Similar to our findings, Prayitno *et al.* 1997 found that RD increased growth when provided at the beginning of the rearing period, but decreased when provided

**Table 2. The body weight gain (BWG), feed conversion ratio (FCR), feed/water intake and W:F ratio of broilers reared in different colour**

Variable	Light colour treatment				SEM <sup>2</sup>	p
	Red	White	Green	Blue		
<b>BWG<sup>1</sup></b>						
(g/bd/wk)						
1-7d						
8-14d	172.83 <sup>a</sup>	166.73 <sup>a,b</sup>	147.83 <sup>c</sup>	149.9 <sup>b,c</sup>	4.503	<b>0.02</b>
15-21d	365.33 <sup>a</sup>	352.68 <sup>a,b</sup>	317.65 <sup>b</sup>	317.27 <sup>b</sup>	9.609	<b>0.02</b>
22-28d	624.52	617.82	578.97	643.65	24.08	0.38
29-35d	591.55 <sup>a,b</sup>	577.22 <sup>b</sup>	789.55 <sup>a</sup>	724.57 <sup>a,b</sup>	51.65	0.09
	712.11	725.45	499.45	641.61	91.97	0.38
<b>FCR</b>						
1-7d	0.93	1.00	0.95	1.00	0.102	0.57
8-14d	1.36	1.38	1.32	1.43	0.142	0.57
15-21d	1.48	1.47	1.5	1.42	0.130	0.71
22-28d	2.17	2.3	1.47	1.75	0.850	0.32
29-35d	1.65	1.77	2.67	2.07	0.950	0.27
<b>Feed Intake</b>						
(g/bd/day)						
1-7d						
8-14d	27.15 <sup>a,b</sup>	28.17 <sup>a</sup>	23.28 <sup>c</sup>	24.72 <sup>b,c</sup>	5.02	0.004
15-21d	38.53 <sup>a</sup>	37.67 <sup>a,b</sup>	32.15 <sup>c</sup>	34.48 <sup>b,c</sup>	8.25	0.003
22-28d	226.48 <sup>a</sup>	223.47 <sup>a</sup>	202.28 <sup>b</sup>	216.98 <sup>a,b</sup>	83.89	0.032
29-35d	396.53 <sup>a</sup>	389.85 <sup>a</sup>	356.85 <sup>b</sup>	388.15 <sup>a,b</sup>	193.4	0.066
	555.90 <sup>a</sup>	560.45 <sup>a</sup>	513.00 <sup>b</sup>	550.98 <sup>a,b</sup>	267.75	0.098
<b>Water Intake</b>						
(g/bd/day)						
1-7d						
8-14d	57.53 <sup>a</sup>	54.90 <sup>a,b</sup>	50.13 <sup>c</sup>	51.75 <sup>b,c</sup>	10.31	<b>0.003</b>
15-21d	102.07 <sup>a</sup>	98.35 <sup>a,b</sup>	89.77 <sup>c</sup>	92.08 <sup>b,c</sup>	30.88	<b>0.004</b>
22-28d	355.62	346.75	348.77	348.25	34.04	0.979
29-35d	722.10	723.70	701.37	707.65	64.24	0.913
	1209.15	1183.82	1070.03	1160.10	102.35	0.854
<b>W:F ration</b>						
1-7d	2.11	1.94	2.15	2.09	0.34	0.34
8-14d	2.65	2.61	2.79	2.67	0.12	0.79
15-21d	1.57	1.55	1.72	1.6	0.21	0.29
22-28d	1.82	1.86	1.96	1.82	0.22	0.46
29-35d	2.18	2.11	2.09	2.11	0.22	0.76

Means within a row followed by different letters significantly differ ( $p < 0.05$ )

<sup>1</sup> n=6

<sup>2</sup> Standard error among 4 means

**Table 3. Final body weight, carcass evaluation data under different light colour treatments**

Variable	Light Colour				SEM	p
	Red	White	Green	Blue		
BW <sup>1</sup> (g)	2526	2507	2347	2550	232.32	0.23
						2
<b>Carcass composition<sup>2</sup></b>						
(g)						
Carcass weight	2076.83	2101.83	2196.66	2161.83	227.17	0.79
Full crop	12.17	9.67	11.17	8.17	3.46	0.24
Gizzard	29.67	28.67	30.83	33.17	5.52	0.54
Liver	61.5	64.33	62.83	61.83	8.55	0.94
Heart	13.17	13.83	12.67	13.17	2.56	0.89
Muscle <sup>3</sup>	367.33	396.33	407.33	381.33	16.64	0.21
Bone <sup>3</sup>	78.66	91.33	88.10	88.27	7.16	0.46
Skin	165.5	173.33	167.67	178.00	28.27	0.87
Shank	23.5	24.83	24.17	24.00	3.69	0.94

<sup>1</sup> Average body weight of 6 replicates at day 35

<sup>2</sup> Mean values of six replicates

<sup>3</sup> right thigh+drum stick

later. In his experiment, red colour lights were provided 23hrs during growing period. But in the current study ALCs were provided 23hrs (brooding period) and <10hrs (growing period).

