


# Evaluation of access to different legume pastures on performance and welfare of broiler chickens during dry season under tropical environment

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## Abstract

There have been a plethora of studies on the effects of access to runs on chickens' welfare and behavioural repertoire with a paucity of information on the comparative advantage of various legume pasture and deep litter system. A total of 200-day-old unsexed Marshall Broiler chicks were weighed and assigned randomly into five experimental groups, viz. deep litter without access to run (DL), deep litter with access to *Stylosanthes hamata* (SH), *Stylosanthes guanensis* (SG), *Mucuna pruriens* (MP) and free run (FR) during dry season. Each treatment had 4 replicates of 10 birds. Data were collected on growth performance, behaviour, tonic immobility (TI), gait score and blood parameters. The data obtained were subjected to One-Way Analysis of Variance in a Completely Randomized Design. Results showed that the final body weight of birds in SH was significantly higher ( $p < .05$ ) than those of SH, MP, FR and DL which were comparable. The feed intake of the birds of DL, SH and FR was higher than those of the other treatment groups. The feed conversion ratio (FCR) of the birds on legume pastures was lower than those without access to pasture. The birds of SH, SG and MP spent higher ( $p < .05$ ) time drinking, preening, dust-bathing, spot pecking and walking standing behaviours while those in DL and FR spent more ( $p < .05$ ) time feeding. Generally, the gait score of the birds on the different legume pastures was similar but better than those without access to pasture. Tonic immobility of the DL birds was longer than that of FR whose duration was longer than those of the birds on the pastures. The study concluded that access to different legume pastures, particularly *Stylosanthes hamata*, improved the welfare of broiler chickens without adverse effect on the performance of the birds.

## KEYWORDS

broiler, Legume pasture, performance, welfare

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There is a scarcity of information on the comparative advantage of various legume pasture. *Stylosanthes hamata* improved the welfare of broiler chickens without adverse effect on the performance of the birds.

## 1 | INTRODUCTION

Poultry performance is influenced by the environment (Oke et al., 2016). Essentially, housing systems are necessary to protect birds from rain, physical hazards and extreme cold and heat (Panda, 1985). A sustainable poultry production requires suitable interaction with their environment (Boggia et al., 2010). Poor environmental conditions expose birds to stress and make them susceptible to diseases and stress (Dozier et al., 2005). In contrast, outdoor access can enhance comfort and decrease stress in birds (Blokhus et al., 2000). An outdoor run has been reported to improve the welfare of broiler chickens (Ruis et al., 2004). There have been growing concerns on the conditions under which chicken production are done and the resultant effects on the health of consumers (Wang et al., 2009). There has therefore been a search for an alternative production system, including pastured poultry production, in which chickens are reared outdoor in a natural environment (Chen et al., 2013; Smith et al., 2012). Pastured poultry production is important in reducing stress conditions and improving welfare status of chickens (Blokhus et al., 2000), while they also have the advantage of exercising their muscles (Remignon & Culioli, 1995).

Due to the perceived improved animal welfare and higher security, quality of meat and several health benefits associated with the consumption of the meat (Lewis et al., 1997; Latter-Dubois, 2000; Sioen et al., 2006; Attia et al., 2016; Attia et al., 2017), there has been a growing interest in poultry products from pasture by consumers in the past few decades (Fanatico et al., 2006; Latter-Dubois, 2000). It is believed that access to pasture improve birds' welfare (Sales, 2014) and also offers the birds access to worms, insects and fresh pasture (Glatz et al. 2005), thereby resulting in improved eggs and meat. Indeed, Ponte et al. (2004) indicated that access to pasture could improve meat quality as a result of availability of the bioactive substances in the plants, including xanthophylls and many anticarcinogenic and hypocholesterolemic compounds. Moreover, consumption of forage plants may provide additional protein and energy to the birds. On the other hand, Berg (2001) indicated that pastured poultry production could increase the exposure of birds to various pathogens, including *Campylobacter* and *Salmonella*. Also, weather elements, such as extreme temperatures, light intensity and photoperiod, are uncontrollable in pastured poultry (Fanatico et al., 2005; Wang et al., 2009).

Our previous studies (Oke et al., 2016) indicated that the performance of laying hens on legume pasture (*Stylosanthes hamata*) was better than grass pasture (*Cynodon dactylon*). Additionally, Ponte et al. (2008) indicated that pasture intake improved the performance of broiler chickens. However, there is scarcity of data on the comparative effects of access to different legume pastures on broiler

chickens in the tropical environments. It is not known whether different legume pastures could influence the welfare and performance of broiler chickens differently, particularly during the dry season in the tropical environment. The present study therefore sought to investigate the effect of access different legume pastures on growth performance and welfare of broiler chickens during dry season under tropical environment.

