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# Effect of floor density on growth performance of Pearl Grey guinea fowl replacement pullets

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# Research Note

# Effect of floor density on growth performance of Pearl Grey guinea fowl replacement pullets

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**ABSTRACT** Little is known of the optimal floor density for the Pearl Grey (PG) guinea fowl pullet. Hence, the objective of this study was to determine the effect of varying floor density on the growth performance of PG guinea fowl pullets. In 3 replicates, 1-d-old guinea keets (n = 786) were weighed individually and randomly assigned to floor pens covered with pine wood shavings at 80, 69, 60, and 53 birds/pen, equivalent to densities of 18, 15.6, 13.6, and 12 birds/m$^2$, respectively. The birds were allowed feeder space of 2.3, 2.7, 3.1, and 3.5 cm/bird, respectively, and water space of 1.2, 1.4, 1.6, and 1.8 cm/bird, respectively. The photoperiod was 23 h at 0 to 11 wk of age (WOA) and 8 h at 12 to 16 WOA. Birds were fed diets comprising 3,000 and 3,100 kcal of ME/kg of diet at 0 to 4 and 5 to 8 WOA, respectively, and 24% CP. At 9 to 16 WOA, the diets comprised 3,100 kcal of ME/kg and 18% CP. Feed and water were provided for ad libitum consumption. Body weight and feed consumption were measured weekly. Overall, BW gains were higher ($P < 0.05$) and feed conversion ratios (FCR) were significantly lower in birds reared at a floor density of 18 birds/m$^2$ than in birds reared on other treatments at 0 to 8 WOA. However, at 9 to 16 WOA, birds at floor densities of 12 birds/m$^2$exhibited higher BW gain and feed consumption and lower FCR ($P <$ 0.05) than those at floor densities of 13.6, 15.6, and 18 birds/m$^2$. Therefore, this study suggests an optimum floor density of 18 and 12 birds/m$^2$ at 0 to 8 and 9 to 16 WOA, respectively, to achieve the highest possible FCR for the PG guinea fowl replacement pullets.

**Key words:** Pearl Grey guinea fowl pullet, floor density, stocking density, growth performance

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## INTRODUCTION

In commercial production, guinea fowl are reared in confinement with management practices similar to those used for chickens. However, limited information is available on optimum stocking density of the guinea fowl pullet. Optimized floor density would minimize overhead costs associated with maintenance of poultry houses and improve efficiency of feed utilization. This implies that profitability can be achieved by efficient management of floor space. The review of Estevez (2007) points out that assigned bird densities have been primarily driven by cost benefit analysis. Poultry producers tend to increase the number of birds per unit of space to reduce housing, equipment, and labor costs per unit of space; this often tends to compromise bird performance.

The goal of the poultry producer is to achieve a balance in which the quest for production efficiency does not supersede the desire to provide a suitable environment and the birds' welfare. The tendency exists to increase the number of birds per unit of space to reduce housing, equipment, and labor costs per unit of space. It is, however, well documented that chickens at high density grow more slowly, produce fewer eggs, and have higher mortality (Van Kampen, 1981; Deaton, 1983). Leeson and Summers (1984) reported a significant reduction in 50-wk BW among growing Leghorn pullets kept at 293 cm$^2$/bird when compared with those kept at 586 cm$^2$/bird. Earlier work (Wells, 1972) also cited evidence that feed consumption (**FC**) was significantly reduced among Leghorn pullets reared in floor pens at high stocking density. Such reduction in FC can lead to poor growth performance, change in social behavior, and mortality. These negative consequences and the quest for profitability necessitate the determination of optimum bird density for various species of poultry, such as the Pearl Gray (**PG**) guinea fowl.

An inverse relationship between stocking density and the welfare of broiler birds has been previously reported. According to Thogerson et al. (2009) higher stocking densities affect the welfare of birds through reduction of feeder space allocation, which may induce aggression, chronic stress, and even mortality. Sørensen et al. (2000) observed that lowering stocking density signifi-


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cantly reduced the prevalence of leg weakness in broiler chickens. In earlier studies Lewis and Hurnik (1990) reported that distance traveled by individual birds was reduced by 20% when floor density was increased from 1,320 to 660 $cm^2$/bird. In numerous reports, movement restriction associated with stocking density has been implicated in leg weakness, severe footpad dermatitis (Berg, 1998), and lack of activity (Arnould and Faure, 2004) in broilers. In addition, recent reports (Buijs et al., 2009) showed a decrease in welfare of broilers as density increased. They observed that increasing floor density of the broiler birds from 35 to 56 kg/$m^2$ resulted in higher incidence of foot dermatitis and fearfulness.

Information on stocking density of the guinea fowl is meager. However, a recent report (Nahashon et al., 2009) revealed that the optimum stocking density of the French variety of guinea fowl at hatch to 8 wk of age (**WOA**) ranged from 12 to 13.6 birds/$m^2$. Reports of Dozier et al. (2005) and Han et al. (2005) reveal that broilers reared at higher densities consumed less feed compared with those reared at lower densities. As a consequence, poor bird performance may be associated with reduced feed intake and poor feed conversion because of limited feeder space, a negative consequence of high stocking density (Sørensen et al., 2000; Dozier et al., 2006).

