Effect of Melatonin and Lighting Regime on Physiological Responses and Reproductive Traits of Layers

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Abstract

Two experiments were conducted to evaluate the effect of melatonin and lighting regime on physiological responses and reproductive traits of two strains of laying birds using 324 laying birds. Each of the experiments consisted of 162 birds. Experiment I was with Nera Black strain while experiment II was with Isa Brown strain. Each of the experiments were grouped into 9 treatments which were further subdivided into three replicates of six birds each in a 2×3 factorial in a completely randomized design. Melatonin and lighting at three levels were administered to the birds four times weekly for 30 weeks. The three levels of melatonin were 0mg, 5mg and 10mg while lighting were 12 hours, 15 hours and 18 hours daily. Melatonin was dissolved in 2mls warm water and the birds were drenched while 100 watt bulbs were used to provide lighting. Results from the physiological responses showed that rectal temperature (RT), respiratory rate (RR) and heart rate (HT) were significantly ($p < 0{:}05$) influenced by both melatonin and lighting regime in the two experiments. Melatonin at 5mg significantly ($p < 0{:}05$) reduced the RT, RR and HT with values of 41.55ºC, 142.56 and 327.11 respectively in experiment I and 40.55ºC, 139.44 and 320.22 respectively in experiment II. Performance characteristics were significantly ($p < 0{:}05$) influenced by both melatonin and lighting regime. The hen day egg production, feed conversion ratio and egg weight of 91.66 %, 1.73 and 61.52g respectively for experiment II and 84.77 %, 1.61 and 70g respectively for experiment I were recorded. The weight of the reproductive organs and the number of follicles were significantly ($p < 0{:}05$) improved by melatonin in both experiments. Large yellow follicles and small white follicles increased significantly with increasing level of melatonin in both experiments. Interaction between melatonin and lighting improved the overall performance of the birds as the groups on 5mg of melatonin and 15hrs lighting performed better than the other groups in both experiments. It is therefore concluded that 5mg melatonin and 15 hours lighting should be used to enhance physiological responses and production performances of laying birds during thermal stress.

Keywords: Follicles and Performance, Layers, Lighting, melatonin, Physiological, Reproductive

INTRODUCTION

Population growth, rising incomes and urbanization are the driving forces behind poultry sector growth. These growth are hindered by losses incurred during production process, most of which are economic losses. Economic losses are incurred by the livestock industries because farm animals are raised in locations and seasons where effective temperature conditions venture outside their zone of thermal comfort (St. Pierre *et al.,* 2003). It is pertinent to note that whenever the homeostatic mechanisms of birds are activated, extra energy is expended in the process which is no longer available for production process.

Melatonin ($C_{13}H_{16}N_2O_2$) is the main neurohormone synthesized and released by the pineal gland. Besides its ability to directly neutralize a number of free radicals and reactive oxygen and nitrogen species, it stimulates several anti-oxidative enzymes which increase its efficiency as an antioxidant (Reiter *et al*., 2000). It is one of the important hormones that prevent metabolic and physiological disorders in poultry but does not attract attention by poultry scientist (Suleyman *et al.*, 2018). It regulates the brain's biological clock, acts on physiological functions and immunity system. Melatonin helps regulate feed consumption, energy metabolism and body heat. It also provides elimination of free radicals in the body. Since lighting affect melatonin secretion and light is also necessary to enhance feeding and photoperiod which enhance egg laying, melatonin and lighting will be combined in this study to see its effect on the physiological response and reproductive performance of the laying birds.

Therefore, the present study is designed to determine the effect of oral administration of melatonin and lighting regime on physiological responses and reproductive performance of two breeds of commercial laying birds during hot dry seasons.

MATERIALS AND METHODS

The experiment was carried out at the Poultry Unit of the Teaching and Research Farm of Ebonyi State University Abakaliki, Ebonyi State Nigeria. The mean temperature was 35^{o}C during raining season and 42^{o}C during hot dry season (Ofomata, 2003).

Three hundred and twenty-four laying birds comprising one hundred and sixty two (162) Nera black (NB) and 162 Isa Brown hens were used for the experiment. They were further subdivided into three replicates of six birds each in a 2×3 factorial in a completely randomized design. The experimental materials used for the study in the two experiments were melatonin supplement and lighting regime. The melatonin was dissolved in warm water at the rate of 5mg/2mls or 10mg/2mls and administered orally by drenching them four times weekly while 100 watt bulbs were used to provide lighting to the birds in each experiment according to the treatment specifications in each group. The three levels of melatonin administered were 0mg, 5mg and 10mg while lighting groups were 12 hours, 15 hours and 18 hours daily. A standard digital clinical thermometer was used to measure the rectal temperature (RT) from 3rd week of the experiment to the end of the experiment. Three birds were randomly selected out of each treatment weekly, growth performance parameters were evaluated

RESULTS AND DISCUSSION

The results of the mean effect of melatonin on the physiological responses of Nera Black and Isa Brown laying birds are presented in table 1 and 2 respectively.