## 2 | MATERIALS AND METHODS

### 2.1 | Paddock establishment

Land dimension of 9.51 m × 13.45 m was ploughed and harrowed prior to the establishment of the paddock. The different legume seeds (*Stylosanthes hamata*, *Stylosanthes guianensis* and *Mucuna pruriens*) used were purchased from National Animal Production Research Institute, Shika, Zaria, Nigeria. Before establishment of paddock, *Stylosanthes hamata* (verano) and *Stylosanthes guianensis* (cook) were scarified using hot water treatment and air dried, then mixed with sandy soil and sown using drilling method during rainy season (Husson et al., 2008) (August-October) for the period of 12 weeks so as to get it well established (Heuzé et al., 2015). While *Mucuna pruriens* (velvet beans) was soaked for 12 hr and air-dried, then the seeds were sown at the rate of 3 kg of seed/ha using 1m by 1m spacing. Irrigation was done twice (morning and evening) per day during the dry season with the source of water from a borehole. Weeding of the pasture was done to remove unwanted plants, fortnightly.

### 2.2 | Experimental birds and management

A total of 200-day-old Marshall Broiler chicks were purchased from a reputable commercial hatchery. The birds were floor brooded for 3 weeks on wood shavings and feed and water were provided for the birds ad libitum. Fixed housing system opened to yards for runs (3 birds per m<sup>2</sup>) as used by Magala (2008) was provided. Birds were weighed and assigned randomly at 3 weeks of age (day 21) into five experimental groups, viz. deep litter without access to run (DL), deep litter with access to *Stylosanthes hamata* (SH), deep litter with access to *Stylosanthes guianensis* (SG) and deep litter with access to *Mucuna pruriens* (MP) and deep litter with access to pasture free run (FR). The size of the pasture run in each of the replicates was 3bird/m<sup>2</sup>. Each treatment had 4 replicates consisting of 10 birds. The experiment lasted for 5 weeks and was carried out during the dry season (November to Early December).

Birds had access to the pasture in the morning between 7:30a.m. and 9:30a.m. and at sunset between 4:00p.m.-7:00p.m.

being the preferred period to explore in the outdoor run area as documented by Dawkins *et al.* (2003). Thereafter, the birds were led into their respective houses through the openings provided in each replicate for entry and exit after each foraging period. The stocking density of 7 birds/m<sup>2</sup> was used. Feed and water troughs were provided for birds in each replicate. Wood shavings at a depth of 8-10cm were used as bedding materials for the deep litter system. Routine management practices in poultry production such as feeding, watering, cleaning of the feeders and drinkers and occasional management practices in poultry production such as vaccination, medication schedule for broilers and change of wet beddings were strictly adhered to. Concentrate feed and water were provided *ad libitum* and also stationed in the outdoors in order to encourage foraging in the pasture area. Relative humidity (%) and temperature (°C) of the environment were monitored by placing a temperature-humidity reader (thermo-hygrometer) within and outside the pen. The concentrate was formulated to meet the NRC (1994) nutrient recommendations for each feeding phase. The composition of the cereal-based diets at starter and finisher phase are presented in Table 1. Conventional vaccinations were administered and lighting schedule was applied according to the management guides.

## 2.3 | Data collection

### 2.3.1 | Growth performance

This was evaluated by measuring feed intake and body weight gain of the chickens with the aid of weighing scale weekly while feed conversion ratio was calculated as:

$$\text{Feed conversion ratio} = \frac{\text{feed intake per bird}}{\text{weight gain per bird}}$$

## 2.4 | Physiological parameters

### 2.4.1 | Rectal temperature (°C)

This was measured by restraining the bird calmly and inserting a digital thermometer into the rectum of the birds through the cloaca until it beeped. Data was taken from two birds per replicate weekly.

## 2.5 | Gait score

At day 56 of age, visual observation for gait score was carried out. Two birds per replicate were selected at randomly from each replicate. Observation of gait score was made according to the method of Kestin *et al.* (1992). Each bird was observed and the ability to walk was assigned to different categories of lameness on a 6-point scale, where score 0 referred to no detectable walking abnormalities and score 5 was assigned to bird that was incapable of sustained walking on its feet. Thereafter, a mean pen gait score per pen was calculated.

