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The European performance indicators of broiler chickens as influenced by stocking density and sex

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Abstract. The aim of this study was to investigate the influence of different stocking densities on the growth performance of Ross 308 broiler chickens up to six weeks of age. A total of 216 one-day broiler chicks were randomly assigned to three treatment groups based on the stocking density: Low (LSD) = 14 chickens m^{-2}, Medium (MSD) = 18 chickens per m^2 and High (HSD) = 22 chickens m^{-2}, with four replications. Higher body weight gain (TWG) was observed for the low (2,043.89 g) and medium (2,008.03 g) compared to the high (1,901.51 g) density. The study revealed that chickens of the LSD treatment consumed significantly ($P < 0.01$) more feed compared to the HSD chickens. High stocking density (22 m^{-2}) tended to improve feed conversion ratio compared to medium (18 m^{-2}) and low (14 m^{-2}) stocking density, but the differences were not significant ($P > 0.05$). From the results of this study it can be concluded that broiler chicks can be stocked up to 22 chickens m^2, as far as required standards are assured.

Key words: broiler chickens, feed intake, growth, sex, stocking density.

INTRODUCTION

Broiler contribution in meat production has increased markedly in the last few decades, and this is mainly due to improved genetic and management practices. Due to its low fat and high protein content, broiler meat is considered as a high quality food by consumers.

Broiler chicken can grow almost anywhere. They are small and therefore need less space compared to other animals. Housing of broiler chickens in large numbers and groups is a mean of reducing housing costs. A study by Package et al. (2015) demonstrated that a closed cage housing system enables the control of the microclimate inside the facilities, improves productivity, land and labour efficiency, and renders broiler production more environmentally friendly. The housing environment is extremely important and has an influence on broiler performance and welfare. Beyond stocking density, another factor that is very important is the quality of litter material, as meat type chickens spend most of their time lying on litter and their foot pads, hock and breast are in constant contact with the material on the floor (Terčič et al., 2015). Among the many factors that can affect broiler growth performance, stocking density and sex are very important (Abudabos et al., 2013b; Qaid et al., 2016). Stocking density can be expressed as a number of birds per unit area or body mass per unit area. According to previous researchers (Estevez et al., 2007; Buijs et al., 2009), stocking density can be different in various countries and husbandry systems. It is one of the most important non-genetic factors in poultry breeding and has critical implications for the broiler industry, as higher returns can be obtained as the number of birds per unit area increases.

From the farmers' perspective, the housing of more birds per unit area may increase the income. However, if densities are over exceeded, economic profit may be lower due to the impairment of bird performance, health and welfare (Adeyemo et al., 2016). Welfare standards of chickens kept for meat production are strictly defined by the Council Directive (2007). This document describes the necessary welfare criteria depending on the total load of yield per unit area. A load of maximum of 33 kg m^{-2} is set as a limit. This directive allows 39 kg m^{-2} if stricter welfare standards are documented, or even 42 kg m^{-2} if exceptionally high welfare standards are met over a prolonged period.

The maximum stocking density may be defined as the number of birds or weight per floor surface (Berg & Yngvesson, 2012) and could affect growth rate and body weight per floor area. High stocking density can reduce growth and final body weight at 42 days (Sekeroglu et al., 2009; Hassanein et al., 2011; Simitzis et al., 2012). In studies implemented by Uzum & Toplu (2013) and Das & Lacin (2014) effects of stocking density on the final body weight, feed intake and feed conversion ratio were also observed. Some researchers (Tsiouris et al., 2015) have also concluded that stocking density may affect the viscosity of intestinal content and the prevalence of necrotic enteritis in chicken. Sex is a factor that could also affect final body weight (Marcu et al., 2013a) with males being superior to females (Azahan et al., 2014; Beg et al., 2016) in growth parameters such as body weight. Being aware of the importance of the number of birds kept in specific surface area, and due to the fact that in Kosovo broilers are normally bred un-sexed, the goal of this study is to find the optimum stocking density and its effects on growth performance in broiler chickens of both sexes.

