

Effects of housing systems on reproductive and physiological response of guinea fowl (*Numida meleagris*)

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Abstract

A study was carried out to investigate the effects of housing systems on reproductive and physiological response of guinea fowl. A total number of 600 hatching eggs were obtained from a reputable Farms in Nigeria. The hatched keets were distributed to different housing systems viz: free range, deep litter and battery cage. A total number of 117 female guinea fowl were selected from the flock and divided into the three housing systems with three replicate having 13 birds each. Twelve birds in each treatment group at week 32 were killed and then dissected for determination of the weights of the reproductive apparatus. Rectal temperature, respiratory rate, heart rate and gastrointestinal tract weights were also taken. Results showed that ovary weights of the birds on the free range (6.07g) was significantly higher ($P < 0.05$) than that of the deep litter (5.20g) while the weights of the birds in the deep litter was higher ($P < 0.05$) than that of the ovaries of the birds raised in the battery cage (4.15g). A similar trend was also observed in the number of large yellow follicles of the birds. The rectal temperature of the birds reared in battery cages (42.21) was higher ($P < 0.05$) than those of deep litter (40.84) and free range (40.27) while there was a similarity in the birds on free range and deep litter. The results clearly showed that rearing guinea fowl on free range improved the reproductive and physiological performance of the birds.

Keywords: guinea fowl, housing systems, reproductive and physiological performance

Introduction

Commercialization of guinea fowl in Africa is still in its rudimentary stage despite the fact that these birds originated from Africa (John and Malebogo, 2013). The birds are still reared with low input at subsistent level with its attendant low productivity. However, it has been shown that guinea fowl production is a viable and profitable enterprise, thus providing opportunity for commercialization in many parts of the world (Nahashon et al., 2006), whereas in Nigeria, the development of intensive guinea fowl housing is still low (Dougnon et al., 2012) and generally in Africa. In comparison with domestic chickens, a few researches have been carried out on guinea fowl (Nalubamba et al., 2010).

Furthermore, despite the tremendous progress made in poultry production, there is still a growing concern on the housing systems of poultry birds. The ban on conventional cages in the EU was came up on welfare issues over hens housed in battery cages (Appleby, 2003; Van Hoorebeke et al., 2010). The use of battery cage for layers has been banned since 2012 in European countries. Also, in the US, a bill was passed in California in 2008, to outlaw the use of conventional cage by 2015. The need for housing hens in alternative systems has been advocated to provide them with increased freedom of movement and the ability to express a wide range of behaviour patterns. There has been a strong debate on the superiority of the housing systems and there are varying and inconclusive results. According to animal welfare activists, the conventional cages cause many welfare problems (Craig and Adams, 1984; Appleby, 2003).

Gerzilov et al. (2012) reported that cages had positive effects on welfare in that they provide a clean, disease-free environment and small group sizes. Hill (1986) showed that physical measures of welfare were marginally worse in alternative systems while Craig and Adams (1984) considered that in high-density cages welfare suffered compared with low-density cages or floor systems. On the other hand, Hulzebosch (2006) reported that laying cages are still the most economic way to produce eggs and the best system for disease prevention. Moreover, Oke (2012) concluded that layers raised on legume-based pasture performed better than hens kept in the deep litter.

Despite several studies carried out on the effects of housing systems on chickens, there exists a meager research conducted on the guinea fowl. This study therefore investigated the effect of housing systems on reproductive and physiological response in guinea fowl. It is believed that this may provide new insights in general to housing systems of guinea fowl.

Materials and Methods

All procedures in this experiment were carried out according to the Institutional Animal Ethics Committee and conformed to the "Guidelines for the Care and Use of Animals in Research".

The study was carried out at the Poultry Unit of the Directorate of University Farms, Federal University of Agriculture, Abeokuta, Nigeria. Three types of housing systems viz: deep litter, battery cage and free range were used. The shelter used for the birds on the free range had the same dimension. The pens were made of wood with wooden floor, dwarf wall of 0.7m and wire net covering the roof. The roof was made of corrugated iron and one part of the walls was opened into the fenced free runs of 70m² and the roof sides were covered with nets to prevent the birds from escaping. The birds in the deep litter housing system were stocked at 0.25m²/bird. The floor of the deep litter housing was cemented and covered with wood shavings. The cage housing system was a wire net supported by metal bars. Standard cages of (48x42x45 cm size) were used with a stocking rate of 4 birds per cage. Each cage was equipped with galvanized feeders and linear drinkers.

