Tropical and Subtropical Agroecosystems, 15 (2012) : 511 - 523

FREE RANGE AND DEEP LITTER HOUSING SYSTEMS: EFFECT ON PERFORMANCE AND BLOOD PROFILE OF TWO STRAINS OF COCKEREL CHICKENS

[SISTEMAS DE CIELO ABIERTO Y CAMA PROFUNDA: EFECTO SOBRE EL RENDIMIENTO Y PERFIL SANGUINEO DE DOS RAZAS DE GALLOS]

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SUMMARY

This study was conducted to determine the performance and blood profile of one hundred and fifty cockerel chickens each of Harco Black and Novogen strains raised on deep litter and free range production systems. Each production system was allotted 150 chicks in three replications of 25 chicks per strain. The birds on deep litter production system were fed *ad libitum* while each of the birds on free range was fed 50 % of its daily feed requirement. The birds were weighed weekly. Blood plasma and serum were collected at the 4th and 12th weeks for laboratory analyses. Data generated were subjected to analysis of variance in a 2×2 factorial arrangement. Novogen strain consumed less feed ($P<0.05$) on free range and had the best feed: gain (2.72 ± 0.14). At the 4th week, strain significantly ($P<0.05$) affected the packed cell volume, haemoglobin, red blood cell count, serum total protein, serum albumin and mean corpuscular haemoglobin concentration and was evident at the 12th week. In conclusion, Novogen strain should be raised on free range for a better performance in terms of feed: gain but in the blood profile, the two strains of birds could be managed in any of the production systems.

Keywords: Production system; performance; feed: gain; blood profile; cockerel chicken.

RESUMEN

Este estudio se condujo para determinar el rendimiento y perfil sanguíneo de ciento cincuenta gallos de las razas Harco Black y Novogen desarrollados en sistemas de cama profunda y cielo abierto. Cada sistema de producción tuvo 150 pollitos en tres replicas de 25 pollos por cada raza. Las aves sobre el sistema de cama profunda se alimentaron ad libitum mientras que las aves en el sistema de cielo abierto se alimentaron con 50% de sus requerimientos diarios. Las aves se pesaron semanalmente. Se colectó plasma sanguíneo y suero en la 4a y 12a semana para el análisis de laboratorio. Los datos generados se analizaron mediante un análisis de variancia en un diseño factorial 2x2. La raza Novogen consumió menos alimento ($P<0.05$) en el sistema de cielo abierto y tuvo la mejor ganancia de peso (2.72 ± 0.14). Al cabo de la 4th semana la raza afectó el volumen celular, hemoglobina, el conteo de células rojas, proteína total del suero, albumina y la media de concentración corpuscular de hemoglobina ($P<0.05$) y fue evidente a la 12a semana. En conclusión, la raza Novogen debería ser explotada en cielo abierto para un mejor rendimiento en términos de alimento: ganancia pero el perfil sanguíneo de ambas razas de aves podría adecuarse en cualquiera de los sistemas de producción.

Palabras clave: Sistema de producción; Alimento: ganancia; Perfil sanguíneo; Gallo.

INTRODUCTION

In recent years, the increased emphasis on regulation has driven changes on how animals are fed and managed and will continue, possibly in an accelerated manner with much pressure on reducing costs to increase supply through the use of larger and more integrated facilities (McWilliams, 1993) in a sustainable production system. In sustainable poultry production, Appleby *et al.* (1992) opined alternatives to confinement housing and cages, such as access to range which is

considered an environmentally sound and economically viable approach. The free-range production system focuses on low-input strategies and support of rural communities by maintaining the family farm. It has been estimated that 80 % of the poultry population in Africa is found in this production system, sometimes called low input/output system. Little attention is given to this mean of production by many development programmes though from 30 to 100 % of the animal protein consumed is from this source. This low input/output system has been a traditional component of small farms all over the developing world (Elson, 1988) including Nigeria. Poultry production is a full time job for many and is considered to be a commercially viable enterprise contributing significantly to Gross National Product (GNP). The environments to which poultry birds are exposed include the housing system, the feed they consume, climatic factors and management systems which affect the performance of the birds (Abeke *et al.*, 1998; Isiaka, 1998).