**TABLE 1** Diet composition for the starter and finisher phase of broiler chicken

Ingredients	Starter phase	Finisher phase
Maize	47.00	50.00
Soya bean meal	18.50	12.00
Groundnut meal cake	15.00	11.00
Fish meal (72% CP)	2.10	2.10
Wheat bran	10.35	17.90
Bone meal	3.0	3.00
Oyster shell	3.00	3.00
Salt	0.25	0.25
Premix <sup>a</sup>	0.25	0.25
Methionine	0.30	0.30
Lysine	0.25	0.20
	100	100
Calculated		
Crude protein (%)	23.05	19.91
ME (MJ/Kg)	11.73	11.71
Ether extract (%)	3.93	3.89
Crude fibre (%)	3.67	3.79
Calcium (%)	1.75	1.74
Phosphorus (%)	0.43	0.41

<sup>a</sup>kg of premix contains: vitamin A: 10,000,000 IU; vitamin D3: 2,000,000 IU; vitamin E: 20,000 IU; vitamin K: 2,250 mg; thiamine B1: 1,750 mg; riboflavin B2: 5,000 mg; pyridoxine B6: 2,750 mg; niacin: 27,500 mg; vitamin B12: 15 mg; pantothenic acid: 7,500 mg; folic acid: 7,500 mg; biotin: 50 mg; choline chloride: 400 g; antioxidant: 125 g; magnesium: 80 g; zinc: 50 g; iron: 20 g; copper: 5 g; iodine: 1.2 g; selenium: 200 mg; cobalt: 200 mg.

## 2.6 | Behavioural observations

Behavioural observations of birds in each pen were carried out at 7 weeks of age. Focal sampling was used to measure the frequency of behavioural events (Martin and Bateson, 1993). These observations were carried out by standing in front of each replicate unit within the first 5 min used for adaptation of birds to the observer's presence. The birds selected were marked a week before with blue and green non-toxic marker for easy identification. After the adaptation period, focal sampling continuously was conducted for 25 min on two randomly selected birds per pen. Data were collected to give the frequency of each behaviour performed per bird per 25-min period. The definitions of the behaviour were done as described by Zhao *et al.* (2014).

## 2.7 | Haematological and biochemical parameters

Blood samples (2 ml) were collected intravenously via the wing vein from 2 birds per replicate sterile tubes containing anticoagulant (EDTA) and the haematological analysis was carried out after

blood collection. Red blood cell and white blood cell counts were determined using a using automated haematology analyser (Sysmex Corporation International Company); differential leucocyte counts (lymphocytes, heterophils, basophils, monocytes and eosinophils) were carried out using blood smears stained with May-Grunwald-Giemsa stain; packed cell volume and haemoglobin (Hb) values were determined, respectively, by microhaematocrit and cyanmethemoglobin as described by Kececi et al. (1998).

Also, blood samples (2 ml) were collected intravenously via the wing vein from 2 birds per replicate into well labelled plain bottles without anticoagulant. Serum was separated by centrifugation at 4000 rpm for 15 min and stored in a freezer at  $-20^{\circ}\text{C}$  until it was used for evaluating serum biochemical parameters including: total protein (g/L), serum albumin (g/dl), serum globulin (g/l), aspartate aminotransferase (AST) (IU/L) and serum glucose (mg/dl) using spectrophotometer, using their respective kit package.

## 2.8 | Plasma triiodothyronine

Blood samples (1 ml) was collected at weeks 5, 6, 7 and 8 intravenously via the wing vein from 2 birds per replicate into EDTA bottles to be analysed for plasma hormone. The plasma was separated by centrifugation at 4000 rpm for 10 min and stored at  $-20^{\circ}\text{C}$ . Plasma triiodothyronine was assayed with immunoenzymatic ELISA kit as described by Tachibana et al. (2007).

## 2.9 | Statistical analysis

Data collected were subjected to one-way analysis of variance in a completely randomized design (CRD) and analysed using SAS statistical computer package (SAS Institute, 2008). Tukey's HSD test was used to compare the significant means at  $p < .05$ . The model was as follows:

$$Y_{ij} = \mu + T_i + \Sigma_{ij},$$

$Y_{ij}$  = Observed value of dependent variable,

$\mu$  = Population mean,

$T_i$  = Effect of  $i^{\text{th}}$  pasture access,

$\Sigma_{ij}$  = Residual error.

