International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 3 Number 3 (2014) pp. 291-302**
http://www.ijcmas.com

Original Research Article

Influence of stocking density on growth performance of family chicks reared up to 18 weeks of age in under an intensive system

Kenaleone Gabanakgosi*, John Cassius Moreki, Shalaulani James Nsoso and Christopher Mareledi Tsopito

Department of Animal Science and Production, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana
Corresponding author

A B S T R A C T

Keywords

Carcass characteristics; family chickens; growth parameters; rearing system; stocking density.

The objective of the study was to evaluate the influence of stocking density on growth performance of family chicks reared up to 18 weeks of age under intensive system. A total of 248 day old chicks were randomly assigned to four stocking densities D_1, D_2, D_3 and D_4 being 10 birds/m^2, 13 birds/m^2, 16 birds/m^2 and 19 birds/m^2 in the first phase (0-6 weeks); 8 birds/m^2, 11 birds/m^2, 14 birds/m^2 and 17 birds/m^2 in the second phase (7-12 weeks) and lastly 6 birds/m^2, 9 birds/m^2, 12 birds/m^2 and 15 birds/m^2 in the third phase (13-18 weeks) due to slaughtering which occurred at the end of each phase in a completely randomized design. The number of replicates per treatment was four. Parameters recorded included feed intake, body weight (BW), body weight gain (BWG), feed conversion ratio (FCR), mortality, final live weight, dressed weight and dressing percentage. Data were analysed using the General Linear Model Procedures in Statistical Analysis System. The growth parameters of family chickens reared in three phases under intensive system were not significantly ($P<0.05$) affected by different stocking densities probably because of slaughtering that occurred at six weekly intervals. A significant stocking density and age interaction occurred for feed intake ($P<0.0002$) and ($P<0.0001$) in the first and third phases, respectively. These results indicate that the optimum stocking density for family chickens under intensive system of management may be 10 birds/m^{2}for first phase, 8 birds/m^2 for second phase and 9 birds/m^2 for third phase.

Introduction

The significance of stocking density in broiler production (*e.g.*, production performance, vitality and health condition of chickens) was established at the beginning of development of industrial poultry production (Skrbić*et al.*, 2009a). As current recommended densities are rather variable it is critical if guidelines are to be established that they be based on sound science (Estevez, 2007). Stocking density has critical implications for the broiler industry because higher returns can be obtained as the number of birds per unit space increases.

In broiler production, stocking density that is floor surface per chicken is a very important welfare factor which directly and indirectly influences and determines the level of growth of chicken body weight (BW) (Škrbić*et al*., 2009b). Profitability can be realized by efficient management of floor space. Poultry producers tend to increase the number of birds per unit of space in order to reduce housing, equipment, and labour costs per unit of space. According to Estevez (2007), the negative consequences of high stocking density include reduced final BW, feed intake and FCR, and greater incidences of foot-pad dermatitis, scratches, bruising, poorer feathering and condemnations. Research consistently indicates that the health and welfare of broilers is compromised if space allowances drop below 0.0625 to 0.07 m^2/bird (equivalent to 34 to 38 kg/m^2) depending on final BW (Estevez, 2007).

The negative consequences of stocking density and the quest for profitability necessitate the evaluation of optimum density allowances for various species of poultry, especially family chickens. Family poultry encompasses the wide variety of small-scale poultry production systems found in rural and peri-urban areas of developing countries (FAO, 2014). Family chickens are usually kept in places of varying sizes in owners' homes with some chickens being widely spaced while others are crowded. These varying stocking densities affect productivity of family chickens.Therefore, this study was carried out to investigate the effect of stocking densities on performance of family chickens up to 18 weeks of age under intensive system.

Materials and Methods

Location

The experiment was carried out at Botswana College of Agriculture (BCA) Guinea Fowl Unit in Sebele at 24º 33′ S, 24º 54′ E at an altitude of 994 m above sea level (Aganga and Omphile, 2000).The study lasted for 18 weeks from April to August 2013. An open open-sided poultry house with concrete floors and roofed with corrugated iron sheets was used.