The rectal temperature and respiratory rate of layers administered different dosage of melatonin differed significantly ($p<0.05$) among the treatment groups in both experiments. The rectal temperature was significantly ($p<0.05$) higher on control groups compared to those on increased levels of melatonin which recorded lower rectal temperatures in both experiments. The reduced rectal temperature indicated that melatonin alleviated the negative impact of heat stress in both experiments. The high rectal temperature in the control groups showed that the layers were already in a stressful condition. This finding is in agreement with the report of Nalini *et al*. (2008) who stated during heat stress physiological adjustment can occur. This report is in agreement with the report of Zeman *et al*. (2001), who noted that supplementation of melatonin at a dose of 150mg/kg of food resulted in a highly significant decline in heat production of 2-week and 3-week-old chickens (8.38% and 13.05%, respectively). Report from the experiment is consistent with report of Apeldoorn *et al.* (1999) who reported that melatonin supplementation in a broiler diet reduces heat production, and more significantly, the physical activity related to heat production. The decline in heat production could be attributed to the hypothermic effect of melatonin (George, 1999). This is also in line with the report of Minka and Ojo, (2012) who observed that the mean colonic temperature value of 40.8 ± 0.2°C was recorded in melatonin-treated quails during transportation and the value was significantly ($p<0.05$) lower than that of 42.4 ± 0.7°C recorded in the control group. The respiratory rates of the laying birds were significantly influenced ($p<0.05$) by the treatment. There were drastic reductions in the respiratory rate of the layers in 5mg and 10mg of melatonin compared to those on 0mg. This indicates that melatonin maintained the thermo-neutral or comfort zone of the thermally stressed layers in both experiments. This finding is in agreement with the report of Sinkalu *et al*. (2010) who noted that broilers presented a significant increase of respiratory rate under high temperatures with values up to 165 breaths per minute.

Table 1: Mean values of the Physiological Responses of Nera Black

PARAMETERS	NBM_0	NBM_5	NBM_{10}	SEM
Rectal Temperature (ºC)	43.11^a	41.55^c	42.28^b	0.74
Respiratory Rate (bpm)	195.44^a	142.56^b	139.33^b	11.20
Heart Rate (bpm)	373.00^a	327.11^c	338.44^b	13.85

[a-c]Means in the same row with different superscripts are significantly different ($p<0.05$)

Table 2. Mean of the physiological responses of Isa Brown

PARAMETERS	ISM_0	ISM_5	ISM_{10}	SEM
Rectal Temperature (ºC)	43.56^a	40.55^c	41.52^b	0.39
Respiratory Rate (bpm)	195.22^a	139.44^c	143.00^b	1.23
Heart Rate (bpm)	337.77	320.22	334.33	8.71

[a-c] Means in the same row with different superscripts are significantly different ($p<0.05$).

The results of the interactive effect of melatonin and lighting on the physiological responses of Nera Black and Isa brown are presented in Table 3 and 4 respectively.

Increased lighting above 15 hours leads to increased RT, RR and HR, this effect was further reduced by the interactive effect of melatonin x lighting regime. The reason for this reduction could be due to the reduced activity brought about by melatonin at higher dosage. Melatonin being an antioxidant interacted with the light that increased the production of carbon dioxide ($C0_2$) leading to increased respiratory rate and heart rate which resulted to respiratory alkalosis due to increased panting rate. Melatonin on the other hand had a lowering effect on RT, RR and HT. The interaction brought about moderate reduction on the above parameters which resulted to stability on the physiological response of the birds in distress. This report is in agreement with the report of Apeldoorn *et al*. (1999) who observed a distinct peak in the body temperature of broilers under continuous lighting but reduced by interactive effect of melatonin.

Main of Melatonin on Performance Evaluation of Nera Black and Isa Brown is presented in table 5 and 6 respectively

Results from the two experiments indicates that significant differences ($p<0.05$) were observed in the finial body weight gain, hen day egg production, Ovary and oviduct weight, feed conversion ratio and mortality in both experiments. This result shows that melatonin improved the hen day production compared to the control group. The mortality rate was significantly influenced by melatonin administration. Mortality rate was significantly higher in the control compared to the melatonin treated group. It was observed that Nera Black layers had higher egg weight, body weight and ovary weight compared to Isa Brown laying birds. Results from this study suggest that melatonin improved the feed efficiency which led to increased weight and hen day egg production in both experiments. This report collaborated the findings of Osei *et al.* (1989) who stated that melatonin administration increased weight gain, hen day egg production and energy retention by an average of 19% in male broiler chickens

Interactive Effect of Melatonin and Lighting Regime on Nera Black and Isa Brown is presented in table 7 and 8 respectively.