# 3 | RESULTS

## 3.1 | Growth performance

The effect of different legume pastures on growth performance of broiler chickens is shown in Table 2. The initial body weight of birds with access to SG was significantly higher ( $p < .05$ ) than those of the birds of SH, MP, FR and DL which were similar, while

the final body weight of birds in SH was also significantly higher ( $p < .05$ ) than those of SG, MP, FR and DL which were comparable. A similar trend was observed in the weight gain. Moreover, the feed intake of the birds of DL, SH and FR was similar but higher than those of the other treatment groups. The FCR of the birds on legume pastures was similar but better than those without access to pasture. There was no difference in the mortality of the birds across treatment groups.

## 3.2 | Rectal temperature

Effects of different legume pastures on heart rate (HR) and rectal temperature (RT) of broiler chickens are represented in Table 3. The heart rate (HR) of the broiler chickens was not significantly ( $p > .05$ ) different at weeks 5, 6 and 8. At week 7, the HR of birds in FR was significantly higher ( $p < .05$ ) than those of DL, SH, SG and MP with the lowest values.

## 3.3 | Gait score

The effect of foraging on different legume pastures on gait score is represented in the Table 4. At gait score 0, the number of birds with high gait score was found to be significantly ( $p < .05$ ) similar and higher in SH, SG, MP and FR than that of DL. While at scores 1 and 2, the gait score of birds was not affected ( $p > .05$ ) by different legume pastures. However, at score 3, the number of birds with high gait score were found to be significantly ( $p < .05$ ) similar and high in FR and DL than those in SH, SG and MP whose scores were statistically the same. Consequently, the sum total of gait score 3, 4 and 5 was of significant effect ( $p < .05$ ).

## 3.4 | Behavioural parameters

The behavioural repertoire and tonic immobility of broiler chickens with access to different legume pastures are shown in Table 5. The overall behaviour repertoire of broiler chickens reared on different legume pastures was influenced ( $p < .05$ ) by access to different legume pastures. The eating behaviour of the birds with access to DL and FR was significantly higher ( $p < .05$ ) of SH, SG and MP. Drinking behaviour was significantly ( $p < .05$ ) low in birds reared on DL. Birds with access to SH, SG and MP birds had significantly higher ( $p < .05$ ) preening frequency. Dust bathing, spot pecking and feather pecking frequency were lower in birds raised on DL. Walking frequency of birds on SH, SG and MP was significantly ( $p < .05$ ) high than those of FR and DL.

The tonic immobility of the birds was similar during the starter phase. However, at 8 weeks of age, the tonic immobility of the birds in DL was higher than those of FR which was also higher than those with access to pasture. The duration of tonic immobility of the birds on pasture was comparable.

**TABLE 2** Effect of foraging different legume pastures on the growth performance of broiler chickens during dry season

Parameter	DL	SH	SG	MP	FR	SEM	p value
Initial weight (kg)	0.58 <sup>a,b</sup>	0.62 <sup>a,b</sup>	0.675 <sup>a,b</sup>	0.59 <sup>a,b</sup>	0.61 <sup>a,b</sup>	0.009	.0001
Final weight (kg)	2.25 <sup>a,b</sup>	2.67 <sup>a,b</sup>	2.31 <sup>a,b</sup>	2.22 <sup>a,b</sup>	2.27 <sup>a,b</sup>	0.044	.0001
Weight gain (kg)	1.67 <sup>a,b</sup>	2.04 <sup>a,b</sup>	1.64 <sup>a,b</sup>	1.63 <sup>a,b</sup>	1.67 <sup>a,b</sup>	43.09	.001
Feed intake (kg)	5.26 <sup>a,b</sup>	4.77 <sup>a,b</sup>	4.23 <sup>a,b</sup>	4.25 <sup>a,b</sup>	5.22 <sup>a,b</sup>	0.113	.000
FCR	3.17 <sup>a,b</sup>	2.34 <sup>a,b</sup>	2.58 <sup>a,b</sup>	2.61 <sup>a,b</sup>	3.16 <sup>a,b</sup>	0.083	.000
Mortality	0.50	0.50	0.25	0.00	0.25	0.138	.752

Abbreviations: SH: *Sytlosanthes hamata*, SG: *Stylonsanthes guainensis*, MP: *Mucuna pruriens*, FR: Free run and DL: deep litter; FCR: Feed Conversion Ratio.

<sup>a,b</sup>Means in the same row with different superscripts differ significantly ( $p < .05$ ).