Experimental Birds, Materials and Management

A total number of 600 hatching eggs were obtained from a reputable Farms in Nigeria. The eggs were incubated in a reliable hatchery. Prior to the arrival of the keets, the pen was cleaned and disinfected. Drinkers and feeders were provided. The floor was covered with wood shavings for the brooding of the keets. The birds were managed on the floor pens (0 to 6 weeks) until they were transferred to the different housing systems. 117 female guinea fowl were selected from the flock and divided into the three housing systems with three replicate having 13 birds each.

At the beginning of the experiment, birds were individually weighed and randomly distributed into three experimental groups. During the experimental period, the birds with access to pasture had access to outdoor run during the day light (8.00 am-6.00 pm). Water and feed were provided ad libitum.

Experimental Diets

The diet was formulated to meet the dietary recommendation for guinea fowl under tropical condition. The NRC (1984) recommendations for amino acids and energy were used as a reference for diet formulation.

Table 1: Composition (g/kg) of experimental diets

Ingredient	0-4weeks	5-8weeks	9-16weeks
Maize	540.00	500.00	473.00
Soybean meal	163.00	140.00	60.00
Fishmeal	60.00	20.00	10.00
Wheat offal	35.00	150.00	300.00
Groundnut cake	160.00	125.00	65.00
Bone meal	20.00	40.00	40.00
Limestone	15.00	18.00	45.00
Salt (NaCl)	2.50	2.50	2.50
*Premix	2.50	2.50	2.50
Methionine	1.00	1.00	1.00
Lysine	0.50	1.00	1.00
TOTAL	100.00	100.00	100.00
Calculated Analyses			
Metabolizable Energy(MJ/Kg)	12.15	11.54	10.97
Protein (%)	24.09	20.23	15.59
Fat (%)	4.92	4.36	3.85
Fiber (%)	3.48	4.03	4.47
Calcium (%)	1.24	1.79	2.70
Av. Phosphorus (%)	0.70	0.87	0.77

*1 kg contains: Vit A: 10,000,000IU, Vit D3: 2,000,000 IU, Vit. E: 12,000 IU, Vit. K3: 2,000mg, Vit. B1: 1,500mg, Vit. B2: 5000mg, Vit. B6: 1500mg, Vit. B12: 10,000mg, Biotin: 20mg, Niacin: 15,000mg, Panthotenic Acid: 5000mg, Manganese: 75000mg, Zinc: 50,000mg, Iron: 25,000mg, Copper: 5,000mg, Iodine: 1,000mg, Selenium: 100mg, Cobalt: 300mg, Choline: 150,000mg, Antioxidant: 125,000mg

Meteorological observations

The ambient temperatures and relative humidity at the level of the birds in the pen at 08:00 and 16:00

were monitored with the aid of hygrometer throughout the experimental period. The values are presented in Table 2.

Table 2: Average daily values for meteorological parameters observed during the experimental period

Time	Parameter	Values
08:00h	Ambient temperature (°C)	27.40
	Relative humidity (%)	90.50
16:00h	Ambient temperature (°C)	33.10
	Relative humidity (%)	75.00
Average	Ambient temperature (°C)	30.25
	Relative humidity (%)	82.75

Data Collection

Reproductive Traits

Twelve birds in each treatment group at week 32 were deprived feed and water overnight prior to slaughtering to facilitate gut emptying. Birds were killed by cervical dislocation and then dissected for determination of the weights of liver, oviduct, and oviduct length. Ovaries were removed for assessment of ovarian morphology (ovary weight, weight and the number of small [5-10 mm diameter] follicles and large [>10 mm diameter] yellow hierarchical follicles). Oviduct length was also recorded.

Dissection and measurement of weight and length of gastrointestinal tract in GIT segments

At 32 weeks, eight bird from each housing system were randomly selected, killed, weighed and dissected. The birds were killed by cervical dislocation. The spleen and liver were dissected and weighed. The GIT was cut into gross morphological segments: crop, gizzard, small intestine and large intestine weights of the segments were taken after the digesta within the different segments was collected and the GIT segments were rinsed in tap water, dried separately with paper towels. The weights were recorded.

Blood Glucose Determination

Blood samples of eight birds per treatment (selected randomly) were collected from jugular veins into tubes (having ethylenediaminetetraacetic acid (EDTA) as anti-coagulant) was collected for determination of blood glucose. The glucose level was determined by the method described by Barham and Trinder (1972).

Physiological measurements

Rectal temperature (RT)

A digital thermometer was inserted through the cloaca inside the rectum of the birds. Each bird was restrained lightly and calmly and the reading lasted until the thermometer beeped.

Respiratory Rate

This was measured by counting the movement of abdominal region or the vent per minute using a stop watch according to Harrison and Biellier (1968).

