

The Effect of Different Photoperiods and Stocking Densities on Fattening Performance, Carcass and Some Stress Parameters in Broilers

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ABSTRACT

This study was carried out for the purpose of investigating the effects of different photoperiods and stocking densities on physiologic parameters such as body weight, feed consumption, feed efficiency, carcass traits and some stress parameters in broiler chickens. Throughout the experiment, 480 day-old male chickens obtained from a commercial hatchery were used. The chicks were placed in different partitions which had three different photoperiod (continuous lighting: 24 hour light, constant lighting: 16 hour light - 8 hour dark, intermittent lighting: 4 hour light - 2 hour dark) were applied. Each photoperiod group was formed with five replicates at two different stocking densities (normal stocking density: 12 broiler/m², high stocking density: 20 broiler/m²). The experiment was carried for 42 days. At the end of the experiment, the effect of photoperiod and stocking density on live weight gain were significant ($P < 0.05$) while photoperiod significantly affected the feed consumption only ($P < 0.05$). The feed efficiency were insignificant ($P > 0.05$) with respect to both factors. The photoperiod programs had significant effects on the relative weight of gizzard, blood, feather percentage values ($P < 0.05$) and breast percentage values ($P < 0.01$). The stocking density has a significant effect on relative heart weight ($P < 0.05$) and entire thigh values ($P < 0.01$). At the end of the experiment, it was ascertained that the photoperiod program and stocking density had no significant ($P > 0.05$) difference on tonic immobility and tibial dyschondroplasia values. However, stocking density had a highly significant effect ($P < 0.01$) on gait score values and on heterophil-lymphocyte rate values ($P < 0.01$).

Keywords: Broiler; Performance; Carcass Traits; Stress; Leg health.

INTRODUCTION

High stocking densities and long lighting periods are two major environmental factors common to broiler production (1). The control of these factors at an optimum level not only increases commercial profitability, but also contributes to securing the supply of the human population with adequate food and animal protein. When determining stocking density, producers should take multiple factors into consideration, which include among others, the size of the broiler chickens, the area occupied by feeders and drinkers, the area of the pen the animals are raised in, animal welfare standards, animal

nutrition, fattening performance and economic return (2). Despite its negative impact on the individual performance of bird's high stocking density remains a primary preference of broiler producers and is still considered appealing in terms of profitability (3, 4). Although no consensus has been reached on the optimum stocking density, research conducted to date suggests a maximum body weight of 30 kg per square meter (5). It is known that as the stocking density increases the fattening performance varies, yet, previous studies have reported variable findings on the direction and strength of such effects (6). To exemplify, while some researchers have reported that

high stocking density is associated with decreased final body weight (3, 7), others have indicated no change in body weight (8, 9).

A second major factor influencing the fattening performance of broiler chickens is the lighting period (10). The lighting period is adjusted according to the age and growth conditions of the animals. During production, it is foreseen that broiler chickens are exposed to a daily dark period of at least 4 hours, however, during the growth period and the rest period the animals needs may exceed this time length (11). The results are contradictory for various parameters affected by photoperiod. For example, reports (12) indicate that continuous lighting is associated with increased feed consumption and some others point out to no difference (13) or decrease (14) being observed in feed consumption. Some studies reported reduced feed conversion (12, 14) and others suggested no change in feed conversion rates when such lighting programs are applied (15). These effects need to be clarified with further research.

For these reasons, this study was carried out for the purpose of investigating the effects of different photoperiods and stocking densities on physiologic and some stress parameters in broiler chickens.

MATERIAL AND METHODS

Birds and husbandry

The Research Animal Ethic Committee of Atatürk University permitted the performance of this experiment. The present study was conducted at the poultry unit of the Research Farm of Atatürk University, Faculty of Veterinary Medicine. Four hundred and eighty day-old male Ross-308 broiler chicks constituted the material of the study. The animals included in the experimental groups were given feed and water *ad libitum*, and the broiler chick ration (Bayramoğlu Yem, Erzurum, Turkey) given between weeks 0-3 contained 24% of crude protein and 3075 kcal/metabolic energy/kg, while the broiler chicken ration given between weeks 3-6 contained 20% of crude protein and 3200 kcal/ metabolic energy /kg.

Experimental design

In three different experiment windowless rooms, lighted only by fluorescent lights, from day 7, the chicks were randomly allocated to 1.0 x 1.0 meter pens, the floor of which was covered with 10 cm layer of wood shavings, such that five

replicates of the two different stocking densities given below were applied in each room with a number of 10 chambers per room and a total of 30 chambers. Mechanical ventilation was performed. The average pen temperature was $32 \pm 1^\circ\text{C}$ in the first week and was then gradually lowered to an average of $24 \pm 2^\circ\text{C}$.

Study design

The stocking densities applied were as follows:

- a) Normal stocking density (NSD): 12 broilers/m²
- b) High stocking density (HSD): 20 broilers/m²

The animals were assigned to 24 hours of continuous lighting in Room 1 (CSL), a constant lighting schedule of 16 hours of light and 8 hours of dark in Room 2 (CTL), and an intermittent lighting schedule based on a 4-time repeated daily exposure to 4 hours of light and 2 hours of dark in Room 3 (IL).

Calculation of the performance values

The chickens were weighed in all groups on days 7, 14, 21, 28 and 35 of the experiment for the calculation of mean body weights and daily, weekly and cumulative body weight gains. The weekly feed consumption of the groups was determined by subtracting the amount of feed remaining in the feeders of each group on days 14, 21, 28, 35 and 42 from the total amount of feed provided to each group per week. Weekly and cumulative feed conversion rates were calculated by dividing feed consumption by body weight gain.