**TABLE 3** Effects of foraging different legume pastures on the rectal temperature of broiler chickens during dry season

Weeks	DL	SH	SG	MP	FR	SEM	p value
5	41.80	41.65	41.70	41.46	41.78	0.053	.451
6	41.80 <sup>a,b</sup>	41.57 <sup>a,b</sup>	41.76 <sup>a,b</sup>	41.85 <sup>a,b</sup>	41.95 <sup>a,b</sup>	0.036	.007
7	41.80	41.56	41.78	41.85	41.78	0.004	.091
8	41.63	41.55	41.66	41.66	41.67	0.048	.931

Abbreviations: DL, deep litter; FR, Free run; MP, *Mucuna pruriens*; SG, *Stylonsanthes guainensis*; SH, *Sytlosanthes hamate*.

<sup>a,b</sup>Means in the same row with different superscripts differ significantly ( $p < .05$ ).

**TABLE 4** Effects of foraging different legume pastures on gait score of broiler chickens during dry season

Gait Score							
Treatment	0	1	2	3	4	5	3 + 4 + 5
SH	30.00 <sup>a,b</sup>	45.00	23.33	1.67 <sup>a,b</sup>	0	0	1.67 <sup>a,b</sup>
SG	36.67 <sup>a,b</sup>	40.00	20.00	3.33 <sup>a,b</sup>	0	0	3.33 <sup>a,b</sup>
MP	31.66 <sup>a,b</sup>	40.00	26.67	1.67 <sup>a,b</sup>	0	0	1.67 <sup>a,b</sup>
FR	30.00 <sup>a,b</sup>	33.33	23.33	13.33 <sup>a,b</sup>	0	0	13.33 <sup>a,b</sup>
DL	18.33 <sup>a,b</sup>	36.66	28.33	16.67 <sup>a,b</sup>	0	0	16.67 <sup>a,b</sup>
SEM	1.703	1.695	1.212	1.597	0	0	1.597
p-value	.002	.270	.219	.000	0	0	.0001

Abbreviations: DL, deep litter; FR, Free run; MP, *Mucuna pruriens*; SG, *Stylonsanthes guainensis*; SH, *Sytlosanthes hamate*.

<sup>a,b</sup>Means in the same column with different superscripts differ significantly ( $p < .05$ ).

### 3.5 | Haematochemical parameters

The effect of foraging different legume pastures on haematochemical parameters of broiler chickens during dry season is presented in Table 6. The packed cell volume (PCV) of broiler chickens with on SG was statistically the same as those of DL, SH and MP, but significantly higher ( $p < .05$ ) than that of FR. However, the other parameters of haematology of broiler chickens at the starter phase including red blood cell (RBC), white blood cell (WBC), haemoglobin, basophil,

eosinophil, heterophil, lymphocyte, monocytes and H:L were not affected ( $p > .05$ ) by access to the different legume pastures.

The total protein and albumin of birds with access to pasture were significantly higher ( $p < .05$ ) than those of DL and FR. The globulin of the birds of SH was statistically similar to those of SG and MP but significantly higher ( $p < .05$ ) than those of FR and DL. However, the creatinine kinase, glucose, alanine amino-transferase and aspartate amino-transferase of the birds across the experimental groups were similar.

**TABLE 5** Effect of foraging different legume pastures on behaviour and tonic immobility of broiler chickens during dry season

Behavioural parameters	DL	SH	SG	MP	FR	SEM	<i>p</i> value
Eating	23.67 <sup>a,b,c</sup>	19.42 <sup>a,b,c</sup>	19.08 <sup>a,b,c</sup>	19.92 <sup>a,b,c</sup>	22.58 <sup>a,b,c</sup>	0.471	.0001
Drinking	2.67 <sup>a,b,c</sup>	4.25 <sup>a,b,c</sup>	4.33 <sup>a,b,c</sup>	4.58 <sup>a,b,c</sup>	3.58 <sup>a,b,c</sup>	0.173	.0001
Preening	0.75 <sup>a,b,c</sup>	1.67 <sup>a,b,c</sup>	1.67 <sup>a,b,c</sup>	1.67 <sup>a,b,c</sup>	0.92 <sup>a,b,c</sup>	0.111	.0001
Dust bathing	1.25 <sup>a,b,c</sup>	2.67 <sup>a,b,c</sup>	2.50 <sup>a,b,c</sup>	2.67 <sup>a,b,c</sup>	2.25 <sup>a,b,c</sup>	0.132	.0001
Spot pecking	4.17 <sup>a,b,c</sup>	7.33 <sup>a,b,c</sup>	7.42 <sup>a,b,c</sup>	7.33 <sup>a,b,c</sup>	6.75 <sup>a,b,c</sup>	0.304	.0001
Walking	12.58 <sup>a,b,c</sup>	15.00 <sup>a,b,c</sup>	15.83 <sup>a,b,c</sup>	15.00 <sup>a,b,c</sup>	13.33 <sup>a,b,c</sup>	0.348	.0001
Tonic immobility <sup>*</sup>	231.9	227.0	221.5	238.4	283.8	13.57	.0267
Tonic immobility <sup>#</sup>	434.4 <sup>a,b,c</sup>	372.1 <sup>a,b,c</sup>	490.0 <sup>a,b,c</sup>	663.3 <sup>a,b,c</sup>	804.0 <sup>a,b,c</sup>	29.22	.0001

Abbreviations: DL, Deep litter; FR, Free run; MP, *Mucuna pruriens*; SG, *Stylosanthes guainensis*; SH, *Sytlosanthes hamate*.