MATERIALS AND METHODS

The present study was conducted at the experimental facilities of Agriculture and Veterinary Faculty of the University of Prishtina and lasted six weeks. This experiment was carried out using a total of 216 one day old commercial Ross 308 broiler chicks. The experiment was organised in two factorial design with stocking density and sex as independent variables. One day-old chicks obtained from a leading broiler commercial company, KonSoni, were first feather sexed and individually weighed to make uniform replicate groups ($P > 0.05$) for each density treatment. Chicks were randomly assigned to 3 stocking density groups (treatments): High Stocking Density (HSD) = 22 chicks (11 female and 11 male), Medium Stocking Density (MSD) = 18 (9 female and 9 male) and Low Stocking Density (LSD) = 14 (7 female and 7 male) birds m^{-2}. Each group was replicated four times. Broiler chickens were housed in four tier wired cages with 1 x 1 metre dimensions for each floor. The height between floors was 0.5 metres. Birds were kept under controlled environmental conditions from day one until day 42. All birds were offered free access to feed and water during the entire rearing period. Diets were formulated based on nutritional requirements according to recommendations by National Research Council (1994). The chickens were fed starter (first three weeks) and grower diet until the end of trial (22–42 days). Birds of each group were individually weighed at 7, 14, 21, 28, 35 and 42 days of age. Total Weight Gain (TWG), Daily Weight Gain (DWG), Total Feed Intake (TFI), Daily Feed Intake (DFI) and Feed Conversion Ratio (FCR)) were calculated weekly and at the end of the feeding period. Feed intake was calculated from the difference between the amount of feed added every week and feed residues of each group at the end of the phase. In the case of mortality, the body weight of the dead bird was recorded. After calculation of viability percentage and FCR, the European Production Efficiency Factor (EPEF) and European Broiler Index (EBI) were used to evaluate the growing performance of broilers as suggested by Van, (2003), Marcu et al. (2013b) and Aviagen, (2015). EPEF and EBI were calculated according to the following formula (Marcu et al., 2013b).

TWG = Body weight (g) at the end – Body weight (g) at start;

ADG (g/chick/d) = TWG/ days of growth period;

FCR (kg feed/kg gain) = Cumulative feed intake (kg) /Total weight gain (kg);

Viability, % = 100 – Mortality, %

$$\text{EPEF} = \frac{\text{Viability (\%) x BW (kg)}}{\text{Age (d) x FCR (kg feed/kg gain)}} x 100$$

$$\text{EBI} = \frac{\text{Viability (\%) x ADG (g/chick/d ay)}}{\text{FCR (kg feed/kg gain) x 10}} x 100$$

Statistical analysis: Raw data obtained from measurements was processed using the Microsoft Excel spreadsheet application. Collected data on growth performance parameters were subjected to analysis by statistical package JMP IN 7 (business unit of SAS). One way Analysis of Variance was used to compare the means of the data and alfa level of 0.05 were used as a borderline to define the significance. Tukey-Kramer HSD post hoc test was used to compare mean group differences.

RESULTS AND DISCUSSION

Broiler chicken growth performance at two ages (1–35 and 1–42), housed in different stocking densities is presented in Tables 1 and 2. The different number of chickens per square metre has significantly ($P < 0.05$) influenced total weight gain, daily weight gain and yield per unit area in both ages. Total (TFI) and daily feed intake (DFI) were significantly affected by stocking density only in 1–42 days of age (Table 2). All other performance indicators were not significantly affected by the number of birds per unit area irrespective of the age. However increasing stocking density decreased total weight gain (TWG).

This tendency is also observed by Farhadi et al. (2016), who reported lower weight gain on day 42 in broilers kept at 18 compared to that reared at the stocking density of 22 birds m^{-2}. TWG was reduced from 142.38 g to 106.52 g with increasing stocking density from 14 to 22 chickens m^{-2} at the age of 42 days. Similar observations were also made by Cengiz et al. (2015), who reported higher body weight gain in six week old Ross 308 broilers reared at LSD (10 birds m^{-2}) than those at HSD (20 birds m^{-2}). Ghosh et al. (2012) also concluded that the increase in bird stocking density significantly affects body weight gain. In fact, our results are inconsistent with those of Nogueira et al. (2013), who worked with 10, 14 and 18 birds m^{-2}. These authors found no significant effect of the stocking density in total weight gain. However, they reported higher body weight gain of broilers at 14 and 18 birds m^{-2} (257.11 g and 330.97 g respectively) compared with the results of the present study for same densities. Our results are also different from that of Uzum & Toplu (2013), who reported lower TWG of birds reared at densities of 18 birds m^{-2}.

