Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.2, 2015

Growth Performance and Carcass Yield of Three Commercial Strains of Broiler Chickens raised in a Tropical Environment

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Abstract
The aim of this study was to evaluate the growth performance and carcass yield of three commercial strains of broiler chickens namely Arbor Acre, Marshal and Ross reared in a tropical environment. 150 day old chicks per strain were brooded in separate brooding pens from day old to 2 weeks of age. At two weeks of age, each strain was separated into sexes and each sex replicated thrice and randomly placed into different pens where brooding continues for the next 2 weeks. Brooding and rearing to 8 weeks took place in the same pen. There were significant ($p<0.05$) strain differences with respect to body weight (1-8 weeks), average weight gain (2-3, 4-5, 6-7 weeks) and average feed intake (1-8 weeks). Arbor Acre had the most superior body weight at 8 weeks and weight gain at 6-7 weeks followed by Ross and Marshal in that order. However, the three strains of broiler chicken were similar in weight gain at 7-8 weeks and average feed conversion ratio at 8 weeks of age. Significant strain x sex interaction were observed in the body weight, weight gain and feed intake of the birds. Arbor Acre males were the most superior in body weight and weight gain compared to the males and females of Ross and Marshal. There was no significant effect of strain on the carcass yield of the birds. Based on its superior performance, Arbor Acre broiler is recommended to broiler farmers in Nigeria.
Keywords: Bodyweight, broiler, carcass yield, feed conversion ratio, superiority.

Introduction

Poultry production is considered to be one of the most popular options in Nigeria in reducing the incidence of malnutrition particularly protein deficiency in the diets of populace (Obasoya *et al* 2005). At present, there is an improvement in potential of broiler strains to provide high quality meat at lower cost (Kemp and Kenny, 2003). Many strains of broiler chickens have been imported into Nigeria. The performance of these birds is affected by genotype x environment interaction. Genotype by environment interaction may cause loss of fitness traits for those genotypes not suited to a particular environment. Therefore broiler farmers should choose for rearing those strains that are best suited in a particular environment. Apart from strains, sex of broiler chickens has significant effect on the performance traits of broilers including body weight, weight gain, feed intake and feed conversion ratio (Balogun *et al* 1997, Shahin and Elazeen 2005, Ajayi and Ayorinde, 2009). Also sex of broiler chickens has significant effect on their carcass traits (Ojedapo et al, 2008, Horniakova and Abas, 2009, Adela Marcus et al 2013). Although separate effect of strain and sex on broiler chicken performance has been widely reported in literature, their interaction has not been given much attention. Ajayi and Ejiofor (2009), Razuki et al (2011, Olawumi *et al* (2012) and Shim *et al* (2012) reported significant strain by sex interaction on live weight, weight gain and carcass traits of broiler chickens. The objectives of the present study were 1: to compare the body weight, weight gain, feed intake, feed conversion ratio and carcass yield of three strains of broilers raised in a tropical environment 2: to determine the effect of strain x sex interaction on the aforementioned traits.

Materials and Methods

Experimental Site

The experiment was conducted at the poultry unit of teaching and research farm, Delta State University, Asaba Campus. Asaba is known to have 7 to 9 months of rainfall annually ranging from 1800mm to 3000mm while maximum day temperature range from 27.50 0C to 30.90 0C.

Housing Management

The brooding house was partitioned into pens in line with the design of the experiment. All the necessary repairs were made in the brooding house such as changing the aluminium roof to prevent leakages, replacement of the wire gauze section of the house that was already weak. The wire gauze section of the brooding pens was covered with black tarpaulin to help conserve heat. The floors of the brooding pens were covered with wood shavings and they were kept dry throughout the experimental period by replacing the wet litter with new ones. Electricity, lantern and stoves were used to heat up the brooding house. Shallow plastic feeders and chick founts were used to provide feed and water to the chicks respectively.

Experimental Birds

A total of 450 day old chicks made up of 150 chicks each of Arbor Acre, Ross and Marshal commercial strains

of broilers were used for the study. The chicks were procured from Zartech farm in Benin, Edo State, Nigeria. The chicks were vaccinated against marek disease, Newcastle disease and gumboro disease at the appropriate ages. Coccidiostat was administered in water periodically as a prophylactic measure. Each strain was housed in separate pens. The chicks were randomly distributed into pens (25 chicks per pen, 6 pens per strain) for each strain x gender group (a total of 18 pens).