Statistical design and Analysis

The data collected were analyzed using a completely randomized design. All the data collected were subjected to Analysis of Variance using SAS (1998) statistical package while significant means ($P < 0.05$) were compared using Duncan's Multiple Range Test contained in the same package.

Results

The result on the effect of housing systems on reproductive parameters of guinea fowl is shown in Table 3. The body weight of the birds in the deep litter and free range were similar but that of the free range was higher ($P < 0.05$) than that of the battery cage. There was no difference between the body weights of the birds on battery cage and that of the deep litter. The ovary weights of the birds on the free range was significantly higher ($P < 0.05$) than that of the deep litter while the weight in the deep litter was higher than that of the ovaries of the birds raised in the battery cage. The weights of the oviducts of the birds kept on the free range was significantly higher than those of the deep litter and battery cage while there was no difference between the weights in the deep litter and battery cage. The liver weights were similar in the birds kept in deep litter and free range but higher ($P < 0.05$) than that of battery cage. Large yellow follicles (LYF) was higher in the fowl in the free range than that of the deep litter while that of the deep litter was higher ($P < 0.05$) than that of the battery cage. Small yellow follicles (SYF) was higher in the fowl raised in the free range than those of the deep litter and battery cage but those of battery cage and deep litter was similar ($P > 0.05$). The abdominal fat pad was similar in the fowl kept on the free range and deep litter but higher ($P < 0.05$) than that of the battery cage.

Table 3: Effects of housing systems on the reproductive parameters of guinea fowl

Parameters	Housing systems			SEM
	Deep litter	Battery cage	Free range	
Body weight (g)	1.44 ^{ab}	1.43 ^b	1.47 ^a	0.01
Ovary weight (g)	5.20 ^b	4.15 ^c	6.07 ^a	0.19
Oviduct weight (g)	17.65 ^b	17.13 ^b	18.75 ^a	0.20
Oviduct length (cm)	43.05 ^b	37.97 ^c	47.12 ^a	0.98
Liver weight (g)	25.00 ^a	22.20 ^b	25.60 ^a	0.51
LYF	3.83 ^b	3.00 ^c	5.33 ^a	0.27
SYF	12.67 ^b	11.50 ^b	14.82 ^a	0.44
AFP	12.03 ^a	10.70 ^b	13.00 ^a	0.29

^{abc} Means within rows with different superscripts are significantly different ($P < 0.05$)

Legends:

LYF: Large yellow follicles

SYF: Small yellow follicles

AFP: Abdominal fat pad

Gastrointestinal Tract Parameters

The effects of housing systems on gastrointestinal tracts development in guinea fowl is shown in Table 4. The weights of gizzard of the birds in the deep litter and free range were similar but that of the deep litter was higher ($P < 0.05$) than that of the battery cage. The birds on free range and battery cage also recorded similar weights. The spleen weights in the birds kept on the free range was higher ($P < 0.05$) than that of the deep litter while that of

the deep litter was higher ($P < 0.05$) than that of the battery cage. Similar trend was observed in the weights of gizzard and small intestine. The weights of the crop of the birds raised on the deep litter and battery cage was similar. The birds on the free range however had higher ($P < 0.05$) weights than those of the battery cage and deep litter. The weights of large intestine was comparable ($P > 0.05$) in fowl kept in the deep litter and free range but significantly higher than that of the battery cage.

Table 4: Effects of housing systems on gastrointestinal tracts development in guinea fowl

Parameters	Housing systems			SEM
	Deep litter	Battery cage	Free range	
Empty gizzard (g)	47.67 ^a	39.33 ^b	45.50 ^{ab}	1.44
Spleen (g)	1.97 ^b	1.18 ^c	2.37 ^a	0.13
Gizzard (g)	58.73 ^b	50.17 ^c	61.42 ^a	1.18
Empty crop (g)	6.15 ^b	5.82 ^b	7.37 ^a	0.18
Small intestine (g)	17.35 ^b	16.55 ^c	19.00 ^a	0.27
Large intestine (g)	18.02 ^a	15.75 ^b	19.10 ^a	0.39

^{abc} Means within rows with different superscripts are significantly different ($P < 0.05$)

Blood glucose levels

The effect of housing system on the blood glucose of guinea fowl is shown in Table 5. The glucose level in

the birds on deep litter was similar ($P > 0.05$) to that of the battery cage but significantly higher than those of the birds on the free range

Table 5: Effect of housing system on the blood glucose of guinea fowl

Housing systems	Blood glucose (mg/dl)
Deep Litter	219.00±2.98 ^a
Battery cage	218.50±2.40 ^a
Free range	198.17±3.03 ^b

^{ab} Means within column with different superscripts are significantly different ($P < 0.05$)

Physiological Traits

Table 6 shows the effects of housing systems on rectal temperature, heart rate and respiratory rate in guinea fowl. The rectal temperature of the birds reared in battery cages was higher ($P < 0.05$) than those of deep litter and free range while there was a similarity in the birds on free range and deep litter. There was no difference ($P > 0.05$)

in the heart rate in the birds across the housing systems. However, the respiratory rate of the birds in the battery cage was higher ($P < 0.05$) than those of the birds on deep litter and free range. The respiratory rate of the birds on the free range was significantly higher than that of the deep litter.

