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Determination of growth potentials of two chicken strains using day old phenotypic markers

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Abstract

This study focused on assessing one day old effect of some phenotypic markers on production traits in Ross broiler chickens (ROBROS) and Southern ecotype breeds of chicken (SEC) as an alternative for genetic markers. The study was conducted at the Akenten Appiah Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) Animal farm unit in Asante Mampong Campus of Ghana from June to December, 2022. One hundred and eighty (180) Ross broiler and 180 Southern ecotype breeds of chicks were used for the research. For each breed, the chicks were put into four groups with 45 chicks in each group. Breast length (BRL), Back length (BL), Circumference of the head (CH) and day-old body weight (DOBW) were taken on the chicks at one day old in group 1, 2, 3, and 4 respectively using a tailor's tape and a weighing scale. Chicks within each group were classified into three (3) sub groups and considered as treatments (T) 1, 2 and 3. The treatments were described as higher (T1), medium (T2), and lower (T3) ranges based on the values obtained from the measurement and reared under randomised completely block design (RCBD). Data on production traits were taken up to week 8 for the Ross broiler and 18 weeks for the Southern ecotype chicken. The results from ANOVA using Statistix indicated that for the Ross broiler chickens, T1 in all the groups were significantly ($P < 0.05$) superior over T3 for feed intake, body weight, body weight gain and feed conversion ratio. T2 were significantly better than T3 in terms of body weight. For the Southern ecotype chickens, T1 were significantly ($P < 0.05$) better than T3 for feed intake, body weight, and body weight gain. However, for feed intake and body weight gain, T2 were significantly ($P < 0.05$) better than T3. Pearson correlation analysis also indicated a high, strong and significant ($P < 0.05$) correlation between day-old phenotypic markers with body weight. Regression equations of day-old phenotypic markers with body weight were positive and significant ($P < 0.05$) with coefficient of determination (R2) ranging from 0.64 to 0.76 for Ross broilers and 0.81 to 0.95 for Southern ecotype chickens. CH and DOBW had the highest R2 values and thus the best predictors of body weight. Breast length, back length, circumference of the head, and day-old body weight taken on the chicks at one day old were effective in predicting final body weight. It was concluded that, the four (4) phenotypic markers could be used for selection purposes efficiently.

Keywords: Growth potential; Phenotypic markers; Production traits; Coefficient of determination

1. Introduction

Indigenous village chicken is the most dominant class of livestock in Ghana which makes up about 60-80% of the total poultry population (Hagan et al., 2013). There is a high preference for indigenous chicken products such as meat and eggs by majority of rural dwellers. This preference is as a result of attributes possessed by these animals such as toughness, pigmentation, taste, leanness and their suitability for special dishes (Islam, 2000). Their productivity is however low due to poor nutrition and low genetic potentials (Aboe et al., 2006). An improvement in the genetic

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potential of our local chicken is key to improving on their performance. Developed countries have seen a massive improvement in their livestock sector as a result of a pivoted advancement from livestock technologies in relation to genetic improvement strategies as compared to Africa countries (Marshall, 2014). Africa is faced with this slower rate of genetic improvement as a result of the lack of public and private sector investment, weak supportive policies and institutional arrangements (Marshall, 2014).

Relationship existing among body traits provides useful information on the performance, productivity and carcass characteristics in animals. In this regard, alternatively cheaper methods involving the use of simple tools to measure some body parts to determine the performance of chicken can be employed (Lesosky et al., 2013). Additionally, relationship between body weight and linear body measurements are important not only in genetic improvement strategies but also useful in the prediction of body weight. Poultry breeders have established that there is a relationship that exist between body weight and linear body parameters such as shank length, breast width, keel length, back length and thigh length. Genetic improvement programs in Ghana are at a minimal rate as far as our local chicken breeds are concerned due to funding for research and logistical constraints. Considering the current lapse in our genetic improvement programs, the use of linear body measurements is an alternative to determine the body weight of our local chicken. The study therefore focused on determining the genetic potentials of our local chicken using phenotypic markers as a selection tool at day old.

1.1. Study location and duration

The experiment was conducted at the Akenten Appiah Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) Animal farm unit in Asante Mampong Municipality within the Ashanti region of Ghana. The experiment lasted for 8 months.

