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Statistical Modelling of Indigenous Chicken with Body Weight and Linear Body Measurements in Bench Maji Zone, South Western Ethiopia

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Abstract

This study was conducted to determine the association between body weight and linear body traits in Bench Maji indigenous chickens in three agro-ecological Zones, and to establish equations for prediction of body weight using linear body measurements. A total of 240 adult female chicken were used from purposively selected 120 households. Body weight was measured using weighing balance. Linear body traits such as body length, wing length, back length, keel bone length, chest width, shank length and circumference were measured using a textile measuring tape. Data were analyzed using the General Linear Model (GLM) procedures of Statistical Analysis System (SPSS.Ver. 20). Correlations between body weight and linear body measurements were determined using Pearson's correlation coefficient. Data were also subjected to simple and multiple linear regression analysis. Correlations between body weight and linear body measurements (body length, wing length, back length, keel bone length, chest width, shank length and circumference) were positive and significant ($P < 0.01$). The values of coefficients of determination (R^2) ranged from 0.19 to 0.25. In this study the best predictor for assessing the body weight of female chickens was Back length, Keel bone length and shank length. The predictive equations showed that there were significant ($P < 0.01$) relationships between body weight and linear body measurements. The coefficients of determination (R^2) values observed in this study shows that the predictive equations could be used to predict body weight accurately using the simple regression model for the study area.

Keywords: Body weight; Coefficients of determination; Linear body measurements; Predictive equation

Introduction

In developing country livestock production in general chicken rearing in particular plays a vital socio-economic role for people with low incomes [1]. In Ethiopia chickens are widely distributed and every rural family owns them. They provide a valuable source of family protein and income [2,3]. Currently the total chicken population in Ethiopia is estimated to be 56.53 million of which 94.31% are indigenous chickens which are mainly kept by small-holder rural farmers in scavenging system [4]. The remaining 3.21 and 2.53 percent are hybrid and exotic chickens, respectively.

The indigenous chickens which have been predominantly kept by the rural society have large variations in body conformation, plumage color and comb type [5,6]. This variations in morphological traits such as feather type, shank color, earlobe colour, and comb types are common among indigenous chicken populationsDue to these morphological variations a number of conformation traits are known to be good indicators for body growth and market values of chickens apart from body weight. Most of scholars in the world have tried to establish the relationship that exist between body weight and linear body measurement traits to establish the relationship of body weight with body length, chest circumference, keel bone length, wingspan length, back length, shank length and circumference. The relationship which exist among the linear body measurement traits will provide a useful information on the performance and carcass value of animals [7]. Relationships between body weight and linear body measurements are important for predicting body weight and can also be applied speedily in selection and breeding programs [8]. The use of body measurements to predict body weight of chicken is now a day becoming popular and few information's are available in this particular area. Thus, due to this reason this study was conducted to determine the relationship between body weight and linear body measurements and to model the relationship between body weight and linear body measurements in Bench Maji indigenous chicken populations.

Materials and Methods

Description of the study area

Bench Maji is one of the Zones of the Ethiopian Southern Nations, Nationalities, and Peoples' Region (SNNPR). Bench Maji is bordered on the south by the Ilemi Triangle, on the west by South Sudan, on the northwest by the Gambela Region, on the north by Sheka, on the northeast by Keffa, and on the east by Debub Omo. The Omo River defines much of its eastern border with Debub Omo. The administrative center of Bench Maji is Mizan Teferi; other towns include Maji. Bench Maji has 142 kilometers of dry-weather roads, for an average road density of 22 kilometers per 1000 square kilometers. The highest point in this Zone is Mount Guraferda (2494 meters). The Omo National Park is located on the western bank of the Omo River. The main food crops in this Zone include maize, godere (taro root), and enset, while sorghum, teff, wheat and barley are cultivated to a significant extent. Although cattle, shoats and poultry are produced in limited numbers, meat and milk are very much appreciated. Cash crops include fruits (bananas, pineapples, oranges) and spices (e.g. coriander and ginger); honey is also an important local source of income. However, coffee is the primary cash crop. Based on the 2007 Census conducted by the CSA, this Zone has a total population of 652,531, of whom 323,348 are men and 329,183 women; with an area of 19,252.00 square kilometers, Bench Maji has a population density of 33.89. While 75,241 or 11.53% are urban inhabitants, a further 398 or 0.06% are pastoralists. A total of 157,598 households were counted in this Zone, which results in an average of 4.14 persons to a household, and 151,940 housing units.

Sampling technique and methods of data collection

The study areas were purposively selected based on their potential for chicken population, accessibility, presence of indigenous chicken production and agro ecology. Before the main survey was commenced, a preliminary assessment was made to identify whether there is pure exotic and/or their crosses in the study areas. From eleven districts of Bench Maji Zone, three districts were selected based on agro ecology. From each districts four rural kebeles were randomly sampled. Then, a total of 120 households, 10 households from each rural kebeles, who possess a minimum of five matured indigenous chickens were randomly selected. Closely adjacent households were also skipped to avoid the risk of sampling chickens sharing the same cock. From each household, 2 matured female chickens were sampled for body weight and linear body measurement traits with a total number of 240 chickens.