Cockerel production management is easier than the broiler production particularly in the rural areas where modern facilities including electric supply are not available. Consumers choice, lower chick price, lower mortality and morbidity, lower management cost, lower initial investment, better market demand, low abdominal fat, less disease susceptibility, more organoleptic preference, family labour utilization and easy management are the strategic advantages for cockerel rearing. Cockerel rearing has attained great importance due to its hardiness and relatively high survival rate, though its production does not appear profitable due to its relatively long maturity period. However, it is well documented (Okosun, 1987) that its live weight increases with age unlike in spent hens in which the live weight decreases with increasing egg production and then age. Housing may not be provided (Huchzermeyer, 1973; Kuit *et al*., 1986; Atunbi and Sonaiya, 1994) and where this is done, usually local materials are used for construction (Atunbi and Sonaiya, 1994). The feed resources vary depending on local conditions and the farming system. Management is minimal with some variations of gender roles in the activities (Olayiwole, 1984; Achiempong, 1992). Despite this low-input by rural farmers on their production, free range birds play many socio-economic roles and provide valuable protein accounting for about 20 % of the protein consumed in developing countries originates from poultry products (Permin, 1997). Although the present poultry industry offers affordable products, many farmers are interested in alternative poultry production system of which the free range is the option particularly in meeting the growing demand for meat and eggs produced by birds that are allowed to express their natural behavior. Little research has been published on rural poultry production, despite the fact that 80% of the poultry population in Africa is kept by the households in their 'backyard' (Permin, 1997; Kitalyi, 1998).

Traditionally, researches are focused on nutrition; hence, much information is available on effect of different energy and protein intakes (Macleod, 1990) but not much documentation on the attendant effects of free range production system on the performance of cockerels. Harco black cockerel used in this study was the male type of the brown-egg laying hybrid which has black feathers with a white spot on the head. The strain originates from America. The thick plumage of this strain protects it from all weather conditions and its highly developed natural immune system gives it the potential to have a long productive life. Being very docile, the birds are not easily stressed which also makes the bird easy to keep free range (www.balbonatetra.com). The Novogen white strain cockerel is the male type of the egg-type Novogen white which has also been developed to perform in various environments and very easy to manage without specific techniques of management (www.novogen-layers.com). The free-range system was adopted to harvest the advantages of increasing the comfort and enhancing the birds' welfare as well as eliminate routine medication and waste disposal problems. In addition, the study sought to compare the performance and blood profile of the common cockerel chicken, Harco black reared in this part of the world mainly on free range and a novel strain; Novogen cockerel.

MATERIALS AND METHODS

Site location

The study was carried out for free range at Bajoo Farms in Odeda Local Government Area of Ogun State, Nigeria located at an altitude of 169 m, latitude 7^0 10' 50''N and longitude 3^0 26' 37''E and for the birds on deep litter at Ayo farms in the same local government area but at an altitude of 175 m, latitude 7^0 10' 50''N and longitude 3^0 24' 49''E. The climate is humid with a mean annual rainfall of 1037 mm. The annual mean temperature and humidity is 34.7 ^oC and 82 %, respectively.

Experimental Birds and management

A total of 300, cockerel chicks from two strains (150 each of Harco Black and Novogen) were used for the study. The birds were sourced from a reputable hatchery in Oyo State, Nigeria. The birds were vaccinated for four weeks before the commencement of the experiment after which no medication was employed. The birds were differentiated on strain basis (150 birds of Harco Black and150 birds Novogen strains, respectively). These were further divided into twelve replicates of 25 birds each using colored numbered rings for identification. In other words, there were 75 birds

each of Harco Black and Novogen in either deep-litter or free-range.

Housing

The birds were brooded on deep litter for 4 weeks in confinement. Thereafter, 150 chicks (were left to roam freely for the remaining 12 weeks of the study on 727.27m² of land with a floor space of 4.84 m²/bird while the other 150 chicks were wholly confined for the period of the experiment on a floor space of about 0.25 m^2/ bird and an average light hours of about 12 h/day. In the free-range system, a mini-shelter with provision for perching of the birds was constructed on the site to protect the birds from rain and allow the birds to exhibit their natural behaviour.

Experimental Diet

The birds on range grazed on pasture which was supplemented on daily basis with a calculated ration containing 17%CP and 13.34 ME KJ/Kg. Each bird on free range was maintained on 50% (24 g/b/d) of its daily feed requirement of about 48 g/b/d for 12 weeks of the experiment. However, birds managed in deep-litter were given feed of the same nutrient and water *ad libitum*. The birds on free-range had access to the following Scavengeable Feed Resource Base (SFRB): household cooking waste, cereal and cereal by-products, vegetable weed particularly *Talinum triangulare,* shrubs, sedges and grasses (including *Platostoma africanum, Momordica charantia Linn, Heliotropium indicum Linn, Cyperus iria Linn, Eragrostis tenella and Eleusine indica Graertn),* animal proteins (maggots and earthworms) and commercially (experimental diet) prepared diet.