Mortalities were recorded on a daily basis. Percentile survival was calculated by dividing the number of surviving birds by the total number of birds included in the experimental group. Variation coefficients related to uniformity was assessed by individually weighing each chicken on day 42 of the experiment; the standard deviation was divided into the mean body weights of the experimental groups.

Determination of the carcass traits

At the end of the experiment, 2 chickens from each group and in total 60 broiler chickens were slaughtered and cut into carcass parts as described by Aksu and Imik (16) and were weighed. The carcass parts and viscera were proportioned to the carcass weight for the calculation of carcass yield and percentages. The broiler chickens selected for slaughter were fasted for 8 h prior to slaughter to ensure that their digestive tract was emptied. Subsequently the birds were eviscerated

manually, washed and allowed to drain for 10 min (17). After evisceration, carcasses were stored at 3 ± 0.5 °C for 24 h. The carcasses were dissected as described by Barbut (18).

Determination of tonic immobility (TI)

On day 40, the chickens were caught avoiding any harm and were transferred to a silent room, where they were restrained on their back in a cradle like U-shaped apparatus to determine tonic immobility (TI) periods as described by Jones and Faure (19).

Determination of gait score (GS)

With an aim to determine the gait score (GS), on day 41 of the experiment, each chicken was taken out of its cage and allowed to walk alone along the passageway for observation. Those reluctant to move were gently prodded. Scoring was made from “0” to “5” as described by Kestin *et al.*, (20). “0” indicates walking smoothly while “5” shows the inability to walk at all.

Determination of tibial dyschondroplasia (TD)

At the end of the experiment, two chickens from each subgroup were sacrificed and in each of these birds the longitudinal section of the left tibial bone extending to the epiphysis was assessed for tibial dyschondroplasia (TD) (21). The measurement of the lesions was performed using a millimeter calliper. The severity of TD was scored as “0” in the case of the non-existence of lesions, “1” in cases where the size of the area of the lesion extending distally was smaller than 0.5 cm; “2” when the size of this area ranged from 0.5 to 1 cm and “3” when this area was larger than 1 cm.

Determination of the heterophil/lymphocyte ratio

With an aim to determine the heterophil to lymphocyte ratio (H/L) blood smears were prepared from blood samples taken from the wing vein (vena cut-in ulnaris) of the chickens on day 39 of the experiment. After fixation in methyl alcohol, these blood smears were stained with Giemsa and observed under an immersion objective for the counting of 100 leukocytes, using a light microscope at $\times 1,000$ magnification.

Statistical analysis

The experiment was arranged in a complete randomized design. Two-way ANOVA was employed using the GLM procedure and differences among experimental groups for

the performance parameters as well as carcass parameters were evaluated by Duncan’s multiple comparison test (SPSS for Windows Release 10.01, SPSS Inc., 1996).

A two-way ANOVA was used to determine the interactions between lighting programs and stocking density with respect to the studied parameters. Differences among the experimental groups for survival rate, tibial dyschondroplasia and gait score were assessed by means of the Kruskal-Wallis test. Significance was considered at a probability of less than or equal to 0.05. The linear model used to test the effects of experimental groups on parameters were as follows:

$$Y_{ijk} = m + L_i + SD_j + (L \cdot SD)_{ij} + e_{ijk}$$

Where, Y_{ijk} = response variable, m = population mean, L_i = lighting program (CSL, CTL, IL), SD_j = stocking density (NSD, HSD), $(L \cdot SD)_{ij}$ = interactions between lighting programs and stocking density, e_{ijk} = experimental error.

RESULTS

Performance

The mean body weights (BW) measured (Figure 1) in the last week of the experiment in groups CSL, CTL and IL were 2469.45 ± 24.5 g, 2384.25 ± 24.5 g and 2399.30 ± 24.5 g, respectively, and it was ascertained that the mean of the final body weight of group CSL was significantly higher than that of groups CTL and IL ($P < 0.05$). Groups CTL and IL did not display any significant difference from each other ($P > 0.05$). When assessed for body weight, group CSL displayed significantly higher values at weeks 2, 3, 4, and 5 compared to the other experimental groups ($P < 0.01$). The comparison of groups CTL and IL demonstrated that at week 2 group IL exhibited values greater than that of group CTL, and during the remaining experimental period, no significant difference existed between the two groups ($P > 0.05$).

Assessment for the body weights associated with stocking density revealed that the mean body weight of the group raised under normal stocking density was significantly higher on day 42 ($P < 0.05$) and more significantly higher on day 21 of the experiment ($P < 0.01$). During the other weeks, stocking density was not observed to have any significant effect on the body weight of the birds.

Assessment of the interaction between lighting period and stocking density revealed the presence of a statistically significant difference to have occurred in only the body weight values measured at week 3 ($P > 0.05$).

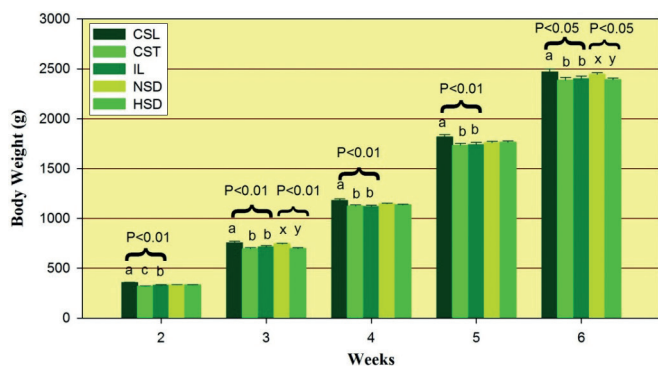


Figure 1: Body weights (g) of the experimental groups. a, b, c showed statistically differences in groups of lighting period treatments (P value are 0.005, 0.008, 0.004, 0.008, 0.043 in week 2, 3, 4, 5, 6 respectively) and x, y showed difference in stocking density groups (P value are 0.004, 0.032 in week 2, 6 respectively).

