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Full Length Research Paper

The influence of population density and duration of breeding on broiler chickens productivity and profitability

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Fattening of broiler chickens is a very specific production process characterized by intensive production principles, rapid increase in broilers, small consumption of food/kg of gain (feed conversion ratio) and a large production of broilers' meat per square meter of surface. In order to increase the profitability of this production, the intention of farmers is to reduce the duration of production as well as to increase population density, with the aim of increasing the production of broiler chickens' meat, calculated per unit of surface (m^2). However, most of the countries in the world, in order to protect and preserve the welfare of poultry, limit the maximum of broilers' meat production by regulations and standards. These researches aim to determine the optimal density and duration of fattening in a way to achieve the best production results and the profitability of fattening the broiler chickens hybrids Cobb 500 in temperate continental climate, while preserving the welfare of poultry. From six different population densities (16.84, 16.33, 14.29, 12.75, 14.80 and 15.46 birds per m^2) and fattening period between 37 and 40 days, the best production and economic performance showed that a group of chickens that was fattened in a period of 40 days had a population density of about 16 birds per m^2. This group of broilers produced the most meat per m^2 (about 33 kg), the welfare of poultry is maintained and the standard was not exceeded, so we can say that the best economy and profitability of fattening broiler chickens in the concerned region is achieved. In other groups of chickens, profitability could be more advantageous if the increased population density goes up to 16 birds per m^2; or the duration of fattening could be extended up to 40 days and by this way the welfare of poultry would not be violated.

Key words: Population density (birds per m^2), duration of fattening, profitability, poultry welfare, broilers.

INTRODUCTION

Success in intensive fattening of broiler chickens, in addition to genotype (hybrid-originate), nutrition, preventive and health care, largely depends on other factors such as population density, duration of fattening and initial weight of one-day chickens. Thus, Skomorucha and Muchacka (2007) and Sabau and Popescu (2009) in their work emphasized that the modern commercial lines of broiler chickens have become more demanding in terms of housing conditions, nutrition and handling. This problem is explored by many researchers in different countries with different geographical, climatic and floristic conditions.

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Abbreviations: PI, production index; **CEE,** coefficient of economic efficiency; **RP,** rate of profitability.

Campo et al. (2005) and Estevez (2007) reported that high population density per square meter caused fear (stressful reaction) and threatens the benefit of birds. In addition, increased population density of broiler chickens reduces the body weight, worse the food conversion and increase mortality (Skomorucha et al., 2004, 2009; Sosnówka-Czajka et al., 2005; Estevez, 2007; Onbaşilar et al., 2008). Campo and Carnicer (1994), Campo et al. (2008) and Sosnówka-Czajka et al. (2005) argued that the effect of stress is different for different genotypes of broiler chickens, that is, some hybrids are more sensitive and others are less sensitive to the occurrence of stress in a given environmental conditions.

Puron et al. (1995) concluded that the best indicators of production and profitability showed chickens (Peterson x Hubbard) fattened at a density of 17 birds per m^2 (males) or 19 birds per m^2 (females). For the above mentioned densities, the most meat per m^2 (42.1 to 40.1 kg/m^2) is produced and the highest profits achieved. In addition, the authors emphasize that the increasing population density decreases the daily gain of broiler chickens and increased feed consumption per kilogram of gain. Similar statements were made by Dozier et al. (2005) who suggested that increased production of broiler meat per square meter from 30 to 45 kg negatively influences final body mass and food conversion. In addition, Dozier et al. (2006) argues that male broiler chickens should be fattened to a weight of about 1.8 kg or to the production of about 30 kg per m^2, this gives best performances and do not cause stress factors. Bessei (2004) points out that most countries accepted standards in intensive broiler production per m^2 which can produce between 30 and 38 kg of live broilers in the state is conditioned by the duration of fattening (about 35 days) and by population density (up to 20 birds per m^2), which depends on the climatic conditions of individual countries. Morris (2009) emphasizes that the standards for poultry welfare of New Zealand were much stricter than European. Ravindran et al. (2006) in the climatic conditions of New Zealand investigated the influence of different densities (16, 20 and 24 birds per m^2) on production performances, features of bodies and welfare of broiler chickens hybrids Ross fattened to 35 days of age. The final weight and daily gain were similar in all three groups of broiler chickens and were not statistically important ($P > 0.05$). The consumption of food in chickens with the highest population density (24 birds per m^2) compared to the other two groups was statistically significantly higher ($P < 0.05$). Thomas et al. (2004) came to the similar conclusion with population density of 5, 10, 15 and 20 birds per m^2.