<sup>a,b,c</sup>Means in the same row with different superscripts differ significantly ( $p < .05$ ).

<sup>\*</sup>Week 4.

<sup>#</sup>Week 8.

The effect of foraging different legume pasture on plasma triiodothyronine ( $T_3$ ) concentration of broiler chickens during dry season is shown in Table 7. Throughout the experimental period, the access to legume pastures had no effect ( $p > .05$ ) on plasma triiodothyronine concentration of the birds.

## 4 | DISCUSSION

This study aimed to compare the benefits of access with different legume pastures on growth performance and physiological responses of broiler chickens during dry season. The findings in this present study showed that the legume pastures improved the final body weight of broiler chickens, particularly those that had access to *Stylosanthes hamata*. This may be due to the beneficial bioactive compounds of stylo as a high yielding forage (Cook et al., 2005) as they have been used to improve nutritive value of natural grasslands (Partridge, 2003). Our findings are in accordance with the results of Ponte et al. (2008) who reported that outdoor raised birds with access to pasture had higher body weights when compared with birds without access to pastures. This observation suggests that the legume pastures contributed to the nutritional value of the birds which consequently improved the body weights. The higher weights of the birds with access to pasture in the present study is congruent to the findings of Ponte et al. (2008) who reported that access to pasture improved the body weights of broiler chickens. Additionally, Santos et al. (2005) reported that birds in semi-confined environment had better body weight gains due to better comfort and welfare. The present study also corroborates our earlier study (Oke et al., 2016) where access to legume pasture improved the performance of hens. However, contrary to the findings in the current study, Jiang et al. (2011) and Chen et al. (2013) indicated that there were no differences in the performance of chickens with outdoor access. The discrepancies in studies may be due to pasture species, environmental conditions and exercise

(Chen et al. 2013). Indeed, rearing systems with access to pastures are constrained by several variables which are uncontrolled, including; photoperiod, temperature and light intensity (Fanatico et al., 2005). The similarity in the mortality of the birds across the treatment groups in the present study is in agreement with the findings of Ipek and Sozcu (2017).

Access to legume pasture had no effect on rectal temperature of broiler chickens throughout the experiment except for week 6. Overall, the rectal temperatures of broiler chickens in this study were still in the normal range of 41.55°C–41.95°C as reported by Aengwanich and Simaraks (2004) and Attia et al. (2011). Similar to our findings, Ipek and Sozcu (2017) reported the rectal temperature of broilers with or without access to pasture were closely related.

High gait score values have been associated with harsh environmental conditions in the broiler house Cordeiro et al. (2009). The general improved gait scores of the boiler chickens with access to pastures in the present study indicate the environment was beneficial to the birds. This observation is in partial consonance with the findings of Kestin et al. (1992) who reported that rearing birds on free range offered good opportunities to exercise and reduced leg weakness. Additionally, access of the birds to the high protein legume pasture in the current study might have also contributed to the good gait score.

According to the findings in the current study, the effect of access to pastures on behavioural performance of broiler chickens was significant. The frequency of eating behaviour of birds with access to pasture area was not as high as those without access to pasture. This could be due to the engagement of birds in the outdoor area with behavioural repertoire (e.g. preening) which might have distracted them. This result is in line with the result of Ipek and Sozcu (2017) who reported that eating behaviour of birds on pasture was lower than those of indoor birds. In contrast to our finding, Fanatico et al. (2008) reported that activity and exercise resulted in increasing feed consumption of birds that had access to free range. Preening and spot pecking behaviours of birds with access to pasture were

**TABLE 6** Effect of foraging different legume pastures on haematochemical parameters of broiler chickens at week 4 during dry season