Chick Sexing

The male chicks were separated from the females using every identifiable physical characteristic such as comb size, wattle size, shank length, early and late feathering at 2 weeks of age and at 4 weeks when the males become distinct from female. The 4th week separation was used to confirm the accuracy or otherwise of the 2 weeks attempt.

Feeding Management

Chicks were fed ad libitum on a broiler starter diet containing 24 % CP and 2900 Kcal /kg/ME from day old to 4 weeks of age followed by a finisher diet containing 21 % CP and 2800 Kcal/kg/ME to 8 weeks of age. Feed and water were made available to the birds all the time.

Data Collection

The initial body weight of the chicks was taken at day old using a sensitive balance. Subsequently, their body weights were taken every week for 8 weeks. Feed and water consumption were recorded daily. Feed conversion ratio was calculated as kg feed divided by weight gain. After taking the final body weight at 8 weeks, the birds were starved of feed overnight and 10 birds randomly selected from each pen. The selected birds were slaughtered, scalded and plucked. After the removal of feathers, the carcasses were weighed before being eviscerated. After evisceration, carcass weights were recorded.

Statistical Analysis

The data collected were subjected to two way analysis of variance in a completely randomized design. Duncan multiple range test was used to separate the means where the ANOVA showed significant effect. The statistical model is as follows

$Yijk = \mu + Si + Aj + (SA)ij + Eijk$

Where Yijk = the individual measurement of each bird

μ = the overall mean

Si = effect of the ith strain

Aj = effect of the jth sex

(SA)ij = interaction effect of strain and sex

Eijk = random error

Results and Discussion

The separation of chicks into sexes based on physical characteristics is presented in Table 1.

Table1: Separation of chicks into sexes based on physical characteristics at 2 week and 4 week of age respectively.

Age	Sex	Arbor Acre	Marshal	Ross
2 weeks	Male	72	72	72
	Female	78	78	78
4 weeks	Male	73	73	75
	Female	77	77	75

A close observation shows that the sexes are close to the ratio of 1:1 which is in agreement with the sex ratio of chicks at hatch. The effect of strain of broiler chicken on body weight is shown in Table 2.

Table2: Mean ± S.E of weekly body weight of three strains of broiler chicken (g).

Strain	Wk 1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
Arbor Acre	118.20 ±1.84^{b}	288.80 ±6.15^{b}	517.60 ±10.23^{b}	819.40 ±16.00^{c}	1089.00 ±26.12^{b}	1404.00 ±34.56^{b}	1743.00 ±45.13^{b}	2037.00 ±53.49^{c}
Marshal	115.36 ±1.70^{b}	282.45 ±6.13^{b}	510.20 ±11.04^{b}	760.69 ±17.86^{b}	987.80 ±20.70^{a}	1297.11 ±30.92^{a}	1546.12 ±34.84^{a}	1823.50 ±38.88^{a}
Ross	105.36 ±2.21^{a}	265.60 ±14.41^{a}	424.80 ±23.59^{a}	696.00 ±32.78^{a}	988.80 ±36.93^{a}	1290.00 ±41.23^{a}	1612.00 ±47.10^{b}	1962.00 ±47.90^{b}

a b means in each column are significantly ($p<0.05$) different.

Arbor Acre and Marshal were significantly ($p<0.05$) superior to Ross broilers at weeks 1, 2, 3 and 4. However, from week 5 to 7, Arbor Acre was the most superior in body weight compared to Marshal and Ross broilers whose body weights were not significantly ($p>0.05$) different from each other at this period. Arbor Acre broilers maintained its superiority in body weight to 8 week of age followed by Ross and Marshal. A similar result was obtained by Udeh *et al* (2011) who reported that Arbor Acre and Ross were superior to Marshal in body weight at 8 week of age. However, the result contradicted those of Olawumi *et al* (2012) who found Marshal superior to Arbor Acre. Amao *et al* (2011) reported that Ross was superior to Marshal at 8 weeks of age which was in agreement with the result obtained in this study. This result also agrees with the finding of Ojedapo et al (2008), Ajayi and Ejiofor (2009), Enaiat *et al* (2010) and Razuki *et al* (2011) who observed significant strain differences in live body weight of broiler chicken slaughtered for carcass evaluation at 8-12 weeks. Table 3 presents the effects of strain and sex interaction on the body weight of the three strains of broiler chicken from 2 to 8 weeks of age. At week 2, Arbor Acre male was significantly ($p<0.05$) superior to Arbor Acre female but comparable to Marshal male, Marshal female and Ross male in body weight. Arbor Acre female was comparable with Ross male, Marshal male and Marshal female in body weight at 2 weeks of age. Ross female had the lowest body weight at 2 week of age. Arbor Acre male was the most superior ($p<0.05$) in body weight at 8 week of age followed by Ross male, Marshal male, Ross female, Arbor Acre female and Marshal female in that order.