Result from this study indicates that the interactive effect of melatonin and lighting increased the body weight ovary weight, oviduct weight and follicles, hen day egg production and feed conversion ratio of the birds in both experiments. The increased number of small yellow follicles and white yellow follicles could be as a result of anti-oxidative effect of melatonin. This antioxidant property of melatonin resulted in increasing the development and growth of these follicles as thermal stress was reduced from the birds.

Table 5: Main Effect of Melatonin on Performance of Nera Black

Parameters	**NBL_{12}**	**NBL_{15}**	**NBL_{18}**	**SEM**
IBWT (kg)	1.20	1.12	1.10	0.03
BWTG (kg)	0.50^{b}	0.60^{a}	0.56^{b}	0.20
FBWT (kg)	1.65^{b}	1.74^{a}	1.73^{a}	0.40
Egg weight (g)	60.78^{b}	70.00^{a}	68.98^{a}	1.95
Ovarywt (g)	42.53^{b}	47.05^{a}	48.27^{a}	1.54
Oviduct wt (g)	56.11	58.03	54.65	0.62
LYF	5.55^{b}	7.30^{a}	7.95^{a}	0.60
SWF	6.35^{b}	8.44^{a}	8.30^{a}	1.53
HDEP (%)	69.33^{c}	76.22^{a}	72.22^{b}	3.99
FCR	1.61^{b}	1.60^{b}	1.68^{a}	0.10
MORTALITY	0.77	0.77	0.88	0.01

$^{a-c}$Means in the same row with different superscripts are significantly different ($p<0.05$)

Table 6: Main of Melatonin on Performance Evaluation of Isa Brown

Parameters	**ISM_0**	**ISM_5**	**ISM_{10}**	SEM
IBWT (kg)	0.95	0.94	0.95	0.07
BWTG (kg)	0.35^{b}	0.37^{ab}	0.38^{a}	0.01
FBWT (kg)	1.30^{b}	1.32^{ab}	1.35^{a}	0.01
Egg weight (g)	59.21^{b}	59.8^{b}	61.52^{a}	0.89
Ovwt (g)	44.22^{bc}	46.63^{b}	48.20^{a}	1.15
Oviwt (g)	54.40^{b}	61.59^{a}	64.18^{a}	2.92
LYF(mm)	5.55^{b}	8.30^{a}	8.11^{a}	4.60
SWF(mm)	6.35^{c}	7.84^{b}	8.50^{b}	2.03
HDEP (%)	79.11^{c}	86.33^{b}	91.66^{a}	3.63
FCR	1.78^{a}	1.79^{a}	1.73^{c}	0.02
MORTALITY	2.00^{a}	0.55^{b}	0.33^{b}	0.52

$^{a-c}$ Means in the same row with different superscripts are significantly different ($p<0.05$)
IBWT= Initial body weight, BWTG = Body weight gain, FBWT = Finial body weight gain
DFI = daily feed intake, TFI, = Total Feed Intake, FCR = Feed Conversion Ratio, HDEP = Hen Day Egg Production

Table 7: Main Interactive Effect of Melatonin and Light on the Performance of Nera Black