Parameter	DL	SH	MP	SG	FR	SEM	p value
PCV (%)	25.50 <sup>a,b</sup>	30.75 <sup>a,b</sup>	28.50 <sup>a,b</sup>	33.75 <sup>a,b</sup>	20.25 <sup>a,b</sup>	1.542	.037
RBC (×10 <sup>12</sup> /L)	2.99	2.46	3.07	2.34	2.87	0.149	.457
WBC (×10 <sup>9</sup> /L)	13.25	5.55	5.40	5.25	4.35	1.819	.562
Haemoglobin (g/dl)	9.63	9.38	10.60	10.10	7.58	0.424	.206
Basophil (10 <sup>9</sup> /L)	0.50	0.20	0.25	0.25	0.00	0.092	.415
Eosinophil (10 <sup>9</sup> /L)	0.50	2.25	2.00	1.25	1.50	0.266	.269
Heterophil (10 <sup>9</sup> /L)	40.25	36.00	35.00	35.25	27.75	1.515	.116
Lymphocyte (10 <sup>9</sup> /L)	53.00	56.00	60.00	57.00	67.00	1.790	.077
Monocyte (10 <sup>9</sup> /L)	2.75	3.50	2.75	3.25	3.00	0.246	.873
H/L	0.77	0.67	0.59	0.63	0.41	0.042	.084
Total protein (g/dl)	4.65 <sup>a,b</sup>	6.15 <sup>a,b</sup>	5.78 <sup>a,b</sup>	6.50 <sup>a,b</sup>	4.32 <sup>a,b</sup>	0.208	.0001
Albumin (g/dl)	2.75 <sup>a,b</sup>	3.63 <sup>a,b</sup>	3.70 <sup>a,b</sup>	4.15 <sup>a,b</sup>	2.55 <sup>a,b</sup>	0.159	.0001
Globulin (g/dl)	1.90 <sup>a,b</sup>	2.53 <sup>a,b</sup>	2.08 <sup>a,b</sup>	2.35 <sup>a,b</sup>	1.78 <sup>a,b</sup>	0.083	.006
Creatinine kinase (mg/dl)	7.75	6.45	6.68	6.90	6.63	0.368	.853
Glucose (mg/dl)	130.5	115.25	119.5	121.75	122.00	3.075	.668
Aspartate amino-transferase (IU/l)	23.42	21.38	21.80	24.30	23.73	0.465	.100
Alanine amino-transferase (IU/l)	68.05	63.12	58.00	56.05	58.90	2.236	.488

Abbreviations: FR, Free run; MP, *Mucuna pruriens*; PCV, Packed cell volume; RBC, Red blood cell; SG, *Stylonsanthes guainensis*; SH, *Sytlosanthes hamate*; WBC, White blood cell; DL, deep litter.  
<sup>a,b</sup>Means in the same row with different superscripts differ significantly ( $p < .05$ ).

**TABLE 7** Effect of foraging different legume pastures on plasma triiodothyronine concentration of broiler chickens during dry season

Weeks	DL	SH	SG	MP	FR	SEM	p value
5	2.32	2.44	2.34	2.37	2.41	0.053	.8708
6	2.20	2.30	2.21	2.35	2.18	0.057	.8771
7	2.28	2.25	2.26	2.25	2.01	0.079	.7394
8	2.19	2.47	2.40	2.38	2.35	0.054	.6108

Abbreviations: DL, deep litter; FR, Free run; MP, *Mucuna pruriens*; SG, *Stylonsanthes guainensis*; SH, *Sytlosanthes hamate*.

higher than those without access to pasture in the present study. This could be ascribed to exposure of those birds to field activities (like flying which can raise dirt particles), insect or pest presence and exercise. This result is similar to that of Zhao et al. (2014) who reported that behaviours, such as preening and spot pecking, were

observed with a higher occurrence with outdoor access than the indoor group in fast-growing broilers.

Interestingly, feather pecking behaviour was higher in birds with access to pastures in this experiment. This may be due to environmental enrichment which fostered or encouraged freedom

of expression of natural behaviour of the birds (Newberry, 1995; Stricklin, 1995). However, this observation is not in consonance with the findings of Huber-Eicher and Wechsler, (1997) and Bozakova *et al.* (2011) who reported that exposing birds to grassland may reduce aggression and the tendencies to engage in feather pecking. The time of exposure of the birds to pasture may have also contributed to this. Early exposure of birds to pasture is important to reduce incidence of feather pecking (Merritt *et al.*, 2010).

The current experiment showed that the birds with access to pastures dust bathed more (and can serve as a mechanism for heat reduction) than birds within confinement, which could be due to absence of natural environment and sand. Dust bathing behaviour is part of the natural behaviours that birds express when they are exposed to environmental complexities (Newberry, 1995). The birds with access to pastures had a more favourable occurrence in expressing walking behaviours than birds without access to pastures and this is attributable to access to space and unrestricted forage area or housing system (Castellini *et al.*, 2012; Dawkins & Hardie, 1989).