Carcass evaluation data revealed that, no significant effect ( $p>0.05$ ) on the weights of full crop, gizzard, liver, heart, skin, muscle, bone and shank (Table 3). Also there was no significant ( $p>0.05$ ) difference in mortality rate among treatments.

Most authors have reported that no effect of ALC on poultry growth, for the same reason (Smith and Phillips 1959; Kondra 1961; Schumaier *et al.* 1968; Peterson and Espenshade, 1971; Wathes *et al.* 1982) they reared birds up to 14 days under common brooding light. However, effects on growth could be attributed as demonstrated in this experiment when providing colour lights during brooding period.

Effects on growth are not usually allometric for all body parts as found by Prayitno *et al.* (1997). He found that there were significant difference in full crop and gizzard, gut content, skin and bone weights under the same ALC treatments of 23hrs. The time period exposed to ALCs in this experiment (9h) would not have sufficient to resulted significant difference in different body parts to obtain similar results as found by Prayitno *et al.* (1997).

There was no significant difference in welfare parameters; HBD, BB and FPD among ALC treatments. Overall, irrespective of the treatment there was evidence of abnormal gait in 25% of the birds sampled and no birds were found to have GS 4 or GS 5. This is in accordance with the findings of Kristensen *et al.* (2006). They found that the gait score was not significantly affected by either light source or intensity.

Moderate to severe HB (score of  $\geq 2$ ) was found 40% of the birds at 35d. The probability of a bird having a particular HBD score was independent of the rearing ALC. Few birds were classed (10.4%) having severe FP lesions (FPD score  $\geq 3$ ). No relationship could be observed with the weight and the

**Table 4. Welfare parameters under different light colour treatments**

Variable*	Light Colour				SEM	p
	Red	White	Green	Blue		
Assessment of Lameness						
LTL <sup>1</sup> (Seconds)	37.58	70.42	97.83	71.75	44.01	0.274
GS <sup>2</sup>	3.00	2.00	1.00	2.00	0.38	0.388
Foot Pad Dermatitis						
Left Leg						
Right Leg	2.00	5.00	5.00	0.00	0.08	0.088
Average FPD	2.00	5.00	0.00	0.00	0.06	0.058
Hock burning damage	2.00	0.50	0.25	0.25	0.08	0.066
Left Leg	3.00	2.00	2.00	2.00	0.57	0.569
Right Leg	3.00	2.00	2.00	2.00	0.40	0.398
Average HBD	3.00	2.00	2.00	2.00	0.48	0.447
Presence of breast blisters	2.00	1.5	1.5	2.00	0.13	0.133

<sup>1</sup> Latency to Lie Test, <sup>2</sup> Gait Score

\*Average of 12 birds per treatment

severity of presence of the HBD, FPD and BB as there was no significant difference in weight among treatments. In total, mortality rate was 3% and no significant difference recorded among ALC treatments. Light treatment had no significant effect on either feed conversion ratio (FCR) or Water: Feed ratio (WFR) (Table 2). Prayitno *et al.* 1997 also found similar results in which no effect on FCR under different ALC treatments.

Similar to the WG, up to 21 days significantly ( $p<0.05$ ) higher FI was recorded by RD and WT compared to GN and BL. Similarly higher WI marked by RD and WT ( $p<0.05$ ) compared to GN and BL up to 12days (Table 2).

During day time FI was almost similar in each treatment (RD=740.08g/bd/d, WT=707.55, GN=677.78 and BL=715.57) whereas birds exposed to RD during NT showed the highest WI 105.17g $\pm$ 18.55. Senaratna *et al.* 2008 also found similar results under same management conditions comparing RD vs. WT light treatments. During dark period both FI and WI were higher in GN and BL treatments to either RD or WT treatments.