Similar to the previous, in tropical climates of north central Nigeria, Yakubu et al. (2009) investigated the influence of population density on fattening and meat-packing properties of two genotypes (Arbor Acres and Anak Bears) of broiler chickens fattened to 28 days of age. Population density of broiler chickens of both genotypes was different and amounted to 8.3, 11.3 and 14.3 birds per m^2. The researches confirmed that the hybrid Arbor Acres achieved better fattening and meat-packing results and that broiler chickens can be successfully and profitably (justified) fattened at the highest density (14.3 birds per m^2) in these climatic conditions. More researches in terms of moderate continental climate (the Republic of Serbia and Bosnia and Herzegovina - Brcko District) were conducted by Mitrovic et al. (2005, 2006) who investigated the influence of population density, duration of fattening and chickens to-day of weight production indicators of fattening broiler chickens hybrids Cobb 500 and Hubbard.

From the above, it may be noted that the problems related to the influence of paragenetic factors on production performance of broiler chickens of different genotypes is constantly activated and interesting for research in all aspects of climate, with special emphasis on the profitability of the respective production. Therefore, researches are continued and expanded on private farms around Brcko District (Mitrovic et al., 2005) in order to determine the impact of population density, duration of fattening on production performance and profitability (economic justification) of broiler chickens hybrids Cobb 500, while preserving the welfare of poultry.

MATERIALS AND METHODS

A total of 6 rounds of broiler chickens heavy hybrids Cobb 500 were fattened in 2009 in private farms around Brcko District, Republic of Serbian. All chickens were fattened in the same facility that has a total production floor area of 980 m² (with the manipulative part of 1,050 m²).

Total occupancy and population density broiler chickens per round were different in some extent and harmonized with the features of moderate continental climate. In round with the lowest population density (12.75 birds/m²), a total of 12,500 birds were moved and the highest was (16.84 birds/m²) 16,500 one-day chickens of both sexes. Depending on the round, the fattening lasted from 37 to 40 days, the average initial weight of broiler chickens was about 40 g. The production duration, as well as population density of broiler chickens through cycles of production are presented in Table 1.

During the production, except for minimal modifications, the technology as well as the program of nutrition according to recommendation by the company that has produced the Cobb 500 hybrid were applied. Chickens were fattened and kept in object made by bricks, with windows and ceiling and kept on the floor with deep litter.

For each round, the following parameters were determined: duration of fattening, body weight at the end of fattening, feed consumption per kilogram of gain (feed conversion ratio) and mortality (mortality) based on their calculated production index (PI):

PI = [Body weight in kg x (100 - % Mortality) / Duration fattening in, days x feed conv. Ratio in kg] x 100.

In addition, for the purpose of considering cost-fattening broiler chickens at different density and duration of fattening the coefficient of economic efficiency (CEE = total revenue / total expenditure) and the rate of profitability (RP = (net profit / total income) x 100) were evaluated. The total cost included: costs for the purchase of one-day chickens, food and litter, the energy costs, fuel, depreciation expenses, other material costs (drugs, vaccines and disinfectants)

and labor costs. The main financial income is achieved by selling of final product, that is, the fattened broiler chickens. Price of one-day chickens in 2009 was about 0.820 BAM, 0.627 BAM pounds of food and the pound of meat 2.10 BAM.

Table 1. Population density of broiler chickens during the period of production.