Table 1. Main effect of treatment on growth performance of broiler chicken (mean±SEM) (1–35 days)

Parameters	Treatment, birds m^{-2}			
	HSD	MSD	LSD	*P*-value
TWG, g per bird	1,511.10^{b} ± 24.16	1,626.15^{a} ± 39.28	1,606.21^{ab} ± 28.44	0.0372
DWG, g per bird per day	43.17^{b} ± 0.69	46.46^{a} ± 1.12	45.85^{ab} ± 0.81	0.0372
TFI, g per bird	2,505.95 ± 46.19	2,666.63 ± 60.16	2,681.96 ± 54.80	0.0586
DFI, g per bird per day	71.59 ± 1.32	76.18 ± 1.72	76.62 ± 1.57	0.0586
FCR	1.66 ± 0.02	1.64 ± 0.03	1.67 ± 0.03	0.7312
Mortality, %	0.68 ± 0.33	0.55 ± 0.56	0.35 ± 0.36	0.8641
YUA, (kg m^{-2})	33.03^{a} ± 0.71	29.21^{b} ± 0.37	23.14^{c} ± 0.52	<.0001
EPEF	266.73 ± 5.61	290.40 ± 9.69	282.25 ± 7.36	0.1135
EBI	258.82 ± 5.46	282.21 ± 9.55	274.33 ± 7.28	0.1113

Note: HSD – High Stocking Density; MSD – Medium Stocking Density; LSD – Low Stocking Density; SEM – Standard error of mean; TWG – Total Weight Gain; DWG – Daily Weight Gain; TFI – Total Feed Intake; DFI – Daily Feed Intake; FCR – Feed Conversion Ratio; YUA – Yield per unit area; EPEF – European Production Efficiency Factor; EBI – European Broiler Index.
^{abc} – means with different superscripts within the same row are significantly different at $P \leq 0.05$.

Table 2. Main effect of treatment on growth performance of broiler chicken (mean ± SEM) (1–42 d)

Parameters	Treatment, birds m^{-2}			
	HSD	MSD	LSD	*P-value*
TWG, g per bird	1,901.51^{b} ± 33.23	2,008.03^{ab} ± 45.48	2,043.89^{a} ± 31.81	0.0355
DWG, g per bird per day	45.27^{b} ± 0.79	47.81^{ab} ± 1.08	48.66^{a} ± 0.76	0.0355
TFI, g per bird	3,337.77^{b} ± 85.54	3,589.13^{a} ± 65.20	3,731.52^{a} ± 70.12	0.0041
DFI, g per bird per day	79.47^{b} ± 2.04	85.46^{a} ± 1.55	88.85^{a} ± 1.67	0.0041
FCR	1.75 ± 0.02	1.79 ± 0.01	1.83 ± 0.02	0.1044
Mortality, %	0.57 ± 0.32	0.46 ± 0.32	0.30 ± 0.30	0.8285
YUA, (kg m^{-2})	41.30^{a} ± 0.66	35.87^{b} ± 0.44	29.27^{c} ± 0.52	<.0001
EPEF	261.68 ± 5.25	273.24 ± 7.66	273.06 ± 6.82	0.4083
EBI	255.47 ± 5.12	266.96 ± 7.58	266.99 ± 6.72	0.3981

Note: HSD – High Stocking Density; MSD – Medium Stocking Density; LSD – Low Stocking Density; SEM – Standard error of mean; TWG – Total Weight Gain; DWG – Daily Weight Gain; TFI – Total Feed Intake; DFI – Daily Feed Intake; FCR – Feed Conversion Ratio; YUA – Yield per unit area; EPEF – European Production Efficiency Factor; EBI – European Broiler Index.
^{abc} – means with different superscripts within the same row are significantly different at $P \leq 0.05$.

The DWG of LSD and HSD groups were 48.66 and 45.27g per day, respectively (Table 2). This is not in accordance with the results of Adeyemo et al. (2016), who found no effect on daily weight gain. This is probably due to the much lower stocking densities in their research (10, 12 and 14 birds m^{-2}) and longer duration of experiment (8 weeks). In our study, the LSD group had higher DWG (+8.95 g) compared with the results of Adeyemo et al. (2016), at the same stocking density. However, TWG reported by the same authors was 180.11 g higher than in our experiment. Other authors (Tong et al.,

2012) have also reported different results for daily body weight gain as an effect of different stocking densities (12.5, 17.5 and 22.5 birds m^{-2}).