Measurements of quantitative traits

A total of 240 indigenous adult female chickens were randomly sampled from each household and was determined by "recalling methods" of the interviewed farmers. Quantitative measurements of linear traits and body weight were taken on sampled indigenous female chickens using a textile measuring tape (cm) and a hanging spring balance (kg). Data on body weight, chest width (the circumference of the breast region), body length (the distance from the tip of the beak to cauda / tail, without feathers), shank length (length of the shank from the top of the hock joint to the bottom of the footpad), shank circumference (measured around the midway of the shank), keel bone length (obtained from sternum to bottom of the keel), back length (length from insertion of the neck into the body to the saddle) and wing length (length between the base of the neck and the uropygial gland gland) were taken from female chicken following FAO's descriptor for the characterization of chicken genetic resources [9].

Statistical Analysis

Data collected on quantitative traits of indigenous chicken populations were coded and entered into a computer using Microsoft Office Excel 2007. Body weight and linear body measurement traits were analyzed using the General Linear Model (GLM) procedures of Statistical Analysis System (SPSS, ver. 20). The model was fitted to main effects of district and sex on body weight and linear body measurements of chickens. Stepwise simple and multiple regression procedure was employed to regress body weight for female chicken to determine the best-fitting regression equations for the prediction of live body weight.

The following model were used for the statistical analysis:

Model

$$Y = B + \beta X \quad \text{..} \quad (1)$$

Simple regression model

$$Y = B + \beta 1X1 + \beta 2X2 + \ldots + \beta kXk \quad \text{..................} \quad (2)$$

Multiple regression model

Where Y = dependent variable (body weight)

Xi = independent variables (BL; CC; KBL; SHL; SHC; BKL; WL)

β0 = the intercept

βi = the slopes

Results

Body weight and body linear parameters

In the present study, Agro ecology had significant effect on body weight and all quantitative traits except back length (Table 1). The overall average body weight of female chicken was 1.36kg. The results for keel bone and wing length, body length and width, shank length and circumference were highly different across all the studied agro ecology. The value of keel bone for chickens reared in low altitude was significantly higher ($P < 0.01$) than, mid and high altitudes. However, there was no significance difference ($P > 0.05$) in keel bone of chickens reared in mid and high altitudes. Wing and body length of chickens reared in the

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study areas were significantly (P < 0.01) different. Wing and body length in high altitude chickens had higher value than mid and low altitudes. The value of back length of chickens reared in all the study agro ecology were not statistically significant (P > 0.05). The value of chest width in chickens reared in low altitude was higher (P < 0.01) than those chickens reared in mid and high altitudes whereas mid and high-altitude chickens had comparable values. Shank length values of chickens measured in high and low altitude had significantly higher values (P < 0.01) than those observed in mid altitude. The shank circumference of chickens reared in low altitude had significantly higher (P < 0.01) values than those reared mid and high altitudes.

Table 1: Body weight and linear body measurement traits of female indigenous chicken populations in three Agro-ecology of Bench Maji Zone (Mean ± SE; N= 240)

Items	N	BW	BL	CW	KBL	SHL	SHC	BKL	WL
Overall	240	1.36	38.2	27.6	10.1	7.2	3.4	17.8	17.1
CV %		6.75	6.25	2.22	6.25	9.49	6.14	6.25	6.45
Agro Ecology		**	**	*	**	**	**	ns	**
Lowland	80	1.38 ± 0.013^{a}	38.1± 0.210^{b}	27.7 ± 0.091^{a}	10.4 ± 0.083^{a}	7.43 ± 0.066^{a}	3.65± 0.029^{a}	17.9 ± 0.150	16.9 ± 0.138^{b}
Highland	80	1.36 ± 0.009^{a}	38.9 ± 0.186^{a}	27.5 ± 0.056^{b}	10.05 ± 0.066^{b}	7.34± 0.056^{a}	3.58± 0.020^{b}	17.9 ± 0.125	17.6 ± 0.114^{a}
Midland	80	1.33 ± 0.007^{b}	37.7 ± 0.158^{b}	27.5± 0.047^{b}	9.95 ± 0.048^{b}	6.93 ± 0.093^{b}	3.55± 0.022^{b}	17.7 ± 0.093	16.8 ± 0.101^{b}

$^{a,\,b,}$ Means between columns within each independent variables bearing different superscript letters are significant (P < 0.05); *(P < 0.05); ** (P < 0.01); ns = non-significance; SE= Standard error of the mean; BW = live body weight; BL = body length; CW = Chest width; KBL= keel bone length; SHL = shank length; SHC = shank circumference; BKL = back length; WL= wing length

Correlations between body weight and linear body measurement

Table 2: Correlation of body weight with linea r body traits of indigenous female chicken (N = 240) populations in Bench Maji Zone, South Western Ethiopia.