As described by Roberts (1999) and enunciated by Sonaiya *et al.* (2002) the value of the SFRB was estimated by weighing the amount of daily feed product/household waste generated by each of twelve (12) families around the experimental site as parameter 'H' divided by the proportion of feed product/ household waste found in the crop of the scavenging birds (assessed visually) as parameter 'p' and multiplied by the percentage of household (66.67%) that kept chickens 'c'. The formula used was:

SFRB = H/p * c

The average daily household leftover available for birds on the range was 123.3 g/d and the SFRB was 35.8 g/b/d including the supplemented diet.

Performance characteristics

The birds were weighed at the beginning of the experiment (4^{th} week of age) and then weighed on a weekly basis. Birds were weighed in morning before giving feed and water. The feed intake and feed: gain were also calculated.

Blood Analysis

At the 4^{th} and 12^{th} weeks of the experiment, blood samples (2 ml each) were collected from each of 3 birds into Ethylene Diamine Tetra-Acetate (EDTA) bottles for haematological analysis. Blood samples were analyzed for Packed Cell Volume (PCV), Erythrocyte Sedimentation Rate (ESR), Red Blood Cell (RBC), White Blood Cell (WBC); Haemoglobin (Hb) concentration was determined using improved Neubauer haemocytometer, Wintrobes microhaematocrit, and colorimetry cyanomethaemoglobin method respectively (Swenson, 1977; Coles, 1986). Differential Leucocytes Count (DLC) was determined using Write's stain. All these methods are standard methods used for haematological parameters (Schalm, 1986). Serum total protein, albumin and globulin were analyzed colorimetrically using diagnostic reagent kit.

The percentage of packed red cells in the blood was determined using the haematocrit centrifuge method as described by Dacie and Lewis (1995). A capillary tube was dipped into sample to fill it to about three-quarter length. Excess blood on the side of the capillary tube was wiped off in other to keep accurate reading. One end of the tube was then sealed over a Bunsen burner. The capillary tube was put into a micro-haematocrit reader and the level of packed cells was regarded as the packed cell volume.

The estimate of the total number of white blood cells was carried out immediately after collection of blood sample from experimental animals using Neubauer haemocytometer counting chamber (Jain, 1986). From blood sample of test animal 0.2 ml of blood sample was pippetted and mixed with 4 ml of WBC diluting fluid (WBC fluid made up of 3 % aqueous solution of acetic acid and 1 % gentian violet). The sample was then put into the haemocytometer and cell counted and expressed as 10^9 WBC per litre of blood.

The haemoglobin concentration (Hb) of each blood sample was determined cyanomethaemoglobin method (Jain, 1986). From each blood sample of experimental animal, 20 µl of blood was mixed with 4 ml of modified Drabkin's solution (Drabkin's solution was prepared by mixing 200 mg potassium ferricyanide, 50 mg potassium cyanide and 140 mg potassium dihydrogen phosphate; volume was made up to 1 liter with distilled water and pH adjusted to 7.0). The mixture of blood sample experimental animal and Drabkin's solution was allowed to stand for 3 minutes before the haemoglobin concentration was read using a spectrophotometer at wavelength of 540 nm. The actual value of haemoglobin was extrapolated from a standard curve.

The mean corpuscular haemoglobin concentration, or MCHC, is a measure of the concentration of haemoglobin in a given volume of packed red blood

cells. It was reported as part of a standard complete blood count. It is calculated by dividing the haemoglobin by the packed cell volume (PCV). It was calculated using the formula: MCHC (grams/liter) = Hb / PCV (Van *et al.,* 2001).

The mean corpuscular haemoglobin, or "mean cell haemoglobin" (MCH), is the average mass of haemoglobin per red blood cell in a sample of blood. It is reported as part of a standard complete blood count. It is calculated by dividing the total mass of haemoglobin by the number of red blood cells in a volume of blood. It was calculated using the formula: MCH (grams/cell) = Hb / RBC (Van *et al.,* 2001).

The mean corpuscular volume, or "mean cell volume" (MCV), is a measure of the average red blood cell volume that is reported as part of a standard complete blood count. It was calculated using the formula: MCV (liter/cell) = PCV/ RBC (Tønnesen *et al.,* 1986).