Rounds (groups)	Season	Moved chicken	Chickens per floor m^2	Duration of fattening (days)
I	Winter	16,500	16.84	38.00
II	Winter/Spring	16,000	16.33	40.00
III	Spring	14,000	14.29	38.00
IV	Summer	12,500	12.75	38.00
V	Summer/Autumn	14,500	14.80	37.00
VI	Autumn	15,150	15.46	37.00
Total	2009	88,650	15.08	38.00

Table 2. The most important parameters of production of Cobb hybrids broiler chickens.

Rounds (groups)	PD	DF	FBW	PM	M	FCR	PI
I	16.84	38.00	1.950	31.80	3.13	1.740	285.69
II	16.33	40.00	2.135	33.42	4.11	1.694	302.13
III	14.29	38.00	2.040	28.47	2.29	1.612	325.40
IV	12.75	38.00	1.957	24.10	3.46	1.625	305.96
V	14.80	37.00	1.990	28.54	3.06	1.637	318.50
VI	15.46	37.00	1.954	28.31	6.27	1.603	308.79
Average	15.08	38.00	2.004	29.09	3.72	1.652	307.35

PD, Population density (birds/m^2 of floor area); DF, duration of fattening (days); FBW, final body weight (kg); PM, production of meat (kg/m^2 of floor area); M, mortality (%), FCR, feed conversion ratio (kg); PI, production index.

RESULTS AND DISCUSSION

The effect of the impact of different density and duration of fattening broiler chickens Cobb 500 hybrids on the basic production performance is shown in Table 2. This shows that increasing population density of broiler chickens was not significantly influence on the final mass of broilers, mortality and also on the conversion of food. However, by increasing population density, the average final weight of broilers was increased as well as the mortality and feed conversion (Campo et al., 2005; Estevez, 2007; Skomorucha et al., 2004; Sosnówka-Czajka et al., 2005; Onbaşilar et al., 2008). Skomorucha et al. (2009) got similar conclusions, as they showed that increasing the density from 13 to 17 birds per m^2 negatively affected the production performance of broiler chickens of different genotypes (Ross 308, Hubbard Flex and Hybro) fattened for 42 days, but Ross 308 chickens hybrids achieved the best production characteristics, that is, they were at least susceptible to stress caused by increasing population density during fattening.

Table 2 also show that a similar effect was population density and period of fattening. With the longer fattening process, the final weight slightly increase of broiler chickens, but the mortality is also increased and feed conversion ratio was poor. Achieved production indicators of fattened broiler chickens are in some way expected bearing in mind that the duration of fattening and population density were set up (programmed) to the climatic conditions of other areas - regions (Table 1). However, at higher density and longer fattening period, more meat per square meter (over 30 kg/m^2) is produced and vice versa (below 30 kg/m^2). In support of this statement is the research of Feddes et al. (2002) who investigated the influence of different population density and 23.8, 17.9, 14.3 and 11.9 birds per m^2 and fattening period for 39 and 42 days. Regardless of the duration of the fattening, the final weight of broiler chickens were obtained with the largest population density of 14.3 birds per m^2, but at least the highest population density (23.8 birds per m^2). In contrast, the most pounds of meat per square meter were produced by broiler chickens fattened at the highest population density (46.9 kg/m^2) and at least the lowest population density (22.9 kg/m^2).

Analyzing the performance of all groups of broiler chickens, it can be seen that the average population density amounted to 15.08 birds per m^2 and average duration of 38 days for fattening, the average final weight of broilers 2.004 kg, 3.72% mortality, feed conversion ratio of 1.652 kg and average production of meat 29.09 kg/m^2 (Table 2). Similar results were obtained by Ravindran et al. (2006) that the population density of 16 birds per m^2 and fattening broiler chickens to the 35 day of age were found on the following performance: the final weight of broilers in 2,028 g, 1.498 kg of food conversion ratio, mortality 2.98 and about 33 kg/m^2 live weight.

Table 3. The financial result in production of broiler chickens, during the 2009 Bosnian Convertible Marks (BAM).