Table3: Effect of strain x sex interaction on the body weight of three strains of broiler chickens (g).

Strain	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
Arbor	310.00	519.30	851.74	1105.22	1546.96	1960.87	2319.57
Acre (M)	±9.49^{c}	±15.35^{c}	±26.32^{d}	±34.24^{c}	±50.27^{b}	±54.80^{b}	±56.87^{c}
(F)	286.89	516.30	791.85	1007.00	1283.33	1557.41	1796.30
	±6.80^{b}	±13.97^{c}	±20.55^{c}	±31.21^{ab}	±33.84^{a}	±45.50^{a}	±50.56^{a}
Marshal	289.13	527.83	808.70	1353.04	1576.09	1623.91	1880.43
(M)	±9.66^{bc}	±19.81^{c}	±31.21^{c}	±35.82^{b}	±56.36^{a}	±55.48^{a}	±49.50^{ab}
(F)	276.56	494.62	718.08	955.17	1247.69	1519.62	1765.38
	±7.78^{bc}	±10.70^{bc}	±14.84^{b}	±21.54^{a}	±27.86^{a}	±31.53^{a}	±37.29^{a}
Ross (M)	285.90	438.20	711.80	1007.10	1291.00	1635.00	2005.90
	±15.36^{bc}	±29.90^{b}	±37.00^{b}	±37.90^{ab}	±48.40^{a}	±50.70^{ab}	±58.60^{b}
(F)	222.50	396.20	662.50	905.00	1287.70	1562.50	1868.80
	±26.^{24a}	±28.22^{a}	±27.97^{a}	±35.57^{a}	±49.50^{a}	±48.40^{a}	±52.60^{ab}

Mean within the same column bearing different superscript letters are significantly ($p<0.05$) different.

This result is consistent with the report of Ajayi and Ejiofor (2009), Razuki *et al* (2011) and Olawumi *et al* (2012) that body weight of broilers is affected by the interaction between strain and sex. This result however contradicted the report of Ojedapo *et al* (2008) who found no significant effect of strain x sex interaction on body weight of broilers. The effect of strain on the weight gain of broilers is shown in Table 4. Arbor Acre and Marshal gained significantly ($p<0.05$) more weight than Ross at 3 week of age. There was no significant difference among the three strains of broilers in weight gain at weeks 3- 4, 5-6 and 7-8 respectively. However, at weeks 4-5 and 6-7, Arbor Acre and Ross gained significantly ($p<0.05$) more weight than Marshal. This is in agreement with the finding of Amao *et al* (2011) who reported that Ross broilers gained more weight than Marshal at the end of 8 week. Gonzales *et al* (1998) reported that weight gain in broiler chickens is significantly affected by strain. Also Abdullah *et al* (2010) reported significant ($p<0.01$) strain effect on the weight gain of broilers at 7-21 and 28-42 days of age.

Table 4: Average daily gain of the three strains of broiler chickens (g/chick/day)

Strain	Wk 2-3	Wk 3-4	Wk 4-5	Wk 5-6	Wk 6-7	Wk 7-8
Arbor Acre	38.80	42.80	38.50	44.80	48.60	43.10
	±6.57^{b}	±9.72	±13.40^{b}	±13.12	±15.05^{b}	±16.60
Marshal	32.50	35.80	33.20	44.20	35.60	39.00
	±12.24^{b}	±8.77	±7.56^{a}	±14.67	±9.58^{a}	±10.25
Ross	22.70	38.70	41.80	42.50	46.00	48.90
	±8.80^{a}	±12.70	±13.39^{b}	±15.27	±12.20^{a}	±17.49

Column means bearing different superscript letters are significantly ($p<0.05$) different.

The effect of strain and sex interaction on weight gain is shown in Table 5. It will be observed that Arbor Acre females recorded the highest weight gain at 3 weeks followed by Marshal male and Marshal female. The least in weight gain at 3 week was Ross female.

Table 5: Effect of strain x sex interaction on the average daily gain of three strains of broiler chickens (g/chick/day).