Also, blood samples (2 ml each) were collected from each of 3 birds for biochemical analysis. In the analysis of the serum total protein, the following were prepared:
Solution 1: Consist 45g of sodium potassium tetrates (Rochelle salt) dissolved in 400 ml of 0.2 N NaOH in a beaker. 15g of $CuSO_4.5H_2O$ and 5 g of potassium iodide were added and dissolve completely by stirring. The mixture was rinsed with 0.2 N NaOH and poured into the flask. The solution was made up to 1 litre with 0.2 N NaOH.
Solution 2: Consist of 0.5 % potassium iodide (KI) in 0.2 N NaOH in Biuret reagent. An aliquot of solution 1 was diluted to 250 ml with solution 2.
An aliquot of 0.1 ml of solution 2 was pipette into a test tube and 2.9 ml H_2O was added. The blank consisting of 0.3 ml distilled water was pipette into the test tube.

To each test tube 0.3 ml of biuret reagent was added and all tube was incubated in 37 ^oC water bath for 10 minutes. The readings were taken at 540 nm after setting the instruments to zero with the blank solution.

Serum total protein (STP) of each sample was calculated using the formula:

$$\text{STP (g/100 ml)} \quad \frac{\text{Optical density of test}}{\text{Optical density of standard}} \times \frac{\text{Concentration of standard}}{1}$$

(Kaneko, 1989).

The serum albumin and globulin were determined as described below:

The bromocresol purple method was used to determine the serum albumin. The bromocresol purple is a stable complex with abundance maximum at 600 nm. The intensity of the colour produce is directly proportional to the albumin concentration of the sample. 4 ml of bromocresol was added to 0.02 ml of each of the serum samples bromocresol purple solution (4 ml) was used as blank. The content of each tube was mixed and left at room temperature for 10minutes at pH 4.2 ± 0.05. After 10 minutes, the test solution was read at a wavelength of 640 nm in a spectrophotometer set to zero with the blank solution. Value of the sample was calculated using the formula:

$$\text{Serum albumin (g/100 ml)} = \frac{\text{Optical density of test}}{\text{Optical density of standard}} \times \frac{\text{concentration of standard}}{1}$$

$$\text{Serum globulin} = \text{Serum total protein (STP)} - \text{Albumin (AB)}$$

Statistical Analysis

The data generated were subjected to a 2-way analysis of variance in a 2×2 factorial experimental layout. Significantly ($P<0.05$) different means were separated using Duncan's Multiple Range Test as contained in SAS (1999) package. The performance of the strains of cockerel chickens reared in the production systems (deep litter and free range) was regressed against the weeks of production (SAS, 1999). The model in the factorial experimental layout is as shown below:

$$Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + \varepsilon_{ijk}$$

Where,
Y_{ijk} = individual observation
μ = general mean

A_i = effect of Factor A (production systems: free range and deep litter)
B_j = effect of Factor B (strains: Harco black and Novogen)
$(AB)_{ij}$ = effect of interaction AB (production system*strain)
ε_{ijk} = experimental error.

RESULTS

The results on the main effect of production system and strain on the performance of cockerel chickens (Table 1) showed no significant (P>0.05) differences on all the parameters considered except in the feed intake (g/b/d) and mortality (%) which was highest (70%) in birds on free-range. Birds on deep litter consumed more than those reared on free range. In the strains, Novogen recorded a lower intake of 37.2 ± 3.5 g/b/d compared to Harco black strain. In the interaction, the lowest (P<0.05) feed intake of 34.3 ± 0.4 g/b/d was obtained in Novogen strain on free range with an attendant best (P<0.05) feed: gain of 2.7 ± 0.1 as shown in Table 2. However, Novogen strain on free range recorded the highest (P<0.05) value of 38% in mortality while Harco black on deep litter recorded the least value (6%).

In Figure 1, it could be observed that the performance in terms of weight gain of Novogen strain of cockerel on deep litter production system was better when compared to those on free range. This finding was corroborated in Figure 2 on the rate of change of weight of Harco black strain of cockerel chicken in the two production system.