Traits	BW	KBL	WL	BL	BKL	CC	SHL	SHC
BW	1							
KBL	.358**	1						
WL	.139*	.340**	1					
BL	.235**	.400**	.749**	1				
BKL	.437**	.356**	.229**	.328**	1			
CC	.203**	.240**	.144*	-0.072	.145*	1		
SHL	.312**	.511**	.301**	.341**	.308**	.214**	1	
SHC	.314**	.426**	.222**	.147*	.310**	.275**	.504**	1

BW = Live body weight; BL = body length; CC = Chest circumference; KBL = keel bone length; SHL = shank length; SHC = shank circumference; BKL= back length; WL = wing Length; *P < 0.05, Significant; **P < 0.01, highly signifcant.

As presented in Table 2, all linear body measurements of chickens in the studied areas were highly correlated with body weight. The correlations of body weight with body length, chest width, keel bone length, shank length, shank circumference, back length and wing length were 0.235, 0.203, 0.358, 0.312, 0.314, 0.437 and 0.139, respectively.

Prediction of body weight using body linear parameters

Predictive equation relating to body weight of indigenous chickens to linear body measurements in the study area was shown in Table 3. Body weight and linear body measurements had significant (P < 0.01) associations.

Table 3: Predictive equations used for prediction of body weight of female chickens reared in the study area.

Parameters	R2 (%)	Predictive equations	LS
BKL	19	Y= 0.71666 + 0.03592(BKL)	**
KBL, BKL	24	Y= 0.49831 + 0.03342 (KBL) + 0.02916(BKL)	**
KBL, BKL, SHC	25	Y= 0.40572 + 0.02647(KBL) + 0.02717(BKL) + 0.05523(SHC)	**

**P <0.01 = highly significant; LS = Level of significant; R2 = coefficient of determination.

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Y = predicted live body weight; KBL = keel bone length; SHC = shank circumference; BKL= back length.

Discussion

Body weight and body linear parameters

The average values of live weight of females observed in the current study was comparable with the findings of Addis et al. ([10]. However lower values of body weight were reported by various scholars in the country [8,11].

The results on linear body measurement traits in the current study was comparable with most of the observations in different parts of the country. Accordingly, the average value of BL in the present study was in close agreement with the reports of Eskindir et al. [11] and Addis et al. [10]. However, it was higher than those reported by Deneke et al. [8] and Emebet et al. [12]. These variations in body length might be due to the age of animals, agro-climatic conditions and status of nutrition of chickens when the data were collected by various scholars.

The average value of CW in the current study was in close agreement with the reports of Eskindir et al. [11] and Deneke et al. [8]. Chest width (chest girth) is an indicator of fleshing of a chicken. The average value of KBL in the present study was also comparable with the report of Deneke et al. [8]. However, higher values of KBL were reported by Eskindir et al. [11] from Horro and Jarso districts of Oromia Zone, which may reflect better frame size in the latter chicken ecotypes Length of keel and shank are also regarded as good indicators of skeletal development of a bird, which is related to the amount of meat a chicken can carry. The results obtained for average SHL in the present study were comparable with the reports of Addisu et al. (2013) and Eskindir et al. [11]. However, it was higher than those reported by Deneke et al. [8] in chickens reared in Southeastern Oromia Regional State of Ethiopia. These variations might be explained by the availability of scavengable feed resources both in quality and quantity in those different study locations.

The present average result pertaining to shank circumference was in close agreement with the reports of different scholars in Ethiopia [8,10]. The average values relating to back length were comparable with those reported by Eskindir et al. [11]. The observed significant effects of age on body weight and linear body measurement traits of chickens in the present study was in line with the reports of Semakula et al. [13] and Ojedapo et al. [14] who noted that, body weight and linear body measurements increases with the advancing age of chickens.

Correlations between body weight and linear body measurements

In the current study, positive and significant ($P < 0.01$) correlations was observed between body weight and linear body measurement traits and are in good agreement with the reports of Addis et al. [10] and Deneke et al. [8]. These positive and significant correlations of body weight with linear body measurements observed in the present study and elsewhere suggest that measuring one of these quantitative traits enables to predict the body weight of local chickens in rural farming society. The results of the present study and findings of other scholars therefore suggests that, selection for any of these linear body measurable traits will cause direct improvement in body weight of indigenous chicken populations [7,15].

In the present study, the R2 values ranged from low (0.19) to relatively high (0.25) indicating that the calculated equations could be used to predict the body weight of chickens. Predictive equations provide a readily available tool in body weight estimation. This is particularly true in rural areas or areas where weighing scales are not available as suggested by Alabi et al. [16], Addis et al. [10] and Liyanage et al. [17,18].

Conclusion

Variations in linear body measurement traits were observed indicating the existence of genetic differences in major performance traits which makes selection between indigenous chicken populations a viable option to improve their genetic potentials. Moreover, authors recommend an in-depth molecular assessment to concretely validate the level of genetic variations and relationship existing among indigenous chicken populations of the study areas.

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