1.2. Experimental animals and data collection

180 Ross broiler and 180 Southern ecotype chicks were put into four groups each on the day of arrival by means of randomization whilst they were under brooding for a period of two weeks with each group comprising of 45 chicks. One (1) Morphological marker was taken on the chicks in each group at one day old using a tailor's tape and a weighing scale. Breast length was measured as the distance between the mid- region of the breast when positioned ventrally. Back length as the distance from the nadir of the neck curve to the base of the tail. Circumference of the head as the circular distance along the entire head region and day-old body weight (DOBW) as the weight of the chick at day old using a weighing scale.

Breast length was taken on the chicks in group 1, back length on the chicks in group 2, circumference of the head on the chicks in group 3 and day- old body weight on the chicks in group 4 for both Ross broiler and Southern ecotype chickens. The values obtained were considered as scores. For each group, the scores were ranked and in turn classified into three ranges as Higher, medium and lower for groups 1, 2 3 and 4 respectively in both Ross and Southern ecotype chickens. The three ranges of morphological measurements were considered as treatments in each of the four groups with each treatment replicated three times for both Ross and Southern ecotype chickens. The chicks were fed on calculated amounts of commercial broiler starter diet containing 21% CP and 2900Kcal/kg/me and a finisher diet containing 19% CP and 3000Kcal/me. Water was also provided to the birds ad-libitum. Feed intake, body weight, body weight gain and feed conversion ratio were determined on weekly basis for the Ross broilers up to 8 weeks and biweekly basis for the Southern ecotype chickens up to 18 weeks.

1.3. Statistical data analysis

ANOVA, Pearson correlation and simple linear regression analysis were done using Statistix software version 9. The simple linear regression model used for predicting final body weight:

$$Y = H + \beta X$$ simple linear regression model for predicting body weight in Ross and Southern Ecotype chickens.

Where
Y = dependent variable (body weight)
X = independent variables (BRL, BL, CH & DOBW)
H = the intercept
β = the slope

2. Results and discussion

Table 1 Effect of breast length (BRL) as a phenotypic marker on body weight (BW) in Ross broiler chickens

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BRL1	162.00^{a}	531.00^{a}	948.30^{a}	1520.00^{a}	2205.00^{a}	2761.70^{a}	3451.70^{a}	4015.00^{a}
BRL2	156.67^{ab}	515.00^{b}	921.67^{a}	1496.70^{a}	2171.70^{a}	2720.00^{a}	3400.00^{a}	3953.30^{a}
BRL3	143.33^{b}	431.67^{c}	781.67^{b}	1421.70^{b}	2060.00^{b}	2398.30^{b}	2871.70^{b}	3258.30^{b}
SEM	4.81	3.37	31.25	20.93	23.43	27.58	47.16	40.74
P-value	0.04	0.00	0.01	0.02	0.01	0.00	0.00	0.00

a-b indicate significant difference between means within the same column at 5% significant level, BRL1: breast length higher range, BRL2: breast length medium range, BRL3: breast length lower range, SEM: standard error of means.

The outstanding performance for body weight by ROBROC with higher breast length followed by ROBROC with medium breast length compared to ROBROC with lower breast length agrees with the finding from Adeyinka et al., (2006) and Oke et al., (2004) who confirmed the reliability of using phenotypic markers as an effective tool for selecting body weight as a trait of interest. They stated that chickens with superior performance for body weight in relation to these linear body measurements are associated with efficient foraging capabilities which makes them exploit food sources more effectively leading to increased body weight. They further attributed this outcome to their distinctive developed digestive systems which enable them to extract and utilize nutrients more efficiently, resulting in increased body weight. The superiority in performance of Ross broiler chickens having higher breast lengths over those with medium and lower ones for body weight could also be due to their enhanced feed consumption capabilities as well as increased muscle mass which facilitates efficient feed utilization that affects overall body weight.