Current estimates of floor space requirement of PG guinea fowl replacement pullets are based on specifications for chickens such as the White Leghorn and broiler breeder pullets. The specific objective of this study, therefore, was to evaluate the effect of various stocking densities on FC, BW gain, and feed conversion ratios (**FCR**) of the PG guinea fowl replacement pullets from hatch to 16 WOA. Information derived from this research will be used to estimate the optimum floor density requirement for the PG guinea fowl replacement pullets.

## MATERIALS AND METHODS

### Birds and Treatments

One-day-old PG guinea keets (n = 786) were obtained from Ideal Poultry Breeding Farms (Cameron, TX) and reared under standard brooding and rearing techniques (Bell and Weaver, 2002; Nahashon et al., 2006). These birds were weighed individually and randomly assigned to floor pens covered with pine wood shavings at 80, 69, 60, and 53 birds/pen, equivalent to floor densities of 18, 15.6, 13.6, and 12 birds/$m^2$, respectively. The average BW of these birds at the end of the trial was 1,461.8, 1,502.2, 1,565.0, and 1,611.9 g/bird, respectively. Feeder space was provided at 2.7, 3.1, 3.5, and 4.0 cm/bird and water space was provided at 1.2, 1.4, 1.6, and 1.8 cm/bird at the floor densities of 18, 15.6, 13.6, and 12 birds/$m^2$, respectively. The average BW of the birds after the trial was 1,461, 1,502, 1,565, and 1,611 g/bird, respectively. At hatch to 4 WOA the experimental birds were fed diets containing 3,000 kcal of ME/kg of diet and 24% CP. The diets fed at 5 to 8 WOA comprised 3,100 kcal of ME/kg of diet and 24% CP, whereas diets fed at 9 to 16 WOA comprised 3,100 kcal of ME/kg of diet and 18% CP (Table 1; Nahashon et al., 2009). Each floor density was replicated 3 times. The diets were fed in mash form and were provided for ad libitum consumption. Water was also provided freely throughout the study.

### Management of Experimental Birds

At 1 d of age, experimental birds were weighed individually and randomly assigned to floor pens covered with pine wood shavings litter to a depth of 10 cm. Each pen was equipped with a brooder that maintained the room or pen temperature at 32.2°C for the first week and reduced gradually by 2.8°C every week until 23.9°C; from this point on, no artificial heating was provided to the birds. The birds received 23 and 8 h of constant lighting from 0 to 11 and 12 to 16 WOA, respectively. Ventilation within the brooder–grower house was maintained by thermostatically controlled exhaust fans. Body weight and FC were measured weekly from hatch to 16 WOA. The FCR was calculated by dividing weekly FC by weekly BW gain for each replicate. Mortality was recorded as it occurred during the entire study period (1–16 WOA) and included birds that were culled. Mortality was weighed and the weights were used to adjust pen-based weekly BW gain, FC, and FCR.

### Statistical Analyses

Data were analyzed by the ANOVA option of the general linear model of SAS/STAT software (SAS Institute, 2002) as completely randomized design with floor density as main effect. The statistical model used to evaluate the effect of floor density on FC, BW gain, FCR, and mortality was $Y_{ijk} = \mu + D_i + R_{ij} + \varepsilon_{ijk}$, where $Y_{ijk}$ = response variables from each individual pen or replications, $\mu$ = the overall mean, $D_i$ = the effect of floor density, $R_{ij}$ = the interexperimental unit (replications) error term, and $\varepsilon_{ijk}$ = the intraexperimental unit error term. The interexperimental unit (replication) error term was used to test the effect of floor density. Least significant difference comparisons were made between treatment means for main effects when a significant $F$-value was found. Differences in mortality among floor densities were analyzed using the chi-squared method. Significance implies $P < 0.05$ unless stated otherwise.

## RESULTS

### FC

Mean FC of Pearl Grey guinea fowl replacement pullets subjected to varying floor densities are presented in Table 2. At early age (1–4 WOA), mean differences in