In Figures 3 and 5, birds on deep litter production system experienced linear growth with the regression equations: Y = 0.109 + 0.103 weeks (S = 0.066; R^2= 97.6) and Y = 0.103 + 0.104 weeks (S = 0.068; R^2= 97.5) for Novogen and Harco black strains, respectively. However, in Figures 4 and 6, the growth of the strains of birds on free range was exponential with the equations: $Y = 0.157e^{-0.166 \text{ weeks}}$ (S = 0.180; R^2= 93.4) and $Y = 0.148e^{-0.173 \text{ weeks}}$ (S = 0.137; R^2= 96.4) for Novogen and Harco black strains, respectively.

Table 1: Main effect of production system (±SE) and strain (±SE) on the performance of cockerel chickens

	Production system		Strain	
Parameters	Deep-litter	Free-range	Harco black	Novogen
Initial weight (g)	173.3 ± 6.7	176.7 ± 5.6	168.3 ± 7.0	181.7 ± 3.1
Final weight (g)	1345.0 ± 37.9	1250.0 ± 34.2	1295.0 ± 47.9	1300.0 ± 34.8
Weight gain (g/b/d)	13.9 ± 0.4	12.5 ± 0.4	13.4 ± 0.6	13.3 ± 0.4
Feed intake (g/b/d)	42.5 ± 1.3^a	35.8 ± 0.8^b	41.1 ± 4.3^a	37.2 ± 3.5^b
Feed: gain	3.1 ± 0.1	2.8 ± 0.1	3.1 ± 0.3	2.8 ± 0.2
Mortality (%)	20.0 ± 1.3^b	70.0 ± 6.2^a	38.0 ± 4.1^b	52.0 ± 3.1^a

[a,b,c,d]: Means in the same row by factor with different superscripts differ significantly (P<0.05)
g/b/d=gram per bird per day

Table 2: Effect of interaction between production system and strain (±SE) on the performance of cockerel chickens

Production system	Deep-litter		Free-range	
Strain	Harco black	Novogen	Harco black	Novogen
Parameters				
Initial weight (g)	166.7 ± 12.0	180.0 ± 5.8	170.0 ± 10.0	183.3 ± 3.3
Final weight (g)	1345.0 ± 83.3	1350.0 ± 15.3	1250.0 ± 50.0	1250.0 ± 57.7
Weight gain (g/b/d)	13.9 ± 0.9	13.9 ± 0.2	12.9 ± 0.7	12.7 ± 0.7
Feed intake (g/b/d)	44.9 ± 0.6^a	39.9 ± 1.4^b	37.3 ± 0.7^b	34.3 ± 0.4^c
Feed: gain	3.2 ± 0.2^a	2.9 ± 0.1^{ab}	2.9 ± 0.2^{ab}	2.7 ± 0.1^b
Mortality (%)	6.0 ± 0.0^d	14.0 ± 1.3^c	32.0 ± 3.4^b	38.0 ± 3.3^a

[a,b,c,d]: Means in the same row with different superscripts differ significantly (P<0.05)
g/b/d=gram per bird per day

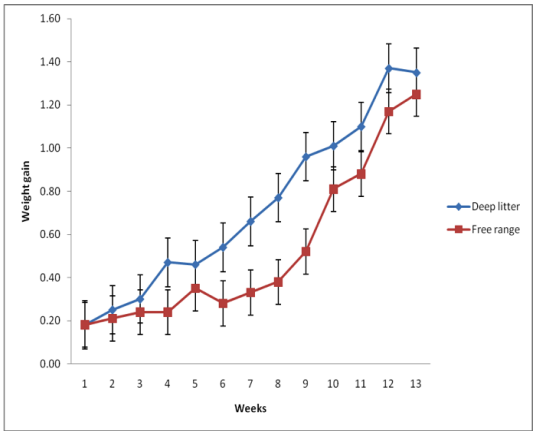

Figure 1: Change of weight of Novogen strain of cockerel chicken on free range and deep litter litter production systems.

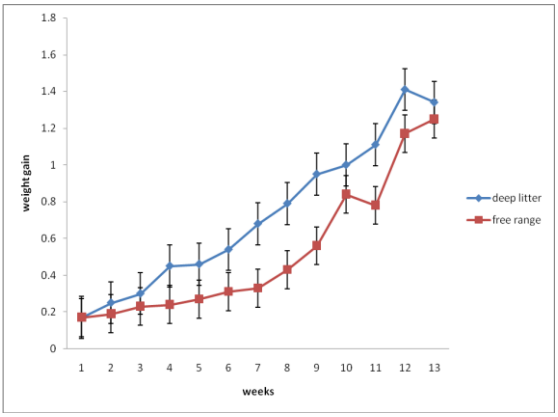

Figure 2: Change of weight of Harco black strain of of cockerel chicken on free range and deep litter production systems.