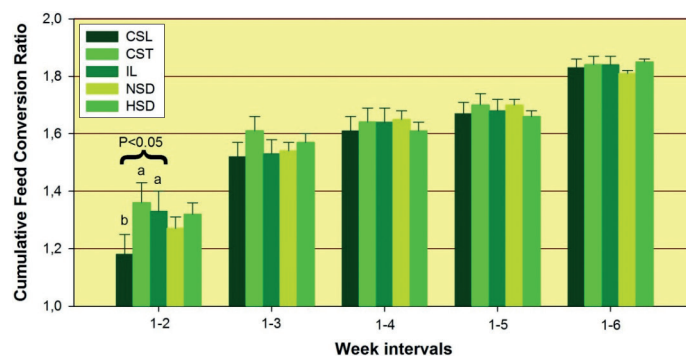


Figure 3: Cumulative feed conversion ratio in the experimental groups. a, b, c shows statistically difference in groups of lighting period treatments (P value is 0.023 in week 1-2) and x,y shows difference in stocking density groups.

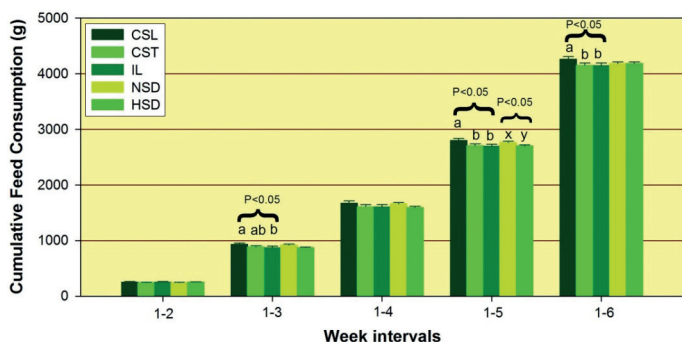


Figure 2: Cumulative food consumption of the experimental groups. a, b, c shows statistically difference in groups of lighting period treatments (P value are 0.035, 0.028, 0.039 in week 1-3, 1- 5 and 1-6 respectively) and x,y shows difference in stocking density groups (P value is 0.041 in week 1-6).

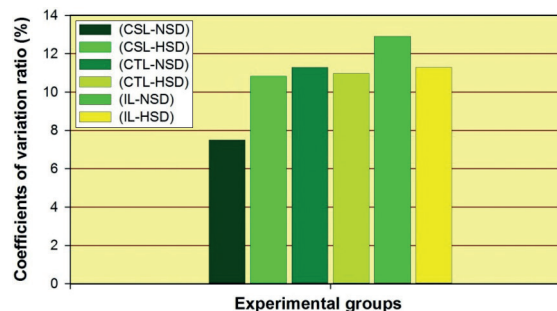


Figure 4: Coefficients of variation ratio relating to body weight in the experimental groups (%).

Based on the measurements performed on days 21, 35 and 42 of the experiment, it was determined that the feed consumption (FC) of group CL was significantly higher than that of the other two groups ($P < 0.05$) (Figure 2). When assessed for stocking density, it was ascertained that the FC of group NSD was significantly higher on days 21 and 35 ($P < 0.05$). The effect of the lighting period on feed conversion rates (FCR) was observed on day 14 (Figure 3), while the impact of interaction between stocking density and photoperiod was only observed on day 21 ($P < 0.05$). Stocking density had no effect on FCR.

The survival rate values in the experimental groups CSL, CTL and IL were 97.50%, 97.85 and 95.85, respectively. It was demonstrated that the effects of lighting period and stocking density on survival rates were statistically insignificant ($P > 0.05$).

Coefficients of variation values relating to body weight in the experimental groups are presented in Figure 4. The maximum variation was calculated in IL-NSD group while the least variation was in CSL-NSD group.

Carcass traits

The carcass traits of the birds are shown in Tables 1 and Table 2. At the end of the experiment, significant differences were observed among the different lighting schedule groups for gizzard, blood and feather percentages ($P < 0.05$) and higher significant differences were observed for whole breast percentages ($P < 0.01$). The percentage of the relative heart weight differed significantly ($P < 0.05$) and the percentage of entire relative thigh weight also differed significantly at a higher rate with stocking density ($P < 0.01$). The interaction between the lighting period and stocking density had a significant effect on the percentages of the gizzard and heart relative weights ($P < 0.05$) and significant effect on the percentages of the head and neck relative weights ($P < 0.01$).

Table 1: The mean and standard error of means of the neck, blood, head, feather, foot and relative organ weights (%BW).