**Table 1.** Composition of experimental diets fed from hatch to 16 wk of age

| | Age, wk | | |
|---|---|---|---|
| Item (% unless noted) | 0–4 | 5–8 | 9–16 |
| Ingredient | | | |
| Corn, yellow no. 2 (8% CP) | 44.93 | 42.03 | 63.9 |
| Soybean meal (48% CP) | 42.70 | 43.30 | 25.5 |
| Alfalfa meal (17% CP) | 1.00 | 1.00 | 1.00 |
| Meat and bone meal (50% CP) | 3.00 | 3.00 | 3.00 |
| Poultry blended fat | 5.80 | 8.00 | 3.90 |
| Dicalcium phosphate (18% P, 22% Ca) | 0.90 | 1.20 | 1.10 |
| Limestone flour (38.8% Ca) | 0.90 | 0.70 | 0.90 |
| Salt | 0.37 | 0.37 | 0.37 |
| Vitamin–mineral premix[1] | 0.25 | 0.25 | 0.25 |
| DL-Methionine (98%)[2] | 0.15 | 0.15 | 0.08 |
| Calculated level | | | |
| ME (kcal/kg of diet) | 3,000 | 3,100 | 3,100 |
| CP | 24 | 24 | 18 |
| Ca | 1.00 | 1.00 | 1.00 |
| Total P | 0.72 | 0.72 | 0.70 |
| Available P | 0.48 | 0.48 | 0.48 |
| Met | 0.53 | 0.53 | 0.38 |
| Met + Cys | 0.92 | 0.92 | 0.69 |
| Lysine | 1.46 | 1.46 | 1.00 |
| Crude fat | 7.70 | 9.56 | 6.52 |
| Analyzed level | | | |
| CP | 23.95 | 23.82 | 17.92 |
| Crude fat | 7.41 | 9.33 | 6.38 |

[1]Provided per kilogram of diet: retinyl acetate, 3,500 IU; cholecalciferol, 1,000 ICU; DL-α-tocopheryl acetate, 4.5 IU; menadione sodium bisulfite complex, 2.8 mg; vitamin $B_{12}$, 5.0 mg; riboflavin, 2.5 mg; pantothenic acid, 4.0 mg; niacin, 15.0 mg; choline, 172 mg; folic acid, 230 mg; ethoxyquin, 56.7 mg; manganese, 65 mg; iodine, 1 mg; iron, 54.8 mg; copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg.

[2]Degussa Corp. (Kennesaw, GA).

FC of birds reared at floor densities of 15.6, 13.6, and 12 birds/m$^2$ were not significant ($P > 0.05$). However, these FC means were higher ($P < 0.05$) than those of birds reared at higher floor density (18 birds/m$^2$) by 30 to 36% and 12% at 1 and 2 WOA, respectively. Cumulative FC of birds reared at 15.6, 13.6, and 12 birds/m$^2$ was significantly higher (15–18%) than that of birds reared at 18 birds/m$^2$ at 1 to 4 WOA. For the most part, cumulative FC of guinea fowl reared at 15.6, 13.6, and 12 birds/m$^2$ was 8 to 11% higher than that of birds reared at 18 birds/m$^2$ from 5 to 8 WOA. Overall, birds reared at higher (18 birds/m$^2$) floor density consumed less feed ($P < 0.05$) compared with those reared at lower floor densities such that 18 < 15.6 < 13.6 = 12 birds/m$^2$. At 9 to 16 WOA, birds reared at a floor density of 12 birds/m$^2$ consumed more feed ($P < 0.05$) than those reared at other floor densities.

## BW Gain

Over the duration of this study, BW gain of the PG guinea fowl improved proportionately with the decrease in floor density. For the most part, at early age (1–2 WOA), birds reared at floor densities of 18 and 15.6 birds/m$^2$ exhibited significantly higher ($P < 0.05$) mean BW gains than those reared at 13.6 and 12 birds/m$^2$. However, as these birds grew older (5–8 WOA), the BW of birds reared at 13.6 and 12 birds/m$^2$ was 6 to 7% higher ($P < 0.05$) than that of birds reared at 15.6 and 18 birds/m$^2$. At this point it was evident that birds reared at lower floor densities performed better than those reared at higher floor densities.

For the most part, significantly higher ($P < 0.05$) BW gains were observed in birds reared at floor densities of 13.6 and 12 birds/m$^2$ than in birds reared at floor densities of 18 and 15.6 birds/m$^2$ during 9 to 16 WOA. Cumulative BW gains of birds reared at floor density of 12 birds/m$^2$ at 9 to 12 WOA were significantly higher ($P < 0.05$) than those of birds reared at all other floor densities. Differences in cumulative mean BW gain of birds that were reared at floor densities of 18 and 15.6 birds/m$^2$ were not significant at 9 to 12 WOA. However, at 14 to 16 WOA, birds reared at a floor density of 12 birds/m$^2$ exhibited 19 to 38% and 100 to 170% higher BW gain ($P < 0.05$) than birds at floor densities of 15.6 and 18 birds/m$^2$, respectively. Therefore, during the period of 13 to 16 WOA, cumulative BW gain of birds reared at lower floor densities was significantly higher ($P < 0.05$) than that of birds reared at higher floor densities such that 12 > 13.6 > 15.6 > 18 birds/m$^2$, respectively.