Abdel–Lattif (2019) also confirmed the reliability of predicting body weight using breast circumference as a marker attributing this positive milestone to consistency of performance. Ukwu et al., (2014) also confirmed the reliability of using breast circumference as a superior and faster method of selection which is also in support of the previous findings. This report as well is in line with the finding of Singh et al., (1987) who reported a higher relationship of bodyweight with chest circumference in grey Bengal goats. The assertion also agrees with the finding of Robinson et al., (2007) who showed that moderate and high body weight hens had greater proportions of carcass protein and ash than low body weight hens. The positive result outcome associated with Ross broiler chickens having higher breast length as compared to those with medium and smaller ones could be attributed to the former having a more efficient metabolism, allowing them to convert feed into energy and body weight more rapidly and effectively. This evidence is also observed in other poultry species, such as Wadi Ross meat type chicken (Amao et al., 2011) and Isa brown chickens (Fayeye et al., 2014).

Nevertheless, some studies have reported contradictory findings. For instance, a study by Ojo et al., (2014) found no significant correlation between breast length and body weight in quails. Another study by Adeleke et al., (2004) reported a negative correlation between breast length and body weight in chickens, suggesting that longer breast length may actually be associated with lower body weight. The difference in these result findings could be attributed to differences in genetic background, breed, as well as analytical procedures and tools. Moreover, a study by Latshaw and Bishop (2001) found that the relationship between breast length and body weight is also influenced by the chicken's genetic background which confirms this current suggestion.

Table 2 Effect of day – old body weight (DOBW) on body weight in Southern ecotype chickens

TREATMENTS (g)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
DOBW1	91.66[a]	228.33[a]	346.67[a]	531.67[a]	708.33[a]	828.33[a]	986.67[a]	1093.30[a]	1233.30[a]
DOBW2	83.33[ab]	195.00[b]	268.33[b]	406.67[b]	573.33[b]	688.33[b]	820.00[b]	930.00[b]	1038.30[b]
DOBW3	80.00[b]	158.33[c]	225.00[c]	340.00[c]	463.33[c]	571.67[c]	653.33[c]	793.30[c]	905.00[c]
SEM	3.33	5.44	6.66	11.14	16.24	21.51	11.30	12.87	20.11
P-value	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

a-c indicates significant difference between means within the same column at 5% significant level, DOBW1: day old body weight higher range, DOBW2: day old body weight medium range, DOBW3: day old body weight lower range, SEM: standard error of means.

The higher body weight scores obtained by Southern ecotype chickens with higher day-old body weight followed by Southern ecotype chickens with medium day-old body weight compared to those with lower day-old body weight is in support of the findings from (Amao et al., 2011; and Assan, 2015). It is reported by Willemsen et al., (2008) that higher initial chick weight affected body weight up to market age which as well is in support of the current finding. This sterling outcome was attributed to the higher muscle mass associated with chickens with higher initial day-old body weight compared to the other groupings. This positive outcome of genetic superiority is also observed in other species, such as Sudanese Kenana cattle (Musa et al., 2011) and Sahel goats (Mohammed and Amin, 1997).

However, this finding contradicts that of Jiang and Yang (2007) and Molenaar (2008) that initial chick weight affected body weight at early age and suddenly declined during market age in studies involving the use of quality meat type broilers suggesting that higher day-old body weight may actually be associated with the presence of unknown quantity of residual yolk in the abdominal region. The variation in these findings could be due to differences in the breeds used as well as environmental provisions.

Table 3 Correlation Matrix among breast length, back length, head circumference and day-old body weight on body weight gain in Ross broiler chickens

	1	2	3	4
Breast length	1	0.94*	0.97*	0.94*
Back length		1	0.90*	0.99*
Head circumference			1	0.89*
Day old body weight				1

Numbers against the parameters in columns correspond with variables in rows; * = significant at p <=0.05

The high positive correlation shown between breast length and back length for body weight gain marked by a correlation coefficiency (r) of 0.94 confirms the finding of Ukwu et al., (2014) who described the high predictive association between live body weight and body measurements. This signifies a strong degree of relationship between the two phenotypic markers for body weight gain on Ross broiler chickens. It also justifies the reliability of using the two phenotypic markers to predict body weight gain. The high positive correlation between Breast length and head circumference for body weight gain characterized by a correlation coefficiency value of 0.97 justifies clearly the stronger degree of relationship between the two phenotypic markers for body weight gain.