L	SD	Neck	Blood	Head	Feather	Tail	Gizzard	Liver	Heart
CSL	NSD	5.77±0.02	4.34±0.12	2.52±0.05	5.52±0.11	1.10±1.18	2.14±0.17	1.30±0.05	0.55±0.02
	HSD	4.93±0.02	4.05±0.12	2.78±0.05	5.28±0.11	1.18±1.18	1.98±0.17	1.90±0.05	0.72±0.02
CTL	NSD	5.39±0.02	3.55±0.12	2.72±0.05	4.83±0.11	1.18±1.18	2.23±0.17	1.96±0.05	0.62±0.02
	HSD	5.84±0.02	3.58±0.12	2.72±0.05	4.79±0.11	1.42±1.18	2.37±0.17	1.95±0.05	0.57±0.02
IL	NSD	5.58±0.02	3.78±0.12	2.69±0.05	5.08±0.11	1.39±1.18	2.46±0.17	1.84±0.05	0.63±0.02
	HSD	5.70±0.02	3.89±0.12	2.47±0.05	5.16±0.11	1.15±1.18	2.08±0.17	1.97±0.05	0.71±0.02
CSL		5.35±0.02	4.19 ^a ±0.90	2.65±0.05	5.40 ^a ±0.15	1.14±1.20	2.06 ^b ±0.09	1.84±0.06	0.63±0.02
CTL		5.62±0.02	3.57 ^b ±0.90	2.72±0.05	4.81 ^b ±0.15	1.30±1.20	2.30 ^a ±0.09	1.96±0.06	0.60±0.02
IL		5.64±0.02	3.83 ^b ±0.90	2.58±0.05	5.12 ^{ab} ±0.15	1.27±1.20	2.27 ^a ±0.09	1.91±0.06	0.67±0.02
NSD		5.58±0.02	3.89±0.02	2.64±0.04	5.15±0.25	1.22±1.23	2.28±0.07	1.86±0.02	0.60±0.03
HSD		5.49±0.02	3.84±0.02	2.66±0.04	5.08±0.25	1.25±1.23	2.14±0.07	1.94±0.02	0.67±0.03
L		NS	*	NS	*	NS	*	NS	NS
SD		NS	NS	NS	NS	NS	NS	NS	*
LxSD		**	NS	**	NS	NS	*	NS	*

L: Lighting programs; SD: Stocking density; CSL: Continuous lighting; CTL: Constant lighting; IL: Intermittent lighting; NSD: Normal stocking density; HSD: High stocking density; NS: Not significant; L x SD: Interactions between lighting programs and stocking density; BW: Body weight; *: P<0.05; **: P<0.01; a, b: Differences between the means with different letters in same columns are significant.

Tonic immobility

Mean TI periods of the groups are given in Figures 5. The effects of lighting period and stocking density alone and the interaction of lighting period and stocking density on the differences observed between the experimental groups for TI values were found to be statistically insignificant (P>0.05).

Tibial dyschondroplasia

The TD scores determined for the groups after the sacrifice of animals are presented in Figure 5. According to these results, the experimental groups did not differ from each other for TD.

Gait score

The GS of the experimental groups included in the present study are given in Figure 5. Based on the gait scores, it was determined that gait score were observed at a higher rate in the group subjected to CSL, when compared to the other two experimental groups.

Heterophil/lymphocyte ratio

The mean blood cell counts determined in the experimental groups are shown in Table 3. According to the results obtained, H/L ratios were affected by the lighting period and stocking density. The H/L ratio was significantly higher in the group exposed to CSL, compared to the other two groups (P<0.01).

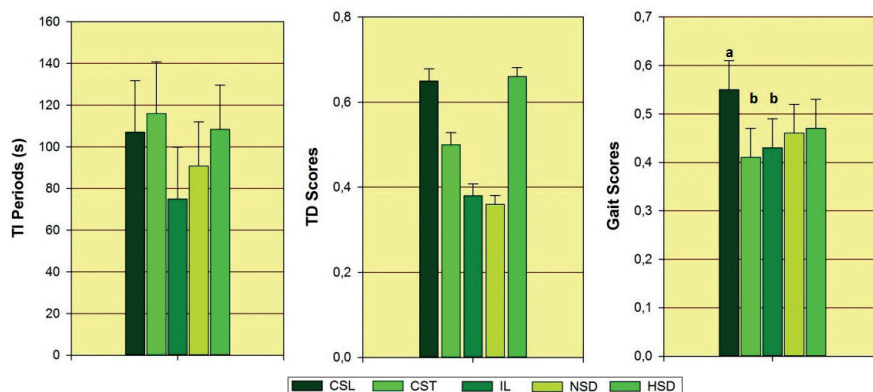


Figure 5: Tonic immobility, tibial dyschondroplasia and gait score values in the experimental groups (P value denoting variation in gait score is 0.025).

Table 2: The mean and standard error of means of the carcass traits (%).

L	SD	Hot Carcass Yield (%BW)	Cold Carcass Yield (%BW)	Breast (%CC)	Thigh (%CC)	Wings (%CC)
CSL	NSD	73.57±1.33	72.88±1.27	45.04±1.13	39.48±2.50	11.15±0.26
	HSD	74.55±1.33	74.02±1.27	44.48±1.13	41.17±2.50	11.34±0.26
CTL	NSD	74.89±1.33	74.04±1.27	43.09±1.13	39.16±2.50	11.29±0.26
	HSD	74.14±1.33	73.31±1.27	41.72±1.13	41.03±2.50	11.57±0.26
IL	NSD	74.72±1.33	74.09±1.27	42.56±1.13	39.07±2.50	11.88±0.26
	HSD	74.50±1.33	73.80±1.27	42.68±1.13	40.76±2.50	11.69±0.26
CSL		74.06±1.30	73.45±1.24	44.76 ^a ±1.12	40.33±2.45	11.25±0.23
CTL		74.52±1.30	73.67±1.24	42.41 ^b ±1.12	40.10±2.45	11.43±0.23
IL		74.61±1.30	73.95±1.24	42.62 ^b ±1.12	39.91±2.45	11.78±0.23
NSD		74.39±2.32	73.67±3.23	43.56±2.10	39.24±0.34	11.44±2.21
HSD		74.40±2.32	73.71±3.23	42.96±2.10	40.99±0.34	11.53±2.21
P<						
L		NS	NS	**	NS	NS
SD		NS	NS	NS	**	NS
LxSD		NS	NS	NS	NS	NS

L: Lighting programs; SD: Stocking density; CSL: Continuous lighting; CTL: Constant lighting; IL: Intermittent lighting; NSD: Normal stocking density; HSD: High stocking density; NS: No significant; L x SD: Interactions between lighting programs and stocking density; BW: Body weight; CC: Cold carcass; *: P<0.05; **: P<0.01; a, b: Differences between the means with different letters in same columns are important.