Design of the study

A total of 248 day old chicks were obtained from a local farmer in Gaborone and reared up to 18 weeks of age under intensive system. A completely randomized design (CRD) was employed in this experiment. Birds were randomly allocated to four stocking densities (treatments) with each treatment having four replicates. The stocking densities were D_1 (10 birds/m^2), D_2 (13 birds/m^2), D_3 (16 birds/m^2) and D_4 (19 birds/m^2) in the first phase (0-6 weeks). Thereafter, stocking density was reduced to D_1 (8 birds/m^2), D_2 (11 birds/m^2), D_3 (14 birds/m^2) and D_4 (17 birds/m^2) in the second phase (7-12 weeks). and further reduced to D_1 (6 birds/m^2), D_2 (9 birds/m^2), D_3 (12 birds/m^2) and D_4 (15 birds/m^2) in the third phase (13-18 weeks). due to slaughtering which occurred at the end of each phase. Each rearing phase lasted for six weeks. Stocking density D_1 (10, 8 and 6 birds/m^2) served as control. Stocking density selection was based on previous studies of Beg *et al* (2011) and Tayeb *et al* (2011) who found stocking density of 10 birds/m^2 is to be ideal for broilers in Bangladesh and Duhok region.

Experimental birds and their management

Prior to the start of the experiment all chicks were individually weighed and randomly distributed to four groups of different stocking densities. Each pen was 1 m^2. In each treatment, replicate birds were assigned identification numbers and then wing banded. The chicks were kept under deep litter management system in a house with windows for ventilation. Each pen was equipped with an electric brooder, feeder, drinker and an automatic drinker.

Data collection was done following two weeks (0-2 weeks of age) of acclimatization of chicks to experimental diets. Data were collected from 3 to 18 weeks of age.

Experimental diets

Birds were fed commercial broiler starter diet (0 to 6 weeks), commercial broiler grower diet (7 to 12 weeks) and commercial broiler finisher diet (13 to 18 weeks). Commercial broiler diets were obtained from retail shops in Gaborone. Feed and water were provided *ad libitum* throughout the experimental period. Birds in each replicate were group fed. Feed intake was measured by giving pre-weighed feed allocated to each replicate group throughout the week and then weighing back all the refusals at the end of the week. Pen body weights were also recorded weekly.

Data collection procedure

Feeds fed to birds and refusals were recorded weekly in each replicate using an electronic balance to the nearest .01g throughout the experimental period. The difference between feed given and left over feeds was used to calculate feed intake (grams). Performance parameters measured included average feed intake, average BW, average BWG, FCR, mortality, dressed weight and dressing percentage. Data were calculated using the formulae given by Djakalia *et al* (2011):

Feed intake (FI) is the ratio between the total quantity of feed consumed (QFC) on a given period over the number of subjects fed (NSF) on the same period.

$$FI\left[{}^{g}/_{day}\right] = \frac{QFC\left({}^{g}/_{day}\right)}{NSF}$$

Body weight (BW) is the ratio between total weight of birds (TWB) in a given flock and the number of birds (NB) of this flock:

$$BW(g) = \frac{TWB\ (g)}{NB}$$

Average weight gain (AWG) represents the difference between the average weight of the current week (AWc) and that of the previous week (AWp). It was determined using the formula, AWG = AWc – Awp

Feed conversion ratio was determined by dividing total feed intake by total BWG (Ratsaka *et al*., 2012). Mortality was recorded daily and calculated as the ratio between the number of the dying birds and the initial total number of birds in the flock multiplied by 100.

At 6, 12 and 18 weeks of age, 2 birds from each replicate were randomly selected and sacrificed by stunning at the BCA slaughter house and carcass weight determined using an electronic balance scale with accuracy 0.001 g.