Strain		2-3 weeks	3-4 weeks	4-5 weeks	5-6 weeks	6-7 weeks	7-8 weeks
Arbor	Acre	29.87	46.90	47.64	51.67	59.76	52.49
M		±8.73^{c}	±16.27	±16.00^{b}	±20.77^{b}	±16.09^{d}	±19.78^{c}
F		35.34	39.37	30.74	38.94	39.16	35.19
		±8.36^{d}	±9.84	±13.95^{a}	±12.21^{a}	±15.37^{b}	20.49^{a}
Marshall	M	34.10	40.13	30.74	47.01	31.86	43.47
		±11.46^{cd}	±13.77	±8.43^{a}	±26.01^{ab}	±15.51^{a}	±12.93^{b}
F		31.16	31.93	35.33	41.70	38.84	35.10
		±6.68^{b}	±8.28	±11.93^{a}	±15.02^{ab}	±9.80^{b}	±13.62^{a}
Ross	M	23.87	39.07	42.19	39.74	49.16	51.26
		±10.03^{b}	±14.30	±19.37^{b}	±29.51^{a}	±30.58^{c}	±32.16^{c}
F		20.36	38.04	41.07	48.21	39.29	43.75
		±16.51^{a}	±16.30	±12.39^{b}	±21.54^{ab}	±13.36^{bc}	±17.45^{b}

Column means bearing different superscript letters are significantly ($p<0.05$) different.
Note: M: male, F: female.

There was no significant ($p>0.05$) strain by sex interaction on the weight gain of the broilers at 4 week of age. During week 5 , Arbor Acre males, Ross males and Ross females gained the highest weight compared to Arbor females, Marshal males and Marshal females whose body weight gain were not significantly ($p>0.05$) different from each other. This is in line with Abdullah *et al* (2010) who reported significant ($p<0.01$) strain x gender interaction on the weight gain of broilers at 28-35 days of age. In week 6, Arbor Acre male gained the highest weight, followed closely by Ross female and Marshal male. The least was Arbor Acre female. Similarly, Arbor Acre male maintained its superiority over others in body weight gain during week 7 and 8. This was followed by Ross male. The least was marshal female (7-8 weeks). This is also in line with Abdullah *et al* (2010) who reported that male broilers tend to gain more weight than females possibly due to their genetic makeup during the embryonic stage, which lead to having different growth potential that varied according to their strain and gender. The effect of strain of broiler chicken on feed intake is shown in Table 6. There was no significant ($p>0.05$) difference between strain in feed intake at weeks 1, 2 and 4. However, in weeks 3, 5, 6, 7 and 8, significant ($p<0.05$) between strain differences in feed intake were obtained. Ross broiler consumed significantly ($p<0.05$) more feed, at weeks 5 and 8, followed by Arbor Acre (weeks 5 and 8). This is in agreement with the findings of Amao *et al* (2011) that Ross consumed more feed than Anak and Marshal broiler to gain more weight. Significant differences between strains on feed intake were reported by Leesen *et al* (1997) and Rondelli *et al* (2003).

Table 6: Average feed intake of Arbor Acre, Marshal and Ross strains of broiler chickens (g/bird/day).

Strain	Wk 1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
Arbor	19.46	46.86	84.09	106.79	101.61	139.84	142.58	125.55
Acre	±3.15	±4.28	±6.51^{a}	±9.15	±7.20^{b}	±5.87^{b}	±3.95^{b}	±3.34^{b}
Marshal	17.89	43.71	80.83	102.99	89.89	118.69	111.06	115.63
	±2.97	±4.27	±6.37^{a}	±9.16	±8.72^{a}	±6.12^{a}	±3.88^{a}	±3.57^{a}
Ross	20.06	52.86	93.90	90.96	132.62	134.30	144.11	153.05
	±2.52	±3.78	6.89^{b}	±2.88	±6.16^{c}	±4.38^{b}	±5.07^{b}	±5.26^{c}

Means on the same column bearing different superscript letters are significantly ($p<0.05$) different.