Rounds (groups)	TC - I	TI - II	GI – III (II-I)	Tax - IV	NI - V (III-IV)
1.	58,732.80	64,279.57	5,546.77	554.68	4,992.09
2.	59,002.50	67,420.08	8,417.58	841.76	7,575.82
3.	50,756.65	57,360.58	6,603.93	660.39	5,943.54
4.	44,584.90	48,601.73	4,016.83	401.68	3,615.15
5.	51,699.60	57,570.49	5,870.89	587.09	5,283.80
6.	51,417.50	57,113.62	5,696.12	569.61	5,126.51
Total	316,193.95	352,346.07	36,152.12	3,615.21	32,536.91

TC, Total costs; TI, total incomes; GI, gross income; tax, 10%; NI, net income.

Table 4. The influence of population density and lasting of production period on productivity, profitability and economic efficiency in broiler production.

Rounds (groups)	PD	DF	PI	CEE	RP
I	16.84	38.00	285.69	1.094	7.77
II	16.33	40.00	302.13	1.143	11.24
III	14.29	38.00	325.40	1.130	10.36
IV	12.75	38.00	305.96	1.090	7.44
V	14.80	37.00	318.50	1.113	9.18
VI	15.46	37.00	308.79	1.111	8.98
Total	15.08	38.00	307.35	1.114	9.23

PD, Population density (birds/m^2 of floor area); DF, duration of fattening (days); PI, production index; CEE, coefficient of economic efficiency; RP, rate of profitability.

Herzegovina, Brcko-District) in population density between 15 and 17 birds per m^2 on floor area and the duration of fattening from 39 to 41 days and that the longer fattening increase the final weight, conversion of food and mortality of broiler chickens, but it reduces the average daily gain and the value of PI.

These researches show to some extent that the value of PI is slightly decreased by increasing population density and duration of the fattening, as also the production of broiler meat in alive state per m^2, which directly affects profitability and cost of the concerned production. Profitability of fattening of broiler chickens on examined farm in 2009 can best be seen from the data shown in Tables 3 and 4.

Table 4 shows that the value of PI was greater with less population density and vice versa. In addition, in the third and fourth round CEE and RP were at a satisfactory level. CEE was 1.114, which indicates that overall revenues were higher than the costs, it can be concluded that the production of broiler chickens in 2009 as analyzed on the farm was economical, that is, that the investments were profitable. In addition, the RP was 9.23% and thus for every 100 monetary units, total revenue 9.23 cash income units and the production of broiler chickens in 2009 was profitable.

In this case, the average population density of 15.08 birds per m^2 and 38 days of fattening per m^2 of floor area produced about 29 kg of broiler meat and it can still be considered (the standards) that the optimal amount of production of broiler meat per m^2 of floor is 33 kg, maximum 35 kg, while preserving the welfare of animals. This fact gives the possibility of improving profitability and economy of such form of production if the extended period of fattening with less density and increased population density in a short period of fattening undoubtedly would increase the profitability of fattening broiler chickens in the given production conditions. For example, Puron et al. (1995) concluded that the best production indicators (final body weight, mortality, feed conversion ratio) and profitability showed chickens fattened in the population density of 17 birds per m^2 (male) or 19 birds per m^2 (female). However, this population density under mentioned conditions are not allowed according to European standards and to the welfare of poultry. In addition, Yakubu et al. (2009) concluded that hybrids Anak Titans and especially hybrid Arbor Acres could be successfully and profitably fattened in a period of 28 days of age at the population density 14.3 birds per m^2.

Conclusion

Based on conducted researches and the results obtained, it can be concluded that the application of modern broiler chicken fattening requires that special attention must be paid to the determining of the optimal population density

and duration of fattening in a way to achieve higher profits. At the same time, chickens need adequate comfort in order to avoid stress factors bearing in mind the welfare of poultry. In countries with moderate continental climate, the successful and profitable fattening of broiler chickens could be arranged in population density between 14 and 15, and 16 birds per m^2 and fattening period should not be longer than 40 days. In this way the average final fattening weight of broiler chickens should be about 2.2 kg and more. In this case, the production results would be between 33 and 35 kg/m^2 meat of live broilers by respecting standards and at the same time ensuring the welfare of poultry.

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