DISCUSSION

Performance

In the group exposed to CSL, high body weights were observed at the end of the experiment resulting from the animals having had free access to feed and water due to lack of daylight restriction. Findings previously reported by many researchers are in agreement with these results (15, 22). However, some studies have reported that CSL does not have any effect on final body weight (15, 23). It was observed that until the age of 14 days, exposure to an IL schedule resulted in a greater body weight gain compared to that induced by a CTL schedule. However, later, the preference of any of these lighting schedules would not make any difference in terms of body weight gain. Similarly, Ozkan *et al.*, (23) have indicated that the exposure of broiler chickens to a CTL in the early growth period led to decreased body weight as a result of a shortened lighting period.

According to these results, if we look with respect of weight gain, CSL appears more appropriate. The decreases observed in the body weights of the chickens raised at a high stocking density during the last week of the experiment suggested that the tolerable level of body weight per square meter was exceeded at the end of the 5th week with negative impact on fattening performance. By the 5th week, which was determined to be the breaking point of the ex-

periment, the body weights of the groups exposed to NSD and HSD were ascertained as 21.12 kg/m² and 36.14 kg/m², respectively.

Based on these results, it may be suggested that the maximum body weight per unit of area should be 36.14 kg/m². Other studies are available, which also suggest that high stocking density decreases body weight (3, 7). Similar to the present study, in an investigation conducted by Hassanein (24), the negative effect of increased stocking density at weeks 3 and 6 on body weight was found to be statistically significant.

In contrast to the findings obtained in the present study, Onbasilar *et al.*, (25) have reported that the effect of the interaction between lighting period and stocking density on the body weight of broiler chickens at weeks 3 and 6 was statistically insignificant (P>0.05).

The present study demonstrated that neither stocking density nor lighting period affected feed conversion, but in the case of exposure to CSL, higher body weights were observed as a result of increased feed consumption. Apart from studies suggesting that exposure to CSL does not alter feed conversion rates (15), there are also studies reporting feed conversion rates to be slightly affected with CSL (14, 15). Studies are also available, which in agreement with this experiment, indicate that neither feed consumption nor feed conversion rates were affected by stocking density (26, 27).

Table 3: Mean values and standard error of means of leucocytes of the experimental groups

L	SD	Heterophile	Lymphocyte	Eosinophile	Monocyte	Basophile	H/L Ratio
CSL	NSD	39.33±2.42	42.13±2.35	4.93±1.24	2.32±0.65	4.61±0.83	0.92±0.10
	HSD	41.12±2.42	39.55±2.35	4.52±1.24	1.62±0.65	5.73±0.83	1.05±0.10
CTL	NSD	22.82±2.42	54.60±2.35	8.42±1.24	2.73±0.65	7.21±0.83	0.43±0.10
	HSD	30.70±2.42	51.70±2.35	8.10±1.24	4.54±0.65	6.82±0.83	0.51±0.10
IL	NSD	27.11±2.42	55.32±2.35	7.70±1.24	3.81±0.65	5.11±0.83	0.42±0.10
	HSD	33.23±2.42	50.12±2.35	5.82±1.24	4.02±0.65	4.74±0.83	0.63±0.10
NSD		29.71±1.31	50.61±1.35	7.00±0.73	2.93±0.31	5.64±0.42	0.62±0.12
HSD		35.02±1.31	47.13±1.35	6.13±0.73	3.32±0.31	5.72±0.42	0.75±0.12
CSL		40.22±2.43	40.81 ^b ±2.32	4.70 ^b ±1.21	1.90 ^b ±0.60	5.11 ^b ±0.80	1.01 ^a ±0.11
CTL		26.71 ^b ±2.43	53.12 ^a ±2.32	8.21 ^a ±1.21	3.62 ^a ±0.60	7.01 ^a ±0.80	0.51 ^b ±0.11
IL		30.11 ^b ±2.43	52.71 ^a ±2.32	6.71 ^{ab} ±1.21	3.91 ^a ±0.60	4.91 ^b ±0.80	0.52 ^b ±0.11
P<							
SD		*	**	NS	NS	NS	**
L		**	**	*	**	*	**
SDxL		NS	NS	NS	NS	NS	NS

L: Lighting programs; SD: Stocking Density; CSL: Continuous lighting; CTL: Constant lighting; IL: Intermittent lighting; NSD: Normal stocking density; HSD: High stocking density; NS: No significant; SD x L: Interactions between Lighting programs and stocking density; *, P<0.05; **, P<0.01 a, b: Differences between the means with different letters in same columns are important.

Another literature report claimed that feed consumption decreases and feed conversion improves with increased stocking density (28). According to our results, it could be concluded that feed efficiency, an economically important trait is not important in deciding on the stocking density in the presence of sufficient feed.

It was ascertained that the lighting schedule and stocking density had no impact on the mortality of the broilers. The highest uniformity on end experimental body weights was observed in the CSL-NSD group, while values pertaining to the other groups were observed to be close to each other. Feddes *et al.*, (29) determined the body weight variation coefficients of broiler groups housed at different stocking densities (11.9, 14.3, 17.9, 23.8, broilers/m²) as 15.3, 13.4, 13.6, and 13.0, respectively. It was observed that, as stocking density increased variation decreased. These numbers are higher than our results. Furthermore, Classen (30) reported that lighting period did not affect uniformity. According to our results of uniformity of CSL-NSD may be preferred.