The effect of strain and sex interaction on feed intake of broilers from 3 to 8 weeks of age is presented in Table 7. Marshal female consumed the lowest quantity of feed from 3 to 6 weeks of age, followed by Arbor Acre female. There was no significant ($p>0.05$) strain x sex interaction effect on the feed intake of the birds at 7 and 8 weeks of age. These results agreed with the reports of Taha *et al* (2010) that male broilers of each strain consumed significantly more feed than their female counterparts. Table 8 shows the feed conversion ratio of the three strains of broilers. There was no significant ($p>0.05$) strain x sex interaction on the mean feed conversion ratio of the three strains of broilers. However, Marshal female, Arbor Acre male and Arbor Acre females were numerically better feed converters than Ross male, Ross female and Marshal male. This is contrary to the report of Amao *et al* (2011) that Ross broilers have better feed conversion ratio than Marshal and Anak. Abdullah *et al* (2010) also reported that feed conversion ratio differed according to strain x sex interaction.

Table 7: Effect of strain x sex interaction on feed intake of broiler chickens (g)

Strain	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
Arbor Acre	98.07	137.18	120.81	157.14	153.57	132.14
M	±9.62^{cd}	±6.67^{d}	±9.01^{c}	±4.25^{c}	±4.93	±3.85
F	70.12	76.40	82.42	122.53	132.51	118.98
	±5.08^{ab}	±3.23^{ab}	±4.51^{b}	±5.63^{b}	±2.54	±4.37
Marshal M	95.03	132.70	117.08	135.71	120.27	126.40
	±9.07^{cd}	±6.45^{d}	±8.40^{c}	±6.33^{b}	±6.18	±3.69
F	66.67	73.28	62.70	101.67	104.42	104.86
	±5.17^{a}	±5.25^{a}	±3.38^{a}	±5.07^{a}	±2.46	±1.68
Ross M	86.56	94.95	149.16	138.23	151.66	159.66
	±5.88^{bc}	±3.25^{c}	±6.01^{d}	±5.01^{b}	±6.63	±3.25
F	116.97	86.96	116.07	130.36	135.70	146.43
	±9.71^{d}	±4.47^{b}	±6.08^{c}	±6.46^{b}	±6.78	±9.73

A, b, c and d means on the same column are significantly ($p<0.05$) different. M = male, F = female.

Table 8: Feed conversion ratio of Arbor Acre (AA), Marshal (MS) and Ross (RS) strain of broilers at different age period.

Strain	2-3 wks	3-4 wks	4-5 wks	5-6 wks	6-7 wks	7-8 wks	Mean ±S.E
Arbor Acre M	3.28	2.92	2.54	3.04	2.57	2.52	2.88±0.16
F	2.79	1.94	2.68	3.15	3.36	3.38	2.88±0.22
Marshal M	2.79	3.31	3.81	2.89	3.69	2.91	3.23±0.18
F	2.14	2.29	1.77	2.89	3.69	2.99	2.63±0.28
Ross M	3.63	2.43	3.54	3.48	3.10	3.11	3.22±0.18
F	5.75	2.29	2.85	2.70	3.45	3.35	3.40±0.50

Mean values are not significantly ($p>0.05$) different.

The mean square values of analysis of variance of fasting live weight, de-feathering weight and dressing weight are presented in Table 8. There was no significant ($P>0.05$) difference across the strains and also no significant ($p>0.05$) sex x strain interaction on the fasting live weight, de-feathering weight and dressing weight. On the other hand, the effect of sex on the aforementioned traits was significant ($p<0.05$) with the male broilers being heavier than the females in fasting live weight, de-feathering weight and dressing weight. This shows that males have more potential for gaining more live weight and higher carcass weight than the females. This is in agreement with the report of Abdullah *et al* (2010) that sex significantly affects the carcass weight of broiler chickens.

Table 9: Variance analysis for fasting live weight, de-feathering weight and dressing weight of broiler chickens

	Mean squares				
Traits	Between treatment (5)	Between strain (2)	Sex (1)	Strain x sex (2)	Residuals (24)
FLW	0.0142**	0.0076^{NS}	0.0513**	0.0023^{NS}	0.0034
DFW	0.0148**	0.0071^{NS}	0.0554**	0.0022^{NS}	0.0036
DW	0.0121**	0.0021^{NS}	0.0375**	0.0095^{NS}	0.0050

** $P<0.01$ NS = Not significant ($p>0.05$)

Note: FLW = Fasting live weight, DFW = De-feathering weight, DW = Dressing weight.

Conclusion and Recommendations

It was concluded from this study that Arbor Acre was the most superior in bodyweight at 8 weeks compared to Ross and Marshal. However, the three strains of broiler chickens did not differ in weight gain, feed conversion ratio at 8 weeks and carcass yield. Based on superiority of bodyweight at 8 weeks, Arbor Acre broiler is recommended to broiler farmers in Nigeria.

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