Stocking density has also significantly affected ($P < 0.05$) feed intake (total and daily) of broilers at six weeks of age (Table 2). Higher total (TFI) and daily (DFI) feed intake were found in LSD and MSD compared to HSD group. Differences were also observed between MSD–HSD while no significant feed intake was observed between LSD–MSD treatment. Results show that chickens of the MSD group had higher TFI than those reported by Uzum & Toplu (2013) and Tong et al. (2012), who also reported different results for DFI. The total amount of feed intake (3,731.52 g per bird) reported in the present study for the LSD group is lower than reported by Beg et al. (2011), who observed intake of 4,307 g per broiler kept at the same stocking density (14 birds m^{-2}). Differences in feed intake may be attributed to different feeding space available (Lemons & Moritz, 2016). Birds in our experiment were offered 4.55; 5.56 and 7.14 cm feeder space for HSD, MSD and LSD treatment respectively, which is higher than in commercial practice.

Results for feed conversion ratio (FCR) and mortality are also shown in Tables 1 and 2. FCR was not significantly influenced ($P > 0.05$) by stocking density. However, FCR tended to be lower in the HSD compared to the other groups. A possible explanation is that birds of the LSD group had more available feeding and moving space, and although consumed more feed, they did not convert it effectively into tissues due to energy losses. This is in agreement with the results of Abudabos et al. (2013a) and Türkyilmaz (2008), who observed that stocking density had no significant effect on FCR. However, these results do not agree with those from trials of Ravindran et al. (2006), who found significant differences in FCR as a result of three different stocking densities (16, 20 and 24 birds m^{-2}). Moreover, according to the findings of the present study, it seems that stocking density has no significant influence on mortality rates ($P > 0.05$), since the applied stocking densities were not over the critical levels according to the Council Directive (2007), and there was no competition of chickens for space. Our findings are also in agreement with the results of Feddes et al. (2002), Guardia et al. (2011), Zuowei et al. (2011), Tong et al. (2012), Adeyemo et al. (2016) and Farhadi et al. (2016), which have shown that stocking density had no effect on mortality rates. Results of the yield per unit area (YUA, kg m^{-2}) shown in Table 2 were significantly ($P < 0.05$) different among density groups at the age of 42 days. As indicated, YUA increased by raising stocking density.

Feddes et al. (2002) also reported that YUA was affected by stocking density. They found a YUA of 46.9 kg m^{-2} in higher stocking densities (23.8 bird m^{-2}), which is significantly higher than that of 34.6, 28.6 and 22.9 kg m^{-2} produced in the stocking densities of 17.9, 14.3 and 11.9 birds m^{-2}, respectively.

The performance of broiler birds was also evaluated in terms of European Broiler Index (EBI) and European Production Efficiency Factor (EPEF), which includes daily weight gain and survival percentage. Higher values of these indicators indicate that the bird's body weight gain is uniform and the flock is in good health (Bhamare et al., 2016). No significant ($P > 0.05$) differences among groups in EPEF and EBI values were observed. However these values were lower than those reported from Aviagen (2015).

The effect of sex on the performance of birds is shown in Tables 3 and 4. Results show non-significant differences ($P > 0.05$) between male and female broilers at both ages in all measured and calculated parameters.

Table 3. Main effect of sex on growth performance of broiler chicken (mean±SEM) (1–35 days)

Parameters	Sex		
	Male	Female	*P*-value
TWG, g per bird	1,596.85 ± 27.10	1,565.46 ± 30.40	0.3980
DWG, g per bird per day	45.62 ± 0.77	44.72 ± 0.87	0.3980
TFI, g per bird	2,659.40 ± 42.73	2,576.96 ± 52.26	0.1930
DFI, g per bird per day	75.98 ± 1.22	73.63 ± 1.49	0.1930
FCR	1.66 ± 0.02	1.64 ± 0.02	0.4920
Mortality, %	0.54 ± 0.29	0.52 ± 0.39	0.9688
YUA, (kg m^{-2})	28.40 ± 1.73	28.52 ± 1.96	0.9628
EPEF	281.39 ± 7.70	278.20 ± 5.82	0.7301
EBI	273.10 ± 7.57	270.47 ± 5.78	0.7735

Note: HSD – High Stocking Density; MSD – Medium Stocking Density; LSD – Low Stocking Density; SEM – Standard error of mean; TWG – Total Weight Gain; DWG – Daily Weight Gain; TFI – Total Feed Intake; DFI – Daily Feed Intake; FCR – Feed Conversion Ratio; YUA – Yield per unit area; EPEF – European Production Efficiency Factor; EBI – European Broiler Index.