Statistical analysis

A General Linear Model (GLM) procedure of Statistical Analysis Systems SAS (9.1) Inc. (2002-2003) was used to estimate the differences between treatment means for different stocking densities. Dunnett's mean test was used to separate Least Square Means. Significance was declared at P<0.05. The following model was used:

Statistical model: $Y_{ijk} = \mu + \tau_i + \gamma_j + (\tau\gamma)_{ij} + \delta_{ijk}$

Where: y_{ijk}=Response variable from i^{th} experimental unit (eu) with j^{th} treatment

μ = General mean effect

τ_i = i^{th} Stocking density's effects on family chickens growth

γ_j=j^{th} age effects on family chickens growth

$(\tau\gamma)_{ij}$= ij^{th} stocking density and age interaction

δ_{ijk} = Error ijk^{th}eu $\sim N(0, \sigma^2_\delta)$

Results and Discussion

Feed intake

Feed intake in the second phase did not vary across the rearing period while it significantly increased with the rearing period in all densities in the first and third phases (Tables 1 to 3). Among the stocking densities for all phases feed intake was not significantly different. However, the highest feed intake was recorded in D_1 (308.71 g) at week 4 in the first phase; in D_1 (601.96 g) at week 8 in the second phase and in D_1 (789.47 g) at week 18 in the third phase. Stocking density did not affect average feed intake because of slaughtering which was done at the end of each phase. In agreement Feddes *et al* (2002) found that birds reared at 11.9 birds/m^2 stocking density consumed the least feed (2,993 g/bird) compared to those at 14.3 birds/m^2 which consumed most feed (3,183 g/bird). These results are in disagreement with Iyasere *et al* (2012) who found that increased stocking density reduces feed intake. Similarly, Tong *et al* (2012) observed that under three stocking densities (12.5, 17.5 and 22.5 birds/m^2) feed intake decreased significantly in each period as stocking density increased. On the contrary, Nahashon *et al* (2009) observed significantly higher feed intake in birds raised at stocking density of 10.7 birds/m^2compared to 15.6, 13.6, and 12 birds/m^2. In this study, significant stocking density and age interaction occurred for feed intake (P<0.0002) and (P<0.0001) in the first and third phases, respectively. The current results indicate that feed intake declined with increased stocking density. Anon (2013) attributed the decline in feed intake to restricted access to the feed, increased heat stress and increased ammonia level which occurs under heavily stocked birds. Also, the physical access to feeders is probably limited due to increased stocking density, as well as, the competition between birds to get to the feeder (Abudabos *et al*., 2013).

Body weight and body weight gain

Body weight increased significantly (P<0.05) over time in all the phases

(Tables1 to 3). However, BW in all phases was not affected by stocking density due to slaughtering which occurred at the end of each phase. The highest BW was recorded in D_1 (409.75 g) at week 6 in the first phase; in D_1 (1269.40 g) at week 12 in the second phase and in D_2 (2033.20 g) at week 18 in the third phase. The result on BW is in agreement with Dozier *et al.* (2006) and Sekeroglu *et al* (2011) who found a significant effect of stocking density on BW of broilers. However, the current finding is in disagreement with El-Deek and Ai-Harthi (2004) and Tayeb *et al* (2011) who found no influence of stocking density on BW of broiler chicks. No stocking density x age interaction for BW in all the phases was found in this study indicating that the influence of stocking density did not vary for BW. In this study, stocking density of 9 birds/m^2 showed better performance in achieving the final market weight because of high feed intake as access to the feed and water was not restricted. Generally, no significant difference was observed in BWG of chickens in all the phases (Tables 1 to 3). The highest BWG was recorded in D_2 (164.17 g) at week 6 in the first phase; in D_1 (1269.40 g) at week 10 in the second phase and in D_2 (352.10 g) at week 18 in the third phase.

The current result is consistent with Iyasere *et al* (2012) who reported that increased stocking density reduces BWG of the birds. Sekeroglu *et al* (2011) raised Ross 308 broilers under three stocking densities (9, 13 and 17 birds/m^2) and observed that BWG at density of 13 birds/m^2 was higher than that of other two stocking densities during the 2nd and 3rd weeks of age. The authors also found that birds reared at stocking density of 17 birds/m^2 had the lowest BWG of all the three groups (9, 13 and 17 birds/m^2) during the 4th, 5th and 6th weeks. No stocking density and age interaction for BWG was observed in all the rearing phases in this study.