The magnitude of differences in BW gain among floor densities ranged from 10% between birds reared at 12 birds/m$^2$ and those at 13.6 birds/m$^2$ to 30% between birds reared at floor densities of 12 birds/m$^2$ and those at 15.6 birds/m$^2$. A similar trend was observed for the cumulative BW gains for the entire 16-wk study period, where the highest and lowest BW gains were observed in birds reared at floor densities of 12 and 18 birds/m$^2$, respectively. The differences in cumulative

**Table 2.** Feed consumption (g/bird per week) of Pearl Gray guinea fowl reared in varying floor densities from hatch to 16 wk of age

| Age (wk) | Floor density (birds/m$^2$) 12 | 13.6 | 15.6 | 18 | Pooled SEM | Probability |
|---|---|---|---|---|---|---|
| 1 | 64.9$^a$ | 63.6$^a$ | 62.0$^a$ | 45.7$^b$ | 1.32 | 0.01 |
| 2 | 108.6$^a$ | 108.0$^a$ | 107.2$^a$ | 96.1$^b$ | 1.18 | 0.02 |
| 3 | 164.3$^b$ | 164.4$^b$ | 175.0$^a$ | 140.6$^c$ | 1.66 | 0.01 |
| 4 | 240.8$^a$ | 234.7$^b$ | 221.3$^c$ | 207.7$^d$ | 0.95 | 0.01 |
| TFC[1] | 578.6$^a$ | 570.7$^a$ | 565.5$^a$ | 490.1$^b$ | 2.42 | 0.03 |
| 5 | 347.1$^a$ | 278.5$^c$ | 287.4$^b$ | 216.6$^d$ | 2.99 | 0.01 |
| 6 | 320.7$^b$ | 296.9$^d$ | 311.3$^c$ | 335.7$^a$ | 1.62 | 0.01 |
| 7 | 341.9$^c$ | 407.7$^a$ | 384.9$^b$ | 333.6$^d$ | 2.84 | 0.01 |
| 8 | 399.6$^b$ | 425.7$^a$ | 392.1$^c$ | 385.8$^d$ | 2.13 | 0.01 |
| TFC[1] | 1,409.3$^a$ | 1,408.7$^a$ | 1,375.7$^b$ | 1,271.7$^c$ | 5.18 | 0.04 |
| 9 | 476.2$^a$ | 445.5$^d$ | 469.7$^b$ | 456.0$^c$ | 1.45 | 0.01 |
| 10 | 451.1$^c$ | 441.2$^d$ | 456.4$^b$ | 479.0$^a$ | 1.13 | 0.01 |
| 11 | 542.4$^a$ | 461.6$^d$ | 510.7$^b$ | 495.5$^c$ | 2.10 | 0.01 |
| 12 | 550.3$^c$ | 592.2$^a$ | 584.9$^b$ | 552.0$^c$ | 2.41 | 0.01 |
| TFC[1] | 2,020.0$^a$ | 1,940.5$^c$ | 2,021.7$^a$ | 1,982.5$^b$ | 9.36 | 0.01 |
| 13 | 528.0$^a$ | 432.8$^d$ | 518.1$^b$ | 502.3$^c$ | 3.10 | 0.03 |
| 14 | 474.4$^a$ | 400.6$^c$ | 406.0$^c$ | 455.6$^b$ | 2.51 | 0.01 |
| 15 | 433.7$^a$ | 392.7$^c$ | 415.0$^b$ | 420.8$^b$ | 3.40 | 0.04 |
| 16 | 430.9$^b$ | 415.9$^c$ | 427.2$^b$ | 455.1$^a$ | 2.61 | 0.02 |
| TFC[1] | 1,867.0$^a$ | 1,642.0$^d$ | 1,766.3$^c$ | 1,833.8$^b$ | 6.20 | 0.01 |
| TFC[2] | 5,874.9$^a$ | 5,561.9$^c$ | 5,729.2$^b$ | 5,578.1$^c$ | 13.21 | 0.03 |

$^{a–d}$Means within rows with no common superscript differ ($P < 0.05$).

[1]Grams of total feed consumption for the previous 4-wk study period.

[2]Grams of total feed consumption for the 16-wk study period.

BW gains among floor densities for the entire 16-wk study period were similar to those observed during the 13 to 16 WOA such that 12 > 13.6 > 15.6 > 18 birds/m$^2$, respectively.

## *Mortality*

Differences in percentage mortality of birds reared at 18 and 15.6 birds/m$^2$ were not significant ($P < 0.05$). However, the mean percentage mortality of birds reared at floor density of 18 birds/m$^2$ was significantly ($P < 0.05$) higher (2.5%) than that of birds reared at floor densities of 13.6 and 12 birds/m$^2$. Mortality was higher at 10 to 16 WOA than at 1 to 9 WOA, especially in birds reared at the higher floor density (18 birds/m$^2$), which may be attributed to limited floor, feeder, and watering space and poor bird welfare. Differences in percentage mortality of birds reared at floor densities of 13.6 and 12 birds/m$^2$ were not significant.

## *FCR*

The FCR of PG guinea fowl reared at varying floor densities from hatch to 16 WOA are presented in Table 3. At 1 to 2 WOA, FCR of birds reared at 12 and 13.6 birds/m$^2$ was 5 to 8% and 17 to 48% higher ($P < 0.05$) than that of birds reared at 15.6 and 18 birds/m$^2$, respectively. Cumulative FCR at 1 to 4 WOA was significantly lower ($P < 0.05$) in birds reared at floor densities of 18 and 15.6 birds/m$^2$ than in those reared at a floor density of 12 birds/m$^2$ such that 18 < 15.6 = 13.6 < 12 birds/m$^2$.