Table 4. Main effect of sex on growth performance of broiler chicken (mean±SEM) (1–42 days)

Parameters	Sex		
	Male	Female	*P*-value
TWG, g per bird	2012.90 ± 33.468	1956.05 ± 34.252	0.2478
DWG, g per bird per day	47.93 ± 0.796	46.57 ± 0.815	0.2478
TFI, g per bird	3,587.86 ± 65.393	3,517.66 ± 85.502	0.5205
DFI, g per bird per day	85.43 ± 1.557	83.75 ± 2.035	0.5205
FCR	1.78 ± 0.019	1.80 ± 0.020	0.6318
Mortality, %	0.45 ± 0.263	0.43 ± 0.248	0.9649
YUA, (kg m^{-2})	35.54 ± 2.121	35.42 ± 2.344	0.9692
EPEF	274.50 ± 6,080	264.15 ± 4.440	0.1828
EBI	268.04 ± 6.014	258.24 ± 4.406	0.2021

Note: HSD – High Stocking Density; MSD – Medium Stocking Density; LSD – Low Stocking Density; S_{em} – Standard error of mean; TWG – Total Weight Gain; DWG – Daily Weight Gain; TFI – Total Feed Intake; DFI – Daily Feed Intake; FCR – Feed Conversion Ratio; YUA – Yield per unit area; EPEF – European Production Efficiency Factor; EBI – European Broiler Index.

However male broilers had slightly higher TWG and DWG (2.82 vs. 2.84%) compared to females. The total feed intake and daily feed intake was nearly similar in both sexes; however, female broilers consumed less feed (3,517.66 vs. 3,587.86 and 83.75 vs. 85.43) than males. Although feed intake was similar in both sexes ($P > 0.05$), male chickens showed better FCR (1.78 vs. 1.80) than females. These findings are comparable to those of San et al. (2010) who reported that up to eight weeks of conventional rearing there is no significant benefit in separate sex growing of broilers. However our results do not agree with those of Ozturk, et al. (1998) who found that Ross PM3 female broilers grew slower than male ones ($P < 0.05$). Same authors observed higher feed consumption of males at 35 days ($P < 0.01$) and 42 days ($P < 0.01$). Shim et al. (2012), also observed significant effect ($P < 0.001$) of sex on body weight gain of broilers during grower (0–35 days) and finisher phase (0–48 days).

Mortality was not significantly affected by the sex of chickens ($P > 0.05$) either at 1–35 (Table 3) or 1–42 days (Table 4) of feeding. A similar finding was reported by Beg et al., 2016 who found that mortality was not different in male, female or unsexed chickens. Shim et al. (2012), reported no effect of sex on mortality during grower phase (0–35 d), but they found significant effect ($P < 0.005$) on this parameter during finisher phase (0–48 days). As seen from the results (Table 4), the average yield per unit area (YUA) for both sexes was almost the same (35.54 and 35.42 g, respectively). Sex did not significantly affect EPEF and EBI values, although these parameters were lower in female chickens than in males.

CONCLUSIONS

Based on the results of this experiment, it can be concluded that growth rate of broiler chickens decreased and the yield per unit area increased as a result of the increase in the stocking density.

The results suggest that the best YUA is obtained when 22 birds per m^2 are reared. Following recommendations of Council Directive (2007), this load requires high welfare standards which cannot be actually assured in common rearing conditions in Kosovo. In this case, slaughtering before the age of 42 days may be more appropriate. For example, if slaughtering is done at the age of 35 days, a calculated load will be 34.26 kg m^{-2}, which is very close to minimum welfare standard set by Council Directive (2007).

Regarding the sex of the broilers, results show no significant effect on the measured parameters.

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