Feed conversion ratio

There was no variation observed in FCR for family chickens in all the phases (Tables 1 to 3). The highest FCR was recorded in D_2 (4.63) at week 4 in the first phase; in D_3 (2.49) at week 12 in the second phase and in D_1 (3.84) at week 14 in the third phase. This indicates that chickens in the above stocking densities are poor converters of feeds to meat, probably because they have not been selected for faster growth rate. Nahashon *et al* (2009) observed significantly lower FCR in birds raised in floor densities of 13.6 and 12 birds/m^2 than those raised on floor densities of 15.6 and 10.7 birds/m^2. Similarly, Sekeroglu *et al* (2011) found that birds reared at 17 birds/m^2 had better FCR than those reared at 9 and 13 birds/m^2 groups at 21-42 days. The current results are in agreement with Sreehari and Sharma (2010) who reported that birds of lower density groups have a chance to consume more feed which is a waste because they cannot convert it into meat and are unable to show better FCR value. The authors also found that FCR between stocking density groups was not significant between 0-21 and 0-42 days but was significant at 21-42 days of age. In this study, a significant stocking density and age interaction occurred for FCR ($P<0.0395$) in the third phase indicating that the influence of stocking density varied for FCR during the third phase.

Mortality

Stocking density did not affect mortality. In the first phase mortality occurred in D_1 at week 4 and 6 (0.22±0.11 % each) and D_2 at week 6 (0.33±0.11 %).

Table.1 Means and standard errors of growth parameters of family chickens reared up to 6 weeks of age under intensive system

Parameter	Density	Age (weeks) 3	4	6	SE	Significance of effect (P) Density	Age	Interaction	CV
Feed intake (g)	10	79.58^{ax}	308.71^{ay}	185.97^{az}	14.12	0.3175	0.0001	0.0002	14.46373
	13	109.07^{ax}	236.29^{by}	222.98^{aby}					
	16	99.43^{ax}	221.61^{by}	252.86^{by}					
	19	121.84^{ax}	262.70^{aby}	241.30^{aby}					
Body weight (g)	10	153.78^{ax}	269.03^{ay}	409.75^{az}	10.59	0.0727	0.0001	0.1940	8.017182
	13	153.57^{ax}	227.33^{ay}	391.49^{az}					
	16	156.78^{ax}	243.36^{ay}	395.60^{az}					
	19	164.32^{ax}	235.63^{ay}	369.48^{az}					
Body Weight Gain (g)	10	-	115.25^{ax}	140.73^{ax}	14.87	0.4016	0.0001	0.2108	25.37018
	13	-	73.76^{ax}	164.17^{ay}					
	16	-	86.58^{ax}	152.24^{ay}					
	19	-	71.32^{ax}	133.85^{ay}					
FCR	10	-	2.83^{ax}	1.36^{ax}	0.58	0.3224	0.0001	0.2601	46.69058
	13	-	4.63^{ax}	1.39^{ay}					
	16	-	2.60^{ax}	1.67^{ax}					
	19	-	3.71^{ax}	1.83^{ay}					

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly $P<0.05$.
FCR=Feed Conversion Ratio; CV= Cumulative Frequency and SE= Standard error.

Table.2 Means and standard errors of growth parameters of family chickens reared from 8 to 12 weeks of age under intensive system

Parameter	Density	Age (weeks)			Significance of effect (P)				
		8	10	12	SE	Density	Age	Interaction	CV
Feed intake (g)	8	601.96^{ax}	564.66^{ax}	553.65^{ax}	34.55	0.0649	0.1162	0.3150	13.03197
	11	470.60^{bx}	502.89^{ax}	513.05^{ax}					
	14	471.37^{bx}	553.44^{ax}	541.02^{ax}					
	17	459.96^{bx}	584.04^{ax}	545.74^{ax}					
Body weight (g)	8	674.27^{ax}	999.35^{ay}	1269.40^{az}	37.66	0.2046	0.0001	0.9868	8.014930
	11	639.06^{ax}	936.95^{ay}	1195.48^{az}					
	14	645.80^{ax}	958.41^{ay}	1178.71^{az}					
	17	634.27^{ax}	955.17^{ay}	1189.77^{az}					
Body Weight Gain (g)	8	264.52^{ax}	325.08^{ax}	270.05^{ax}	26.43	0.6842	0.0016	0.9441	19.41427
	11	247.56^{ax}	297.90^{ax}	258.51^{ax}					
	14	250.20^{ax}	312.61^{ax}	220.30^{ax}					
	17	264.79^{ax}	320.90^{ax}	234.60^{ax}					
FCR	8	2.41^{ax}	1.76^{ax}	2.06^{ax}	0.21	0.6281	0.0159	0.3668	20.35758
	11	1.96^{ax}	1.71^{ax}	2.02^{ax}					
	14	1.95^{ax}	1.85^{ax}	2.49^{ax}					
	17	1.84^{ax}	1.83^{ax}	2.34^{ax}					