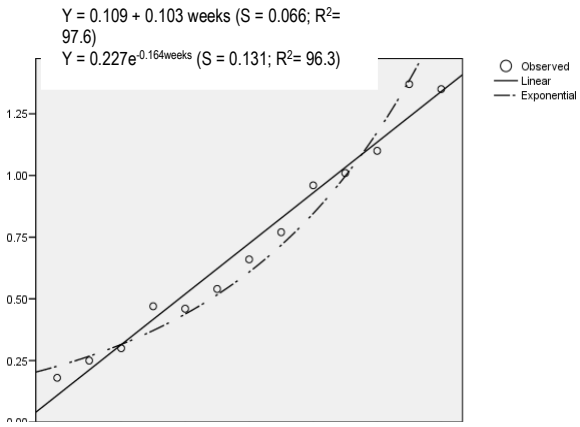

Figure 3: Curve fit of the growth of Novogen strain on deep litter production system

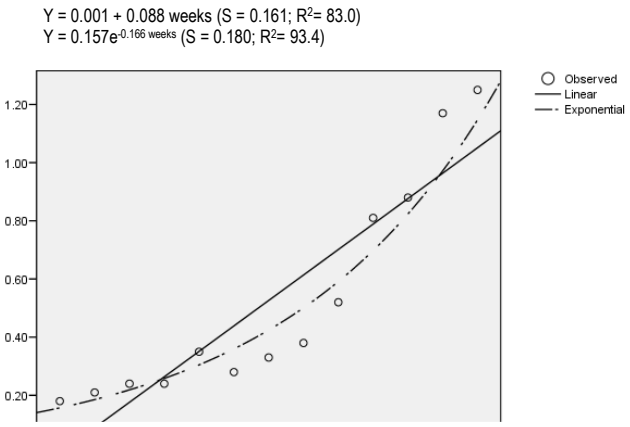

Figure 4: Curve fit of the growth of Novogen strain on free range production

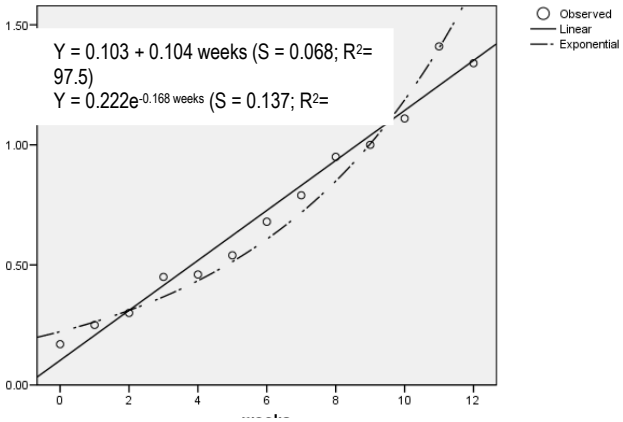

Figure 5: Curve fit of the growth of Harco black strain on deep litter production system.

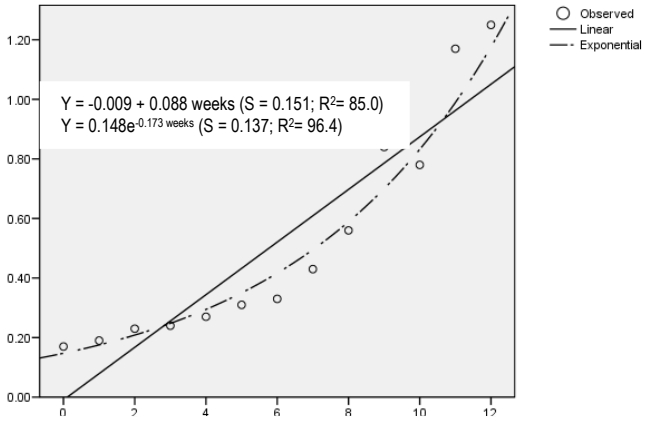

Figure 6: Curve fit of the growth of Harco black strain on free range production system

The effect of strain on the blood parameters of cockerel chickens at the 4th week is presented in Table 4. Significant (P<0.05) difference was found within strain with Novogen having the highest values of 21.3, 7.2, 2.3, 31.9,19.0 and 17.9 for PCV, Hb, RBC, total protein, albumin and MCHC, respectively and a least value of 0.2 for MCV.