The ages of 5 to 7 WOA seem to be a transitional period of significant shift on the optimum floor density for the PG guinea fowl replacement pullets. At 5 to 6 WOA, FCR of birds at a floor density of 18 birds/m$^2$ was significantly lower ($P < 0.05$) than that of birds reared at floor density of 15.6, 13.6, and 12 birds/m$^2$. However, at 8 WOA a shift in performance occurred such that birds reared at a floor density of 12 birds/m$^2$ had an FCR that was 6 and 8% lower ($P < 0.05$) than that of birds reared at floor densities of 13.6 and 15.6 birds/m$^2$, respectively. For the most part, at 9 to 12 WOA, the FCR of birds reared at floor densities of 12 and 13.6 birds/m$^2$ was significantly lower ($P < 0.05$) than that of birds reared at floor densities of 18 and 15.6 birds/m$^2$. Overall, both average weekly FCR and cumulative FCR at 13 to 16 WOA increased significantly ($P < 0.05$) with increase in bird density such that 12 < 13.6 < 15.6 < 18 birds/m$^2$, respectively.

# DISCUSSION

This study shows that, for the most part, birds reared at floor densities of 12, 13.6, and 15.6 birds/m$^2$ consumed more feed than those reared at a floor density of 18 birds/m$^2$. It is presumed that birds reared at the lower floor densities had ample floor, feeder, and watering space when compared with those reared at a higher floor density. Consequently, increasing the bird density to 18 birds/m$^2$ may have reduced movement of the birds within pens, resulting in lower energy expenditure, which may have contributed to lower FC. Birds consume feed first to meet their energy requirements (Richards, 2003; Richards and Proszkowiec-Weglarz,

**Table 3.** Feed conversion ratio (g of feed/g of weight gain) of Pearl Gray guinea fowl reared in varying floor densities from hatch to 16 wk of age

| | Floor density (birds/m$^2$) | | | | | |
|---|---|---|---|---|---|---|
| Age (wk) | 12 | 13.6 | 15.6 | 18 | Pooled SEM | Probability |
| 1 | 1.53$^{ab}$ | 1.58$^{a}$ | 1.46$^{b}$ | 1.07$^{c}$ | 0.041 | 0.03 |
| 2 | 1.82$^{a}$ | 1.78$^{a}$ | 1.69$^{b}$ | 1.55$^{c}$ | 0.033 | 0.01 |
| 3 | 1.95$^{b}$ | 1.79$^{c}$ | 2.14$^{a}$ | 1.77$^{c}$ | 0.042 | 0.05 |
| 4 | 2.18$^{a}$ | 2.02$^{a}$ | 1.78$^{b}$ | 1.84$^{b}$ | 0.058 | 0.01 |
| AFCR[1] | 1.87$^{a}$ | 1.79$^{b}$ | 1.77$^{b}$ | 1.56$^{c}$ | 0.037 | 0.02 |
| 5 | 2.39$^{a}$ | 2.07$^{b}$ | 2.29$^{a}$ | 1.92$^{c}$ | 0.035 | 0.01 |
| 6 | 2.54$^{b}$ | 2.60$^{b}$ | 2.78$^{a}$ | 2.29$^{c}$ | 0.030 | 0.01 |
| 7 | 2.95$^{a}$ | 2.84$^{ab}$ | 2.80$^{b}$ | 2.91$^{a}$ | 0.041 | 0.04 |
| 8 | 3.08$^{b}$ | 3.28$^{a}$ | 3.32$^{a}$ | 3.32$^{a}$ | 0.053 | 0.05 |
| AFCR[1] | 2.74$^{ab}$ | 2.70$^{b}$ | 2.80$^{a}$ | 2.61$^{c}$ | 0.048 | 0.05 |
| 9 | 3.67$^{b}$ | 3.46$^{c}$ | 4.18$^{a}$ | 3.78$^{b}$ | 0.045 | 0.03 |
| 10 | 4.31$^{c}$ | 5.37$^{a}$ | 5.04$^{b}$ | 4.13$^{a}$ | 0.056 | 0.05 |
| 11 | 5.45$^{b}$ | 5.72$^{b}$ | 6.39$^{a}$ | 6.29$^{a}$ | 0.084 | 0.02 |
| 12 | 5.66$^{c}$ | 5.72$^{c}$ | 6.10$^{b}$ | 7.00$^{a}$ | 0.047 | 0.01 |
| AFCR[1] | 4.77$^{c}$ | 5.07$^{b}$ | 5.43$^{a}$ | 5.30$^{a}$ | 0.051 | 0.01 |
| 13 | 5.17$^{c}$ | 5.64$^{b}$ | 5.62$^{b}$ | 11.56$^{a}$ | 0.062 | 0.04 |
| 14 | 4.44$^{c}$ | 4.40$^{c}$ | 5.05$^{b}$ | 7.74$^{a}$ | 0.073 | 0.05 |
| 15 | 4.75$^{c}$ | 4.56$^{c}$ | 7.14$^{b}$ | 7.83$^{a}$ | 0.206 | 0.04 |
| 16 | 7.54$^{d}$ | 9.43$^{c}$ | 20.63$^{a}$ | 18.13$^{b}$ | 0.516 | 0.03 |
| AFCR[1] | 5.48$^{d}$ | 6.01$^{c}$ | 9.61$^{b}$ | 11.32$^{a}$ | 0.317 | 0.02 |
| AFCR[2] | 3.72$^{b}$ | 3.89$^{b}$ | 4.90$^{a}$ | 5.20$^{a}$ | 0.079 | 0.05 |