Table 6: Effects of housing systems on rectal temperature, heart rate and respiratory rate in guinea fowl

Parameters	Housing systems			
	Deep litter	Battery cage	Free range	SEM
Heart rate	142.40	168.00	165.20	5.96
Rectal temperature	40.84 ^b	42.21 ^a	40.27 ^b	0.23
Respiratory rate	41.60 ^c	74.40 ^a	61.10 ^b	3.09

^{abc} Means within rows with different superscripts are significantly different ($P < 0.05$)

Discussion

The weights of the guinea fowl on the free range were higher than those of the guinea fowl on the battery cage. This is at variance with observations of Castellini et al. (2002), who reported that outdoor treatments reduced growth rate compared to the conventional housing. Abbas et al. (2008) reported that temperature and photoperiod have the potential to influence growth. The lower body weight recorded in the battery cage may be due the fact the birds' welfare were compromised as a result of the fact that they were kept in total confinement (battery cage).

Gilbert et al. (1993) reported that there were two mechanisms controlling the size and dynamics of forming of yellow follicles: one controlling the follicle growth and other controlling the atresia thereby leading to continuity in laying of eggs and pauses are regulated.

The heavier oviduct and ovary weights of the guinea fowl on the free range is an indication of an accelerated rate of reproductive development. This difference in reproductive development may be related to the early sexual maturation of the guinea fowl on the free range. Additional proteins obtained by the birds from the plants on the free range may have been contributory to higher reproductive organs development. This corroborates the observation of Robinson et al. (1998). The pronounced increase in ovary and oviduct weights in the hens on the free range may be considered as a good indicator of the potential productivity as this was accompanied by increase in large yellow follicles and small yellow follicles that may be related to the rate of laying (Enaiat et al., 2009).

Our observation of higher oviduct weight in the guinea fowl kept on the free range in this present study is in agreement with the findings of Klein et al. (2013) who reported that free-range hens had significantly heavier oviduct weights than oviducts of battery cage.

The higher liver weights in the birds in free range and deep litter suggests that the liver can respond quickly to changes in the metabolic status. The fact

that the liver weights of the guinea fowl on free range was higher than those in the battery cage may also indicate that the fowl are capable of metabolizing plants consume on free range for production. Indeed the liver is the main source of egg proteins and yolk materials (Bourin et al., 2012). The higher liver weights also corresponds to the follicle recruitment in the guinea fowl kept in the free range in this study.

Several metabolic changes are reflected in the contents of glucose in blood. Adverse effects of environmental stress on domestic birds have shown a marked increase in blood glucose concentration (Donkoh, 1989) Thus, it is apparent that the inhibition of performance and production in heat-stressed birds is mediated via the blood glucose. Normal body functions of birds are efficient if the body temperature is kept constant or at least maintained within narrow limits. In the present study, there was an elevated plasma glucose level of the guinea fowl in the battery cage and deep litter housing systems than that obtained from the birds on the free range. This is at variance with the findings of Pavlik et al. (2007) who reported that housing system did not prove any effect on the concentration of glucose in laying hens raised in conventional cage system, enriched cage system and deep litter system. The poor performance recorded for the guinea fowl kept in the battery cage in this study may be explained by the stress levels of the birds as shown by the blood glucose level. The stress level may have elicited gluconeogenesis, in which amino acids are converted to glucose, and therefore blood glucose levels increased (Siegel and van Kampen, 1984; Malheiros et al., 2003). This may indicate that the conventional battery cage is not appropriate for housing guinea fowl.

The guinea fowl reared on deep litter and free range had lower rectal temperature compared to the caged fowl in the battery cages. The observed variation in the rectal temperature of the guinea fowl in the different housing types could be attributed to the fact the fowl on the free range and deep litter had greater space which enhanced air circulation and thermal changes between the

birds and the environment. This observation corroborates the findings of Barbosa et al. (2006) who reported a higher rectal temperature in the hens reared in battery cage than that of the deep litter housing system.

As a result of the findings in this study, it can be concluded that rearing guinea fowl on free range improved the reproductive and physiological performance of the birds.

Conflict of Interest

The authors declare that they have no conflict of interest.

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