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;$P<0.05$.
FCR=Feed Conversion Ratio; CV= Cumulative Frequency and SE= Standard error.

Table.3 Means and standard errors of growth parameters of family chickens reared from 14 to 18 weeks of age under intensive system

Parameter	Density	Age (weeks)			Significance of effect (P)				
		14	16	18	SE	Density	Age	Interaction	CV
Feed intake (g)	6	690.47^{ax}	435.63^{ay}	789.47^{az}	27.34	0.0001	0.0001	0.0001	9.895659
	9	647.55^{ax}	525.08^{ay}	614.37^{bxy}					
	12	434.77^{bxy}	431.09^{ax}	543.34^{by}					
	15	452.32^{bx}	429.55^{ax}	637.79^{by}					
Body weight (g)	6	1476.75^{ax}	1708.49^{axy}	1920.07^{ay}	76.76	0.7416	0.0001	0.8449	9.100213
	9	1428.25^{ax}	1681.10^{axy}	2033.20^{az}					
	12	1452.72^{ax}	1643.64^{axy}	1848.69^{ay}					
	15	1487.70^{ax}	1675.36^{axy}	1889.14^{ay}					
Body Weight Gain (g)	6	207.35^{ax}	231.75^{ax}	211.58^{ax}	44.34	0.3188	0.4615	0.2587	37.23666
	9	232.78^{ax}	252.85^{ax}	352.10^{bx}					
	12	274.02^{ax}	190.92^{ax}	205.05^{ax}					
	15	297.93^{ax}	187.66^{ax}	213.77^{ax}					
FCR	6	3.84^{ax}	1.93^{ax}	3.87^{ax}	0.50	0.1371	0.0383	0.0395	38.17738
	9	2.82^{abx}	2.09^{ax}	2.24^{ax}					
	12	1.60^{bx}	2.40^{ax}	3.25^{ax}					
	15	1.56^{bx}	2.53^{ax}	3.20^{ax}					

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;P<0.05.
FCR=Feed Conversion Ratio; CV= Cumulative Frequency and SE= Standard error.

Table.4 Mean carcass characteristics and live weight of family chickens slaughtered at 6 weeks

Parameter	Density	Age (weeks)	Significance of effect (P)		
		6	SE	Treatment	CV
Live weight (g)	10	496.63[a]	27.33	0.8073	11.45082
	13	463.88[a]			
	16	483.25[a]			
	19	465.50[a]			
Dressed weight (g)	10	285.75[a]	18.24	0.8164	13.20156
	13	268.75[a]			
	16	284.63[a]			
	19	266.50[a]			
Dressing (%)	10	57.50[a]	0.81	0.4933	2.799843
	13	57.75[a]			
	16	58.88[a]			
	19	57.15[a]			

[ab]Means in the same column within a parameter with different superscripts differ significantly;P<0.05.; CV= Cumulative Frequency and SE= Standard error.

Table.5 Mean carcass characteristics and live weight of family chickens laughtered at 12 weeks

Parame	Density	Age (weeks)	Significance of effect (P)		
		12	SE	Treatment	CV
Live weight (g)	8	1594.63[a]	76.28	0.6887	9.573201
	11	1656.38[a]			
	14	1598.88[a]			
	17	1524.50[a]			
Dressed weight (g)	8	974.05[a]	52.15	0.3878	10.40969
	11	913.525[a]			
	14	1079.38[a]			
	17	1040.68[a]			
Dressing (%)	8	61.15[a]	2.95	0.0350	9.322359
	11	55.80[a]			
	14	67.55[b]			
	17	68.28[b]			

[ab]Means in the same column within a parameter with different superscripts differ significantly;P<0.05.; CV= Cumulative Frequency and SE= Standard error.