$^{a-d}$Means within rows with no common superscript differ ($P < 0.05$).

[1]Average feed conversion ratio for the previous 4-wk study period.

[2]Average feed conversion ratio for the 16-wk study period.

2007). Previous studies on broilers have shown that distance traveled by individual birds was reduced by 20% when floor density was increased from 1,320 to 660 cm$^2$/bird (Lewis and Hurnik, 1990). Such reduction in distance moved may have led to reduction in number of visits to the feeders and drinkers and shortened the periods of uninterrupted rest. These factors may have contributed to the decrease in FC.

Correlations between floor density and FC are also in agreement with the FC where birds at higher floor densities consumed less feed compared with those at lower floor densities and vice versa (Table 4). The correlations between floor density and FC were negative and highly significant ($P < 0.05$). Nahashon et al. (2006) reported similar observations that suggested that limited feeder space was associated with decreased FC and poor bird performance. Estevez (2007) also observed reduction in FC of broilers when environmental conditions deteriorated at constant density. Such notion implied that deterioration of environmental conditions such as reduction in feeder and watering space may be associated with the reduction in feed intake. Recent reports have also shown that guinea fowl of the French variety (Nahashon et al., 2009) and broilers (Dozier et al., 2005) reared at lower bird densities tend to significantly consume more feed than their counterparts reared at higher floor densities.

Regarding the effect of floor density on BW gain at 1 to 4 WOA, birds reared at floor densities of 18 and 15.6 birds/m$^2$ exhibited significantly higher BW gains than those at 13.6 and 12 birds/m$^2$. This may be attributed to increased movement and energy expenditure in birds at 13.6 and 12 birds/m$^2$ compared with those at 18 and 15.6 birds/m$^2$. It is presumed that at this early age birds at all floor densities had ample floor space until 5 to 8 WOA, which was considered a transitional phase. It was observed that at 5 to 8 WOA, the BW of birds reared at 13.6 and 12 birds/m$^2$ was 6 to 7% higher ($P <$

**Table 4.** Correlation coefficients among growth performance parameters and floor density of Pearl Grey guinea fowl reared in varying floor densities from hatch to 16 wk of age[1]

| Item | Feed consumption | BW gain | Feed conversion | No. of observations |
|---|---|---|---|---|
| Hatch to 9 wk of age | | | | |
| Floor density | −0.454** | 0.032 | 0.995** | 785 |
| Feed consumption | | 0.324* | −0.445** | 784 |
| BW gain | | | −0.343* | 784 |
| 10 to 16 wk of age | | | | |
| Floor density | 0.363* | −0.295* | 0.476** | 733 |
| Feed consumption | | 0.211* | 0.225* | 733 |
| BW gain | | | −0.253* | 733 |

[1]Correlations were derived from cumulative feed consumption, BW gain, and average feed conversion ratios for the durations of study: hatch to 9 wk of age and 10 to 16 wk of age.

*$P < 0.05$; **$P < 0.01$.

0.05) than that of birds reared at 15.6 and 18 birds/m$^2$. At this point, it was evident that birds reared at lower floor densities performed better than those reared at higher floor densities, possibly because birds at higher floor densities (15.6 and 18 birds/m$^2$) may have started to experience constraints of limited space such as reduction in feeder space and therefore reduction in FC (Table 2). These observations are in agreement with the report of Leeson and Summers (1984) that White Leghorn pullets kept at 293 cm$^2$/bird had a significant reduction in 50-wk BW compared with those reared at 586 cm$^2$/bird.