Parameter	M_0L_{12}	M_0L_{15}	M_0L_{18}	M_5L_{12}	M_5L_{15}	M_5L_{18}	$M_{10}L_{12}$	$M_{10}L_{15}$	$M_{10}L_{18}$	SEM
IBWT (kg)	1.16	1.26	1.16	1.13	1.13	1.12	1.06	1.20	1.13	0.04
BWTG (kg)	0.41^{b}	0.58^{ab}	0.38^{ab}	0.34^{b}	0.39^{ab}	0.39^{ab}	0.34^{b}	0.39^{ab}	0.42^{a}	0.09
FBWT (kg)	1.63^{b}	1.73^{ab}	1.73^{ab}	1.66^{ab}	1.76^{a}	1.73^{ab}	1.67^{ab}	1.78^{a}	1.73^{ab}	0.62
EWT (g)	62.83^{de}	66.90^{cd}	66.93^{e}	64.13^{bcd}	67.90^{b}	67.33^{bc}	69.43.^{b}	70.90^{a}	70.20^{bc}	3.17
OVAWT(g)	45.76^{b}	46.10^{b}	44.73^{c}	47.00^{a}	47.20^{a}	46.96^{a}	47.03^{a}	47.96^{a}	46.83^{a}	0.78
OVDWT(g)	55.76^{d}	55.83^{d}	55.73^{d}	57.00^{c}	57.43^{c}	59.66^{bc}	61.53^{ab}	63.23^{a}	60.2^{b}	1.70
LYF (mm)	5.00^{e}	7.00^{e}	7.00^{e}	5.66^{de}	8.00^{bc}	7.66^{cd}	8.66^{ab}	9.00^{a}	8.96^{a}	0.21
SWF (mm)	6.33^{ed}	7.13^{c}	7.80^{c}	6.10^{d}	8.66^{ab}	7.95^{ab}	8.00^{bc}	9.66^{a}	7.33^{bc}	1.57
HDEP (%)	77.33^{c}	79.33^{c}	78.33^{c}	82.00^{bc}	96.00^{a}	86.20^{b}	78.66^{c}	89.33^{a}	86.70^{b}	3.70
FCR	1.6^{bcd}	1.64^{bcd}	1.73^{a}	1.61^{cde}	1.63^{bcd}	1.65^{bc}	1.59^{d}	1.57^{e}	1.67^{b}	0.02
MORT	1.00^{ab}	1.33^{a}	1.66^{a}	1.00^{ab}	0.33^{ab}	0.33^{b}	0.33^{b}	0.00^{c}	0.66^{ab}	0.20

$^{\mathbf{a\text{-}e}}$Means in the same row with different superscripts are significantly different ($p<0.05$).

Table 8: Main Interactive Effect of Melatonin and Lighting Regime on Isa Brown

Parameters	M_0L_{12}	M_0L_{15}	M_0L_{18}	M_5L_{12}	M_5L_{15}	M_5L_{18}	$M_{10}L_{12}$	$M_{10}L_{15}$	$M_{10}L_{18}$	SEM
IBWT (kg)	0.95	0.97	0.93	0.94	0.93	0.92	0.96	9.94	0.96	0.05
BWTG (kg)	0.33^{b}	0.34^{b}	0.38^{ab}	0.34^{b}	0.39^{ab}	0.39^{ab}	0.34^{b}	0.39^{ab}	0.42^{a}	0.03
FBWT (kg)	1.28^{d}	1.31^{bcd}	1.31^{bcd}	1.29^{cd}	1.32^{bcd}	1.35^{abc}	1.30^{bcd}	1.36^{ab}	1.39^{a}	0.02
EWT (g)	59.16^{c}	58.66^{e}	59.43d^{c}	59.40^{cd}	60.56^{bc}	61.36^{ab}	61.36^{ab}	62.26^{a}	60.93^{bc}	0.70
OVAWT(g)	40.76^{c}	42.10^{bc}	40.73^{c}	43.00^{b}	45.20^{ab}	46.20^{a}	46.95^{a}	47.20^{a}	46.83^{a}	1.98
OVDWT(g)	55.76^{d}	55.83^{d}	56.73^{d}	57.00^{c}	57.43^{c}	59.66^{bc}	61.53^{ab}	63.23^{a}	60.2^{b}	2.70
LYF(mm)	6.00^{d}	8.00^{c}	8.00^{c}	8.66^{c}	8.95^{c}	10.60^{b}	10.76^{b}	12.00^{a}	10.86^{b}	2.40
SWF(mm)	7.33^{de}	7.30^{de}	6.00^{e}	7.70^{cd}	8.66^{ab}	8.00^{b}	8.83^{ab}	9.66^{a}	8.33^{ab}	0.71
HDEP (%)	78.00^{d}	80.00^{cd}	79.33^{cd}	83.33^{bc}	90.00^{a}	85.33^{bc}	91.00^{a}	94.00^{a}	90.00^{a}	3.27
FCR	1.73^{d}	1.80^{cd}	1.82^{ab}	1.73^{bc}	1.78^{a}	1.87^{a}	1.68^{d}	1.72^{cd}	1.80^{b}	0.29
MORT	1.66^{ab}	2.00^{ab}	2.33^{a}	1.00^{bc}	0.66^{cd}	0.00^{d}	0.33^{d}	0.00^{d}	0.66^{cd}	0.46

$^{\mathbf{a\text{-}d}}$Means in the same row with different superscripts are significantly different ($p<0.05$)

IBWT= Initial body weight, BWTG = Body weight gain, FBWT = final body weight gain, OVIWT= Ovary weight, OVIWT= Oviduct weight, LYF= Large yellow follicle, SWF= Small Yellow Follicle, FCR = Feed Conversion Ratio, HDEP = Hen Day Egg Production

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