Tonic immobility has been used to assess fearfulness in chickens (Campo *et al.*, 2008; Sanotra *et al.*, 2001). The lower duration of tonic immobility recorded in the birds with access to pasture at the finisher phase in the present study suggests that the birds felt safe and comfortable on the pasture. This observation corresponds to the behaviours of the birds in a natural environment. A natural environment such as the use of pasture may help to reduce fearfulness in birds (Jones & Waddington, 1992). In contrast to our findings, Zhao *et al.* (2014) observed higher tonic immobility in broiler chickens with outdoor access. This variability may be due to the presence of the legume pasture in the present study, as it has been shown that complexity of the environment can aid decreasing fearfulness in chickens (Jones, 2002).

The results obtained in this study showed that the effect of access to pastures on the haematological parameters of broiler chickens were not significant except the packed cell volume of the birds. Generally, the data were closely related and the values were within the normal reference range for broiler chickens (Talebi *et al.*, 2005). The slight increase in the PCV of the birds in SG may be due to nutrients of the plants the birds had access to, as diet has been shown to influence haematological parameters (Perelman, 1999; Islam *et al.*, 2004). More so, it has been reported that high PCV values indicate an increase in circulating red blood cell which is the resultant effect of good nutrition and welfare (Sales and Mallet, 2008; Talebi *et al.*, 2005). The similarity in the haematological values of the birds suggests that access to pastures was not stressful to the birds in the present study. Stress conditions have been shown to influence leukocyte count and heterophil-to-lymphocyte ratio (Attia *et al.*, 2018; Attia & Hassan, 2017; Oke *et al.*, 2021; Puvadolpirod & Thaxton, 2000). [Correction added on 10 May 2021, after first online publication: In this paragraph, the reference "Sobayo *et al.* 2008" has been replaced with "Sales and Mallet, 2008".]

The present study revealed that most of the serum biochemical parameters were not affected by access to pasture, except for total protein, albumin and globulin. The higher protein of the birds that

had access to pasture may be attributed to the consumption of the pasture plants by the birds. This observation indicates that broiler chickens were able to metabolize legume pastures for production. Intake of pasture may constitute a source of protein for growing birds (Ponte *et al.*, 2008). Previous study has shown that outdoor access without established pasture did not influence the serum biochemical parameters of birds (Alabi *et al.*, 2015).

In this present study, effect of access to pasture on plasma triiodothyronine hormone ( $T_3$ ) concentration of broiler chickens was not significant throughout the study period. The result from this present study is substantiated by the normal range of values reported by May (1982). The similarity in the levels of plasma  $T_3$  of the birds suggests the birds had similar metabolic rate.

In conclusion, the growth performance of broiler chickens with access to different legume pastures was improved by access to pasture, particularly *Stylosanthes hamata*. The natural behaviour (like preening, walking, standing and dust bathing) of birds with access to pasture run was more frequently expressed with excellent gait score. The overall values derived for blood profile (haematological and serum biochemical indices) were within the normal range for broiler chickens, indicating that access to legume pastures had no ill effect on broiler chickens.

#### AUTHOR CONTRIBUTION

**Oyegunle Emmanuel OKE:** Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing-original draft. **Janet Akande:** Formal analysis; Investigation; Methodology; Project administration; Resources; Writing-original draft. **Deji Ekunseitan:** Conceptualization; Formal analysis; Investigation; Methodology; Project administration; Supervision; Writing-original draft. **Ibukunoluwa Sodipo:** Formal analysis; Investigation; Methodology; Resources; Writing-original draft. **Samson Rahman:** Conceptualization; Investigation; Methodology; Resources. **Olusiji Smith:** Conceptualization; Funding acquisition; Methodology; Project administration; Resources; Supervision; Visualization; Writing-original draft. **Okanlawon Onagbesan:** Conceptualization; Methodology; Project administration; Resources; Supervision.

#### ANIMAL WELFARE STATEMENT

This study was carried out in accordance with guidelines for regulation of animal experimentation of Federal University of Agriculture, Abeokuta, Nigeria, and birds were treated in compliance with the Guide for the Care and Use of Agricultural Animals in Research and Teaching (2010).

#### Peer Review

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[Correction added on 10 May 2021, after first online publication: The full reference for “Sobayo et al. (2008)” has been replaced with “Sales and Mallet (2008)” in the References list.]

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