The period 9 to 16 WOA was considered a postaccelerated growth phase and it was characterized by lower BW gain compared with earlier ages of hatch to 8 WOA. During the period 9 to 16 WOA, birds reared at floor densities of 13.6 and 12 birds/m$^2$ were heavier than birds reared at floor densities of 18 and 15.6 birds/m$^2$. This observation was consistent with the report of Mtileni et al. (2007) that broiler breeders kept in a group of 15 birds/pen were 183 g heavier ($P < 0.05$) than those kept in groups of 20 birds/pen. These observations are also in agreement with the reports of Estevez et al. (1997) and Keeling et al. (2003) that stocking density could adversely affect BW gain of broilers and Leghorn layers, respectively. Bilgili and Hess (1995) reported a similar trend where broiler chickens exhibited depressed BW gain when floor density was increased from 10.5 to 13.2 birds/m$^2$. Negative and significant correlations between BW gain and floor density further support the premise that during 9 to 16 WOA birds had attained higher BW to a point where floor space was limited to the extent that it had a negative effect on BW gain of the birds (Table 4). Another possible explanation is that these birds had advanced in age and gained more weight to a point where competition for floor and feeder space was beginning to influence bird performance. Feddes et al. (2002) suggested that a decrease in feed and water intake by birds at higher stocking densities is usually associated with lack of physical access to feed and water. In support of this observation, correlations between FC and BW gain were positive and significant ($P < 0.05$) at hatch to 16 WOA. These correlations were higher in the younger birds (hatch to 9 WOA) than in those aged 10 to 16 WOA (0.324 and 0.211, respectively). This observation clearly indicated that these birds responded more to FC because of their rapid growth rate at early age opposed to their growth rate at later ages (Tables 2 and 5).

Consequences of increased floor density (e.g., reduced FC and BW gain; limited floor, feeder, and watering space; poor bird welfare; Buijs et al., 2009) may also lead to mortality. Mortality was higher at higher floor density (18 birds/m$^2$) and especially at a later age of 10 to 16 WOA compared with 1 to 9 WOA, possibly because of these consequences of high stocking density. Consistent with these observations, Dozier et al. (2005) reported a significant ($P < 0.05$) increase in mortality when stocking density of heavy broilers was increased from 30 kg/m$^2$ to 35, 40, and 45 kg/m$^2$ at 49 d of age. However, few other reports that were contrary to these observations (Feddes et al., 2002) indicated that stocking density had no significant effect ($P > 0.05$) on mortality of broiler birds.

**Table 5.** Body weight gain (g/bird per week) of Pearl Gray guinea fowl reared in varying floor densities from hatch to 16 wk of age

| | Floor density (birds/m$^2$) | | | | | |
|---|---|---|---|---|---|---|
| Age (wk) | 12 | 13.6 | 15.6 | 18 | Pooled SEM | Probability |
| 1 | 43.8$^a$ | 41.2$^b$ | 42.8$^a$ | 43.8$^a$ | 0.52 | 0.02 |
| 2 | 60.8$^b$ | 60.8$^b$ | 63.8$^a$ | 63.2$^a$ | 0.75 | 0.02 |
| 3 | 87.5$^b$ | 92.5$^a$ | 84.8$^b$ | 79.4$^c$ | 1.15 | 0.01 |
| 4 | 119.7$^b$ | 119.0$^b$ | 130.7$^a$ | 119.4$^b$ | 1.34 | 0.01 |
| CBWG[1] | 311.8$^{bc}$ | 313.5$^b$ | 322.1$^a$ | 305.8$^c$ | 2.56 | 0.04 |
| 5 | 145.0$^a$ | 136.7$^b$ | 128.9$^c$ | 116.2$^d$ | 2.10 | 0.02 |
| 6 | 129.6$^b$ | 120.3$^c$ | 115.4$^d$ | 149.0$^a$ | 1.60 | 0.01 |
| 7 | 116.7$^c$ | 140.2$^a$ | 138.8$^a$ | 117.1$^c$ | 1.74 | 0.01 |
| 8 | 134.5$^a$ | 133.5$^a$ | 113.6$^b$ | 119.1$^b$ | 1.96 | 0.01 |
| CBWG[1] | 525.8$^a$ | 530.7$^a$ | 496.7$^b$ | 501.4$^b$ | 2.73 | 0.03 |
| 9 | 130.5$^a$ | 127.6$^a$ | 116.3$^c$ | 122.3$^b$ | 1.75 | 0.01 |
| 10 | 110.5$^b$ | 94.5$^c$ | 105.3$^b$ | 123.5$^a$ | 2.21 | 0.02 |
| 11 | 102.8$^a$ | 74.9$^c$ | 85.9$^b$ | 79.0$^c$ | 2.10 | 0.03 |
| 12 | 84.7$^b$ | 108.3$^a$ | 103.3$^a$ | 87.9$^b$ | 2.41 | 0.04 |
| CBWG[1] | 428.5$^a$ | 405.3$^c$ | 410.8$^{bc}$ | 412.7$^b$ | 3.62 | 0.05 |
| 13 | 59.9$^c$ | 76.0$^b$ | 94.1$^a$ | 43.0$^d$ | 2.00 | 0.01 |
| 14 | 112.8$^a$ | 81.9$^c$ | 73.1$^d$ | 64.5$^b$ | 1.94 | 0.01 |
| 15 | 90.8$^a$ | 88.2$^a$ | 59.4$^b$ | 54.3$^b$ | 1.89 | 0.04 |
| 16 | 57.0$^a$ | 44.0$^a$ | 20.7$^b$ | 25.1$^b$ | 2.21 | 0.02 |
| CBWG[1] | 320.5$^a$ | 290.1$^b$ | 247.3$^c$ | 186.9$^d$ | 3.29 | 0.02 |
| CBWG[2] | 1,586.6$^a$ | 1,539.6$^b$ | 1,476.9$^c$ | 1,406.8$^d$ | 6.48 | 0.05 |
| Mortality | 6.2$^b$ | 5.7$^b$ | 6.4$^{ab}$ | 7.8$^a$ | 0.79 | 0.05 |

[a–d]Means within rows with no common superscript differ ($P < 0.05$).