It is also worth to note that, it is much more reliable to predict body weight gain using breast length or head circumference as a marker or indicator. This finding is in line with that of Alabi et al., (2012) who reported a high, positive and significant relationship between linear body measurements and body weight. The correlation coefficiency of 0.94 attributed to breast length and day-old body weight as phenotypic markers affirms the high degree of relationship between breast length and day-old body weight for body weight gain. Considering all two phenotypic markers, body weight gain was highest at their highest level of measurement. This clearly indicates that, phenotypic markers at higher ranges influence body weight gain better than phenotypic markers at medium and lower ranges.
The higher positive correlation exhibited between Back length and head circumference proves that, there was a stronger degree of relationship between back length and head circumference as phenotypic markers on influencing body weight

gain. The extremely higher positive correlation coefficiency of 0.99 shown between back length and day-old body weight on the influence of body weight gain as a parameter signals a stronger degree of association between the two phenotypic markers on body weight gain. Head circumference and day - old body weight also had 0.89 as a correlation coefficiency for body weight gain. It also signifies a high degree of association between the two phenotypic markers for body weight gain. It is justifiable from these findings that all four phenotypic markers at high levels of measurement could influence body weight gain. This report affirms the findings of Ikeh and Okwesili, (2021) that linear body measurement traits of Nigerian heavy ecotype local hens were strongly and positively correlated.

Table 4 Linear regression of phenotypic markers on body weight in Southern ecotype chickens

MARKERS	PREDICTION EQUATIONS	R^2	ADJUSTED R^2	LS
BRL	BW= 272.37 +284.52BRL	0.91	0.89	*
BL	BW= -402.29 + 279.50BL	0.94	0.93	*
CH	BW= -770.88 + 333.19CH	0.81	0.79	*
DOBW	BW= 139.55 + 32.83DOBW	0.95	0.94	*

BW- body weight, BRL- breast length, BL- back length, CH- circumference of the head, DOBW- day old body weight, R2 – coefficient of determination, LS- level of significance, *significant at $P < 0.05$

The coefficient of determination recorded for breast length in this study was 91%, indicating that breast length could be used to predict body weight efficiently from the prediction equation BW= 272.37+ 284.52BRL. This finding is in line with Obike et al., (2019) who recorded an R^2 of 92% for breast width in a linear regression model when working with Noiler, Arbor Acre broiler and Yoruba ecotype cockerels. The R^2 obtained is also higher than 66% coefficient of determination for body girth obtained by Ukwu et al., (2014). With a 91% coefficient of determination, it implies that only 9% of the variation in body weight is not accounted for by breast length. Back length also had a coefficient of determination value of 94%. This indicates that, the variation in body weight among the southern ecotype chickens is attributed to back length with a percentage margin of 94%.

With an R^2 of 94%, body weight could be predicted from the equation BW= -402.29 + 279.50BL. The R^2 value obtained in this research is higher than the 79% obtained by Ukwu et al., (2014) when they studied Nigerian indigenous chickens. The difference in these result outcomes as well could be due to differences in the breeds used and the environmental conditions under which the studies were conducted. With a significant R^2 value of 81%, body weight could be predicted with the equation BW= -770.88 + 333.19CH using circumference of the head as a marker. The R^2 obtained for head circumference is relatively higher than 56% recorded for head length by Gwaza and Haruna (2018) when they studied French broiler Guinea fowls. The variation could be due to differences in breed, environmental provisions and the regression procedure used. The present study also recorded a coefficient of determination value of 95% for day old body weight as a marker. This presents day old body weight as a marker fit to predict body weight with the equation BW= 139.55 +32.83DOBW. The four markers have proven to be more resilient and reliable in predicting body weight effectively and efficiently.

3. Conclusions

- Phenotypic markers taken at day-old affected feed intake, body weight, body weight gain and feed conversion ratio in Ross broiler chickens as well as Southern ecotype chickens.
- A strong positive correlation was established between the phenotypic markers with body weight gain in both Ross broiler and Southern ecotype chickens.
- There was a strong linear relationship between the phenotypic markers and body weight for both Ross broiler and Southern ecotype chickens.
- Predictive equations generated for determining body weight using these phenotypic markers were efficient.
- Farmers can select for birds that possess superior growth potentials using these phenotypic markers and body weight taken at day old at higher ranges.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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