The effect of production system and strain on the blood parameters of cockerel chickens at the 12th week is presented in Table 5. Significant (P<0.05) differences were found in PCV, Hb and MCHC within the strains with Harco black having the highest values of 30.7, 10.4, and 26.0, respectively.

The effect of interaction between the production system and the strain on the blood parameters of cockerel chickens at the 12th week is presented in Table 6. Significant (P<0.05) difference was found in the interaction between the production system and the strain for WBC with Novogen having the highest and the least values of 3.0 and 2.9 for birds managed in deep litter and free range, respectively while Harco black had the highest and least values of 2.8 and 2.0 for birds managed in deep litter and free range, respectively in RBC.

Table 4: Effect of strain ±SE on the blood parameters of cockerel chickens at the 4th week.

	Strain	
Parameters	Harco black	Novogen
PCV (%)	14.7 ± 0.8^{b}	21.3 ± 1.1^{a}
Hb (g/dl)	4.9 ± 0.2^{b}	7.2 ± 0.3^{a}
WBC ($\times 10^{3}$/l)	2.6 ± 0.1	2.5 ± 0.1
RBC (10^{6}/mm^{3})	1.5 ± 0.1^{b}	2.3 ± 0.1^{a}
ESR (MM/hr)	3.7 ± 0.2	3.7 ± 0.2
Total protein (g/dl)	22.4 ± 1.4^{b}	31.9 ± 2.6^{a}
Albumin (g/dl)	14.7 ± 1.3^{b}	19.0 ± 0.5^{a}
MCHC (%)	12.4 ± 1.6^{b}	17.9 ± 0.8^{a}
MCV (µm^{3})	0.3 ± 0.0^{a}	0.2 ± 0.0^{b}
MCH ($\times 10^{1}$/ gram)	3.2 ± 0.1	3.1 ± 0.0

[a,b]: Means in the same row by factor with different superscripts differ significantly (P<0.05)
SE – Standard Error

Table 5: Main effect of production system (±SE) and strain (±SE) on the blood parameters of cockerel chickens at the 12th week

	Production system		Strain	
Parameters	Deep litter	Free range	Harco black	Novogen
PCV (%)	28.3 ± 1.5	28.3 ± 1.2	30.7 ± 1.2^{a}	26.0 ± 2.1^{b}
Hb (g/dl)	9.6 ± 0.5	9.6 ± 0.4	10.4 ± 0.4^{a}	8.8 ± 0.7^{b}
WBC (10^{6}/mm^{3})	2.9 ± 0.1	3.0 ± 0.1	3.0 ± 0.0	2.9 ± 0.1
RBC ($\times 10^{12}$/l)	2.5 ± 0.2	2.1 ± 0.2	2.4 ± 0.2	2.2 ± 0.2
ESR (MM/hr)	3.0 ± 0.5	3.0 ± 0.6	3.0 ± 1.0	3.0 ± 0.6
Total protein (g/dl)	55.3 ± 2.3	55.3 ± 2.3	53.4 ± 4.5	57.4 ± 1.4
Albumin (g/dl)	26.1 ± 0.8	26.1 ± 2.3	25.6 ± 1.5	26.5 ± 0.6
MCHC (%)	24.0 ± 1.3	24.0 ± 1.0	26.0 ± 1.0^{a}	22.1 ± 1.7^{b}
MCV (µm^{3})	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0
MCH ($\times 10^{1}$/ gram)	3.8 ± 0.2	4.9 ± 0.5	4.7 ± 0.2	3.9 ± 0.3

[a,b]: Means in the same row by factor with different superscripts differ significantly (P<0.05)
SE = Standard error

Table 6: Effect of interaction between production system and strain (±SE) on the blood parameters of cockerel chickens at the 12th week