Carcass traits

In terms of carcass traits, it was determined that hot and cold carcass yields were not influenced by the treatments investigated, whilst the weight of the whole breast, as one of the carcass parts of major interest, was affected by the lighting

period and the entire thigh weight was affected by stocking density. Some researchers (14, 31) compared group CSL with group IL (1-h light:3-h dark), observed no statistically significant difference between the groups for heart and gizzard weights. These results, excluding that for the gizzard, are in agreement with the findings obtained in the present study.

Onbasilar *et al.*, (26) found that, hot and cold carcass yields and thigh, breast and tail weights were not affected by stocking density, as also observed in the present study. Jayalakshmi *et al.*, (33) reported that while stocking density had an effect on hot carcass yield (P<0.01), differing from our results, it had no effect on breast, tail, drumstick and thigh weights. However, Dozier *et al.*, (7) reported that stocking density from 30 kg bw/m² to 45 kg bw/m² had no effect on cold carcass yield. This result is in agreement with that obtained in this study.

Altanet *et al.*, (34) have proposed that the lighting period does not induce any alteration in hot carcass yield or breast muscle weight. This result is in agreement with ours except for hot carcass yield. Furthermore, Onbasilar *et al.*, (14) upon comparing CSL with IL (1-h light:3-h dark) observed no difference in hot and cold carcass yields or breast, tail and thigh weights. Excluding those for thigh weight, these findings are in support of the results obtained in the present study. As seen, there numerous different findings on this issue and

therefore these parameters may have to be examined by other means. We are reporting that there is a significant effect on breast ratio for stocking density and thigh ratio for lighting period and no effects on hot and cold carcass yield for both treatments.

Tonic immobility

The length of the TI period was observed not to have been affected by either treatments. Researchers, including Ozkan *et al.*, (23), Stub and Vestegaard (34) compared the CSL group with the CTL group exposed to 16 h of light and 8 h of dark and determined that no statistically significant difference existed between these groups for the length of the TI period, thus similar to our results.

However, contradictory to the present study, there are researches in which CSL has been reported to increase the length of the TI period (15, 35, 36) and contrary to the findings obtained in this study. Previous studies suggest that increased stocking density can increase the length of the TI period (15, 37). However, comparable to our results, Skomorucha *et al.*, (38) stated that stocking density has no effects on TI in broilers. These different results may be due to the effects of different practitioners as the TI duration can be affected by numerous external and internal factors in chickens.

Tibial dyschondroplasia

In the present study, it was determined that no significant difference was observed for the incidence of TD between either the different lighting period groups or the different stocking density groups. In agreement with the findings of the present study, Onbasilar *et al.*, (15) reported that the incidence of TD did not vary with the lighting period.

Gait score

It was ascertained that while the GS was affected by the lighting period ($P < 0.01$), it was not influenced by the stocking density. There are other studies, which similar to this research indicate that stocking density has no effect on GS (39, 40, 41). On the other hand, there are other studies that report GS to worsen with increased stocking density (3, 42, 43). Physiological and anatomical changes that occur in the organism can be interpreted if multiple factors are taken into consideration and not only one factor is focused on. Today, it is well known that gait disorders develop as a result of the effect of multiple factors (44). In the present study, the most

severe leg disorders having been observed in the group that was exposed to CSL was attributed to the rapidly increasing body weights of the animals included in this group. Although a study is available, which suggest that CSL decreases gait disorders (45), there are also other studies, which are in agreement with the present study and indicate that CSL increases gait disorders (23, 42). The extremely rapid weight gain is undesirable causing the metabolic and morphological abnormalities. In brief, CSL is not appropriate in terms of leg health.

Heterophil/lymphocyte ratio

H/L ratios are a reliable marker indicating the presence of stress in poultry. High value indicates the presence of more stress than low values. In this study, the H/L ratios of groups CSL, CTL and IL were determined as 1.0, 0.5 and 0.5, respectively. It was demonstrated that both the stocking density and lighting schedule had statistically very significant effects on the H/L ratio ($P < 0.01$). There are previous researches, which similarly to the present study, report that increased stocking density increases the H/L ratio (15). This study has explicitly demonstrated the effect of the lighting period on the H/L ratio. While the H/L ratio of groups CTL and IL were only half of that of group CSL, they did not differ from each other. Campo *et al.*, (36) compared CSL with a schedule of 14 h of light and 10 h of dark, and in agreement with the present study, determined that the H/L ratio was 1.13 and 0.36, respectively. There are further studies that report the H/L ratio to vary with the length of the lighting period (15). In contradiction to the present study, other research has shown that the H/L ratio does not vary with the lighting period (23). It was observed that while eosinophil, monocyte and basophil counts were affected by the lighting period, they were not affected by the stocking density. H/L ratios indicated that there was more stress in CSL group. The cause of the stress may be that birds rest in the dark in their natural habitat, however under the circumstances of continuous light they are currently deprived of this resulting in a higher metabolic rate.

CONCLUSIONS

1. According to the values of body weight and uniformity (Coefficients of variation), CSL was superior to other groups until the end of the trial, while no significant dif-

ferences were detected between the groups CTL and IL. When studying cold carcass weight, although the weight of CSL group was greater than others, this differences were not statistically significant.