Table 6: Mean carcass characteristics and live weight of family chickens slaughtered at 18 weeks

Parameter	Density	Age (weeks)	Significance of effect (P)		
		18	SE	Treatment	CV
Live weight (g)	6	2319.38[a]	81.75	0.2739	6.778734
	9	2540.25[a]			
	12	2436.88[a]			
	15	2351.25[a]			
Dressed weight (g)	6	1605.13[a]	72.88	0.4094	8.656268
	9	1765.75[a]			
	12	1725.13[a]			
	15	1639.25[a]			
Dressing (%)	6	69.20[a]	1.07	0.7437	3.057189
	9	69.43[a]			
	12	70.75[a]			
	15	69.63[a]			

[ab]Means in the same column within a parameter with different superscripts differ significantly;P<0.05.; CV= Cumulative Frequency and SE= Standard error.

The highest mortality was recorded in the third phase at week 16 in stocking density D_4 at week 16 (0.52±0.18 %). This may be overcrowded. This finding on mortality is consistent with Feddes *et al* (2002) who found that stocking density had no effect on mortality. In agreement with Beg *et al* (2011) no significant ($P<0.4100$) stocking density and age interaction was observed for mortality in this study.

Carcass characteristics and live weight

All carcass characteristics were not affected by stocking density in all the phases (Tables 4 to 6). The highest live weight was recorded in D_1 (496.63 g) at week 6 in the first phase; in D_2 (1656.38 g) at week 12 in the second phase and in D_2 (2540.25 g) at week 18 in the third phase. The current result is in contrast to Beg *et al* (2011) who reported that the average live weight of Cobb-500 broiler

due to pecking which occurred as birds were

birds under stocking density D_3 (12 birds/m^2) was significantly higher under four stocking densities (8, 10, 12 and 14 bird/m^2) at 6 weeks of age. In contrast, Tayeb *et al* (2011) found no significant effect of stocking density on carcass weight under three stocking densities (8.66, 10.41 and 13.36 birds/m^2).

In this study, the highest dressed weight was recorded in D_3 (2496.63 g) at week 6 in the first phase; in D_3 (1079.38 g) at week 12 in the second phase and in D_2 (1765.75 g) at week 18 in the third phase. In contrast, Beg *et al* (2011) found that dressing percentage of birds on D_1 (8 birds/m^2) and D_2 (10 birds/m^2) stocking densities was significantly ($P<0.05$) higher compared to D_3 (12 birds/m^2) and D_4 (14 birds/m^2) stocking densities. The authors concluded that lower stocking density resulted in higher dressing percentage. According to Skrbic et al. (2008), low stocking density provides more intensive growth for broilers and higher yield of processed carcass. Also, low stocking density allows for better body development and carcass conformation (Skrbic et al., 2009a).The highest dressing percentage was recorded in D3 (58.88 %) at week 6 in the first phase; in D_4 (68.28 %) at week 12 in the second phase and in D_3 (70.75 %) at week 18 in the third phase. The present results are in disagreement with Sekeroglu *et al* (2011) who reported no influence of stocking density on carcass yield. Similarly, Tayeb *et al* (2011) reported no significant effect of different stocking density on carcass weight and dressing percentage of broiler chickens.

The growth parameters of family chickens reared under intensive system were not significantly affected by the different stocking densities probably due to the slaughtering that occurred at 6, 12 and 18 weeks of age. Stocking density of 10 birds/m^2 for the first phase (1-6 weeks), 8 birds/m^2 for the second phase (7-12 weeks) and 9 birds/m^2 for the third phase (13-18 weeks) had better performance for almost all growth parameters. The current results suggest that the optimum stocking density for family chickens reared under intensive system may be 10 birds/m^2 for the first phase, 8 birds/m^2 for the second phase and 9 birds/m^2 for the third phase.

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