[1]Cumulative BW gain for the previous 4-wk study period.

[2]Cumulative BW gain for the 16-wk study period.

Feed conversion ratios of the PG guinea fowl were higher in birds at 12 and 13.6 birds/m$^2$ than in birds reared at 15.6 and 18 birds/m$^2$ at 1 to 4 WOA. Possibly, these birds reared at lower floor densities had excessive floor space that allowed increased free movement of birds and increased expenditure of energy, factors that may be associated with an increase in FC. Previous reports (Al-Rawi et al., 1976) have also suggested increased energy expenditure when the floor density of layers was increased. According to Hill (1986), increasing floor space increased physical activity of birds and the resulting decline in feed efficiency may be a result of increased FC because of wastage or changes in nutritional requirements as a result of increased physical activity. Wang et al. (2009) also speculated that birds reared in expansive floor space tend to exhibit a higher metabolism than those reared at higher floor densities and thus increased movement would consume more energy. At 8 WOA and beyond, a shift occurred in performance such that birds reared at a floor density of 12 birds/m$^2$ had a significantly lower FCR than birds reared at floor densities of 13.6 and 15.6 birds/m$^2$. This may be attributed to increase in body size of these birds causing reduction in the finite floor and feeding space. Such an effect would be felt significantly in pens holding more birds per square meter. Recent studies evaluating the effect of feeder space on performance of Hy-Line hens demonstrated that decreasing floor space can result in poor feed efficiency even without impairing the welfare of the birds (Thogerson et al., 2009). These observations are further supported by the positive and significant correlation coefficients between floor density and FCR from hatch to 16 WOA. These correlations were twice as high in younger birds (hatch to 9 WOA) than in the older birds (10–16 WOA); they were 0.995 and 0.476, respectively. Previous reports have also shown that decreasing floor space or increasing floor density is usually associated with poor feed efficiency or higher FCR because of competition for feeder space leading to lower FC and poor BW gain (Thogerson et al., 2009).

For the most part, at 9 to 12 WOA, the FCR of birds reared at floor densities of 12 and 13.6 birds/m$^2$ was significantly lower ($P < 0.05$) than that of birds reared at floor densities of 18 and 15.6 birds/m$^2$. These observations are in agreement with previous reports that overcrowding negatively effects feed efficiency because low ranking birds are usually prevented by their pen mates from accessing the inadequate feeder space (Hughes, 1983). Feed wastage, especially in birds reared at higher floor densities and in litter floor housing systems, is also a contributing factor to the high FCR (Thogerson et al., 2009). Thogerson et al. (2009) also suggested that although limited feeder space is available in high floor densities at any given time, other social factors such as increased physiological stress may also contribute to poor bird performance and hence poor feed efficiency. The higher correlation values at hatch to 9 WOA than those observed at 10 to 16 WOA may be attributed to excess floor space at hatch to 9 WOA resulting in increased FC as a result of increased activity and metabolism of these birds. Previous reports have also suggested increased energy expenditure (Al-Rawi et al., 1976) and increased metabolism (Wang et al., 2009) to be associated with an increase in floor space or a decrease in floor density. The negative and significant correlations between FC and FCR observed at 10 to 16 WOA are partly attributable to a decline in BW gain and possible increase in FC, leading to poor feed efficiency or higher FCR. These factors are attributed to negative effects of overcrowding and possible feed wastage (Hill, 1986).

Therefore, based on conditions of this study, PG guinea fowl replacement pullets reared at floor density of 18 birds/m$^2$ exhibited significantly higher BW gains ($P < 0.05$) and lower FCR when compared with those reared at other floor densities at hatch to 8 WOA. However, at 9 to 16 WOA, birds at floor densities of 12 birds/m$^2$exhibited significantly higher ($P < 0.05$) BW gains and lower FCR than those reared under other floor density treatments. These observations suggest that the PG guinea replacement pullet will exhibit optimum performance at floor densities of 18 and 12 birds/m$^2$ at 0 to 8 and 9 to 16 WOA, respectively. In this study, stocking density of 12 to 18 birds/m$^2$ did not seem to influence bird performance at early age. However, it is worth noting that over time birds grew bigger and occupied more of the static space available, gradually decreasing the amount of space available to the birds and compromising bird welfare. Evaluating floor density using the birds per square meter model seems to be a challenge similar to employing the BW per area model in growing birds whose BW changes over time. It should, however, be noted that although floor density was expressed as birds per square meter, such a model would seem appropriate when evaluating birds at early age.

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