2. The lighting period and stocking density do not have effects neither on survival rate nor TI and TD. However, it was found that gait score of broilers reared in groups CSL deteriorated.
3. Taking into account H/L ratio, CSL groups were exposed to more stress than other groups. As in humans (46), stress may be responsible from eating excessively and as a result growing fat. Nevertheless, rearing broiler chickens is an economic issue, getting higher BW with same FCR and same mortality is indicative of better performance and more income and even the uniformity was better in this group. For ethical reasons, requirements of darkness had to be supplied with the CTL or IL because, broilers need a dark period for non-stressed life.
4. When examining the effects of stocking density on fattening performance, it was concluded that as stocking density exceed 36.14 kg/m², performance values deteriorated. We highly recommend this value as the upper limit.

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REFERENCES

1. Shanawany, M.: Broiler performance under high stocking densities. *Br. Poultry Sci.* 29: 43-52, 1988.
2. Montero, D., Izquierdo, M., Tort, L., Robaina, L. and Vergara, J.: High stocking density produces crowding stress altering some physiological and biochemical parameters in gilthead seabream, *sparus aurata*, juveniles. *Fish Physiol. Biochem.* 20: 53-60, 1999.
3. Sorensen, P., Su, G. and Kestin, S.: Effects of age and stocking density on leg weakness in broiler chickens. *Poultry Sci.* 79: 864-870, 2000.
4. Dawkins, M.S., Donnelly, C.A. and Jones, T.A.: Chicken welfare is influenced more by housing conditions than by stocking density. *Nature.* 427: 342-343, 2004.
5. Dozier, W., Thaxton, J.P., Purswell, J.L., Olanrewaju, H.A., Branton, S.L. and Roush, W.B.: Stocking density effects on male broilers grown to 1.8 kilograms of body weight. *Poultry Sci.*, 85: 344-351, 2006.
6. Bolton, W., Dewar, W., Jones, R.M. and Thompson, R.: Effect of stocking density on performance of broiler chicks. *Br. Poultry Sci.*, 13:157-162, 1972.
7. Dozier, W., Thaxton, J., Branton, S., Morgan, G., Miles, D., Roush, W., Lott, B. and Vizzier-Thaxton, Y.: Stocking density Effects on growth performance and processing yields of heavy broilers. *Poultry Sci.* 84: 1332-1338, 2005.
8. Işcan, K.M., Cetin, O., Tepeli, C. and Dere, S.: The effects of stocking density on broiler performance. *Turk J. Vet. Anim. Sci.* 20: 331-335, 1996.
9. Kaynak, İ., Güneş, H. and Koçak, O.: Yerleşim sıklığının broiler performansına etkileri. *Istanbul Univ. Vet. Fak. Derg.* 36: 9-19, 2010.
10. Newcombe, M., Cartwright, A. and Harter-Hennis, J.M.: The effect of increasing photoperiod and feed restriction in sexed broiler-type birds. I. Growth and abdominal fat cellularity. *Br. Poultry Sci.* 33:415-425, 1992.
11. Olanrewaju, H.A., Thaxton, J.P., Dozier, W.A., Purswell, J., Roush, W.B. and Branton, S.L.: A review of lighting programs for broiler production. *Int. J. Poultry Sci.* 5: 301-308, 2006.
12. Onbasilar, E.E., Erol, H., Cantekin, Z. and Kaya, Ü.: Influence of intermittent lighting on broiler performance, incidence of tibial dyschondroplasia, tonic immobility, some blood parameters and antibody production. *Asian-Aust. J. Anim. Sci.* 20:550-555, 2007.
13. Bölükbaşı, Ş.C. and Yılmaz, M.: The effect of intermittent lighting schedule on growth performance of broilers. *J. Fac. Agric.* 34:245-248, 2010.
14. Ingram, D., Hatten, L. and Mcpherson, B.: Effects of light restriction on broiler performance and specific body structure measurements. *J. App. Poultry Res.* 9: 501-504, 2000.
15. Onbasilar, E.E., Poyraz, O., Erdem, E. and Oztürk, H.: Influence of lighting periods and stocking densities on performance, carcass characteristics and some stress parameters in broilers. *Arch. Geflügelkd.* 72: 193-200, 2008a.
16. Aksu, M.i. and Imik, H.: Influence of dietary sorghum (sorghum vulgare) and corn supplemented with methionine on cut-up pieces weights of broiler carcass and quality properties of breast and drumsticks meat. *Food Sci. Tech. Int.* 13: 361-367, 2007.
17. Yalçın, S., Özkan, S., Açıkgöz, Z. and Özkan, K.: Effect of dietary methionine on performance, carcass characteristics and breast meat composition of heterozygous naked neck birds under spring and summer conditions. *Br. Poultry Sci.* 40: 688-694, 1999.
18. Barbut, S.: *Poultry Products Processing. An industry guide.* Boca Raton, Florida, USA: CRC Press LLC; 129 p, 2002.
19. Jones, R.B. and Faure, J.M.: Sex and strain comparisons of tonic immobility. *Behav. Processes.* 6: 47-55, 1981.
20. Kestin, S., Knowles, T., Tinch, A. and Gregory, N.: Prevalence of leg weakness in broiler chickens and its relationship with genotype. *Vet. Rec.* 131: 190-192, 1992.
21. Huff, W.: Evaluation of tibial dyschondroplasia during aflatoxicosis and feed restriction in young broiler chickens. *Poultry Sci.* 59: 991-993, 1980.