Irrespective of the ALC treatment, the dominant behaviour of the broilers was Ly (64.15%], Wf (26.00%)] and Et(6.98%)] received second and third places respectively (Table 5).

Findings of the present study revealed that the rearing ALC particularly affected bird behaviour than growth. ALC significantly affected Sl. Birds reared in RD performed the

**Table 5. Common behaviours performed by broilers irrespective of the light environment at 35d**

Behaviour	Time Budget (%)
Eating	6.98%
Drinking	5.08%
Standing	2.43%
Walking	0.71%
Lying	64.15%
Head Movement	0.10%
Wing Flapping	26.00%
Scratching Floor	6.00%
Dozing	3.56%
Sleeping	7.34%
Bird Interaction	0.39%
Dust Bathing	0.42%
Body Shaking	0.15%
Vocalization	0.63%
Preening	5.48%
Flying	1.00%
Litter Eating	2.08%
Wing Leg Stretching	1.22%
Idling	0.40%
Other	0.32%

highest SI during 3<sup>rd</sup> (0.36%±0.17) and 5<sup>th</sup> week(0.53%±0.29) compared to other ALC treatments and second to white(0.49%±0.07) during 4<sup>th</sup> week. Prayitno *et al.* 1997 also found that birds in the RD and WT spent longer SL time. BL reared birds performed highest SI during MN and EV. During NT, it became to the second place. As BL gives a cooling and calming effect, birds may tend to more SI under BL showing more inactive under BL. GN reared birds performed significantly a lower SI behavior (0.31%±0.19).

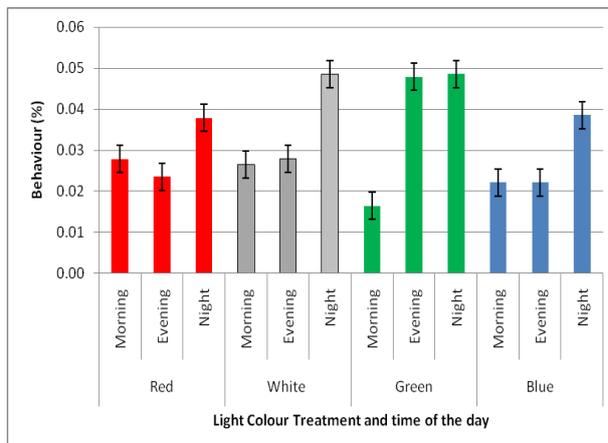
Though there was no direct treatment effect on some of the behaviours, either interaction with the time of the day (TD) or age (AG) showed significant effects. Et and Sf behaviours significantly affected ( $p < 0.05$ ) with the interaction of ALC\*TD where highest Et recorded by GN(0.05%±0.03). Interaction of the ALC\*AG showed a significant effect on Dz marking higher values in WT (0.03%±0.02) and RD (0.03%±0.01) compared with GN and BL.

Similar to the findings of Prayitno *et al.* 1997 there were no overall treatment effect on Et.

But the interaction with TD demonstrated that the Et at NT (under respective LC) increased significantly in RD, WT and BL and to a lesser extent the GN compared in the EN (Fig. 2). Under WT or GN birds performed more Et than RD or BL. Et was significantly affected by the AG, TD as well as the interaction ALC\*TD.

Birds in the NT were more active under WT, RD and GN lights compared with BL. This is evidence by greater Et (Fig.2) and Wk performed under these treatments. In turkeys also BL light has also been found to reduce activity compared with WT, GN or RD light (Levenick and Leighton 1988).

Db and Id behaviours were significantly affected by ALC\*TD\*AG three factor interaction. Highest Db behaviour performed by GN exposed birds during MN at the 4<sup>th</sup> week (0.02%±0.02). Ly and Hm behaviours were significantly affected by TD. Bi, Vc, Pr and other behaviours were only significantly

**Fig. 2. Eating behaviour under different light colour environments at different sessions**

affected by the AG. LE, W/Ls were affected by AG and the TD. Bi, Vc and Pr were affected by only the AG.

## CONCLUSION

Rearing colour of light affected bird behaviour than growth. Providing red colour light up to 21d has beneficial effects on weight gain and on other carcass parameters. Further researches are suggested to rear broilers in red light providing cheap, low cost starter rations to obtain financial benefits.

## ACKNOWLEDGMENT

DS conceived and design of the study, TSS and WWDAG participated in the design and coordination, DS and AAPM carried out the experiments, data collection and performed the statistical analysis, DS drafted the manuscript and finalized the manuscript. All authors read and approved the final manuscript.

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