Production system	Deep litter		Free range	
Strain	Harco black	Novogen	Harco black	Novogen
Parameters				
PCV (%)	30.7 ± 1.2	26.0 ± 2.1	30.7 ± 1.7	26.0 ± 2.7
Hb (g/dl)	10.4 ± 0.4	8.8 ± 0.7	10.4 ± 0.6	8.8 ± 0.6
WBC (10^6/mm^3)	2.8 ± 0.0^{b}	3.0 ± 0.1^{ab}	3.2 ± 0.1^{a}	2.9 ± 0.1^{ab}
RBC ($\times10^{12}$/l)	2.8 ± 0.2^{a}	2.3 ± 0.2^{ab}	2.0 ± 0.2^{b}	2.2 ± 0.2^{ab}
ESR (MM/hr)	3.0 ± 1.0	3.0 ± 0.6	3.0 ± 0.8	3.0 ± 0.5
Total protein (g/dl)	53.4 ± 4.5	57.3 ± 1.4	53.4 ± 3.3	57.3 ± 2.3
Albumin (g/dl)	25.6 ± 1.4	26.5 ± 0.6	25.6 ± 1.2	26.5 ± 0.6
MCHC (%)	26.0 ± 1.0	22.1 ± 1.7	26.0 ± 1.4	22.1 ± 1.4
MCV (μm^3)	0.2 ± 0.0	0.2 ± 2.7	0.2 ± 0.0	0.2 ± 0.0
MCH ($\times10^1$/ gram)	3.8 ± 0.2	3.8 ± 0.3	5.6 ± 0.7	4.1 ± 0.7

^{a,b}: Means in the same row with different superscripts differ significantly ($P<0.05$)

DISCUSSION

The result of the performance of birds in deep-litter and free-range systems in terms of final weight, and average daily gains showed no significant effect. In general, the weight according to production systems was in descending order for birds on free range systems. This was expected because the chickens dispensed a lot of energy as they scavenged for feed in free-range system (Wood-Gush *et al.,* 1978). The results also agreed with the observations of Castellini *et al.* (2002) who reported that outdoor organic treatments reduced growth rate when compared to conventional system. The reduced feed intake of birds on free -range showed that intake of the birds on free range was being controlled by their requirements which are in consonance with the reports by Forbes (2006).

The production system affect the mortality rate as birds managed on free range had a higher mortality. This was similar to the findings of Muchadeyi *et al.* (2004) who reported that high mortality rate is considered the major constraint to village chicken production systems. The high mortality found in this study was due to rearing conditions of the chicks at an early age (from the 4th week on range), flooding and cold weather. The same causes of low survivability rates have been reported by (Guèye, 1998; Gondwe, 2004).

Strain had effect on the PCV, Hb, RBC, total protein, Albumin, MCHC and MCV. At the beginning of the study (4th week), lower PCV was detected and it gradually increased as the experiment advanced. This was similar to what the authors Kiferndorf and Keller (1990); Kollakowski and Keller (1990) and Gupta *et al.,* (2002) reported that strain and age had been implicated as factors that affect haematological parameters of a given species. This observation disagreed with the findings of Awotwi (1991) that there was no strain effect on hematological parameters of egg-type chicken.

The lowest and highest PCV were observed at the 4th week and 12th week, respectively. This corroborated the findings of Nirmalon (1973); Montes *et al.* (1983). The hemoglobin concentration (Hb) also increased with the advancement of the experiment, being lowest at the 4th week and highest at the 12th week. This was slightly higher than the values reported by Islam *et al.* (2004) but in the same range with those reported by Datta *et al.* (1994). Novogen had greater haemoglobin concentration compared to Harco black. Higher Hb in Novogen was an indication of strain difference. Oyewale (1987) reported a higher haemoglobin (Hb) concentration in Nigerian domestic fowls. The white blood cell also increased as the experiment advanced although there were no significant differences. The RBC was lowest at the beginning of the experiment and gradually increased as the experiment advanced. This was similar to the findings of Kai and Pranklin (1984) who reported that erythrocyte number is lower in early age and gradually increased with ages. Kundu *et al.* (1993) also reported a lower RBC in day-old chicks and higher in 3 months old chicks. The values of ESR in Harco black and Novogen are similar and also increased as the experiment advanced. The increase in values of ESR in this study was in accordance with those of Kundu *et al.* (1993).

CONCLUSION

It could be concluded that; Novogen strain on free range had a better performance in terms of feed:

gain. There were strain differences in the blood parameters with Novogen having the highest values for PCV, Hb, RBC, total protein, Albumin and MCHC, respectively, at the 4th week. While at the 12th week, Harco Black recorded the highest values in PCV, Hb and MCHC.

ACKNOWLEDGEMENT

The authors gratefulyl acknowledge the Institute of Food Security, Environmental Resources and Research (IFSERAR) of the University of Agriculture, Abeokuta, Ogun State, Nigeria for providing the aids-in-grant for the study.

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Submitted October 23, 2011 – Accepted November 28, 2011
Revised received November 30, 2011