22. Rozenboim, I., Robinzon, B. and Rosenstrauch, A.: Effect of light source and regimen on growing broilers. *Br. Poultry Sci.* 40: 452-457, 1999.
23. Özkan, S., Yalcın, S., Akbaş, Y., Kırkpınar, F., Gevrekçi, Y. and Türkmüt L.: Effects of short day (16L: 8D) length on broilers: some physiological and welfare indices. *World Poultry Sci. J.* 62:584, 2006.
24. Hassanein, H.H.M.: Growth performance and carcass yield of broilers as affected by stocking density and enzymatic growth promoters. *Asian J. Poultry Sci.* 5: 94-101, 2011.
25. Onbasilar, E.E., Poyraz, O. and Cetin, S.: Effects of breeder age and stocking density on performance, carcass characteristics and some stress parameters of broilers. *Asian-aust. J. Anim. Sci.* 21: 262-269, 2008b.
26. Mortari, A.C., Rosa, A.P., Zanella, I., Neto, C.B., Visentin, P.R. and Brites, L.B.P.: performance of broilers reared in different population density, in winter, in South Brazil. *Ciencia Rural.* 32: 493-497, 2002.
27. El-Deek, A. and Al-Harathi, M.: Responses of modern broiler chicks to stocking density, green tea, commercial multi enzymes and their interactions on productive performance, carcass characteristics, liver composition and plasma constituents. *Int. J. Poultry Sci.* 3: 635-645, 2004.
28. Sekeroglu, A., Sarica, M., Gulay, M.S. and Duman, M.: Effect of stocking density on chick performance, internal organ weights and blood parameters in broilers. *J. Anim. Vet. Adv.* 10: 246-250, 2011.
29. Feddes, J., Emmanuel, E. and Zuidhoft, M.: Broiler performance, body weight variance, feed and water intake, and carcass quality at different stocking densities. *Poultry Sci.* 81: 774-779, 2002.
30. Classen, H.L.: Day length affects performance, health and condemnations in broiler chickens. *proc. of the 16th annual Australian Poult. Sci. Symposium, February 9-11, University of Sydney, 112-116, 2004.*
31. Başer, E.: Farklı aydınlatma programları ile mısır ve trikitale esaslı rasyonların etlik piliçlerin verim performansı karkas özellikleri ve yağlanması üzerine etkileri. Ph.d. Thesis, University of Selçuk, Konya, Turkey, 2006.
32. Jayalakshmi, T., Kumararaj, R., Sivakumar, T. and Vanan, T.: Carcass characteristics of commercial broilers reared under varying stocking densities. *Tamilnadu J. Veterinary and Animal Sci.* 5: 132-135, 2009.
33. Altan, O., Altan A. and Ozkan, S.: Değişik aydınlatma yöntemlerinin etlik piliç performansı üzerine etkisi. *Turk J. Vet. Anim. Sci.* 22: 97-102, 1998.
34. Stub, C. and Vestegaard, K.: Influence of zinc bacitracin, light regimen and dustbathing on the health and welfare of broiler chickens. *Br. Poultry Sci.* 42: 564-568, 2001.
35. Sanotra, G.S., Lund, J.D. and Vestergaard, K.: Influence of light-dark schedules and stocking density on behaviour, risk of leg problems and occurrence of chronic fear in broilers. *Br. Poultry Sci.* 43: 344-354, 2002.
36. Campo, J., Gil, M., Davila, S. and Munoz, I.: Effect of lighting stress on fluctuating asymmetry, heterophil-to-lymphocyte ratio, and tonic immobility duration in eleven breeds of chickens. *Poultry Sci.* 86: 37-45, 2007.
37. Vestergaard, S. and Sanotra, G.: Relationships between leg disorders and changes in the behaviour of broiler chickens. *Veterinary Rec.*, 144: 205-209, 1999.
38. Skomorucha, I., Muchacka, R., Sosnowka-Czajka, E. and Herbut, E.: Response of broiler chickens from three genetic groups to different stocking densities. *Ann. Anim. Sci.* 9:175-184, 2009.
39. Ravindran, V., Thomas, D.V., Thomas, D.G. and Morel, P.C.H.: Performance and welfare of broilers as affected by stocking density and zinc bacitracin supplementation. *Animal Sci. J.* 77: 110-116, 2006.
40. Skrbic, Z., Pavlovski, Z., Luki, M., Peri, L., Milo, N. and Evi N.: The effect of stocking density on certain broiler welfare parameters. *Biotechnol Anim. Husbandry.* 25: 11-21, 2009.
41. Yakubu, A., Gwaska, J.A. and Salako, A.E.: Strain and placement density effects on welfare, haematological and serum biochemical indices of broilers in north central nigeria. *Acta Agr. Slovenica.* 94: 153-158, 2009.
42. Sanotra, G.S., Lund, J.D., Ersbøll, A., Petersen, J. and Vestergaard, K.: Monitoring leg problems in broilers: A survey of commercial broiler production in Denmark. *World Poultry Sci. J.* 57: 55-69, 2001.
43. Sanotra, G.S., Lawson, L.G., Vestergaard, K. and Thomsen, M.G.: Influence of stocking density on tonic immobility, lameness, and tibial dyschondroplasia in broilers. *J. App. Animal Welfare Sci.*, 4: 71-87, 2001.
44. Bradshaw, R.R., Kirkden, R. and Broom, D.: A review of the aetiology and pathology of leg weakness in broilers in relation to welfare. *Avian. Poultry Biol. Rev.* 13: 45-103, 2002.
45. Sorensen, P.G. and Kestin, S.: The effect of photoperiod: Scotoperiod on leg weakness in broiler chickens. *Poultry Sci.* 78: 336-342, 1999.
46. Dallman, M. F., Pecoraro, N., Akana, S. F., La Fleur, S. E., Gomez, F., Houshyar, H. and Manalo, S.: Chronic stress and obesity: a new view of "comfort food". *P. Natl. Acad. Sci.* 100: 11696-11701, 2003.