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Estimation of live body weight using zoometrical measurements for improved marketing of indigenous chicken in the Lake Victoria basin of Uganda

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Abstract

The relationship between zoometrical measurements and live body weight was determined in indigenous chicken of the Lake Victoria Crescent Agro-ecological Zone in Uganda. A sample of 493 mature birds (342 females and 151 males) was used to measure body length, femur circumference, chest circumference, femur length, femur circumference, shank length, and keel length.

The effect of age and sex was significant ($P < 0.01$) for all measurements. Males showed higher live body weights and other body measurements than their female counterparts ($P < 0.01$) while all body measurements, increased with age. An average mature male chicken weighed 2.11 ± 0.27 kg while a female weighed 1.48 ± 0.15 kg. Correlation coefficients between body weight and other measurements were high and positive ($P < 0.01$) except for Body Length and Femur Circumference in females. Chest Circumference was the best single live weight estimator ($r = 0.88$) closely followed by Body Length ($r = 0.81$), and Femur Length ($r = 0.80$) while Femur Circumference ($r = 0.29$) was the least. Prediction of Live Body Weight from Chest Circumference using the power model ($R^2 = 0.83$) was the most reliable compared to simple linear regression (0.76) and polynomial ($R^2 = 0.77$).

The strong relationship between Live Body Weight and other body measurements could be exploited to increase the economic value of the indigenous chicken. Determination of live body weights of chickens using the heart girth could earn farmers between $0.6 and $0.65 more while buyers will save between $0.1 and $0.2per kilogram body weight of chicken thus should be encouraged.

Key words: Economic value, premium price, zoometrical measurements

Introduction

Poultry production is vital in the livelihoods of many Ugandan households, especially the resource poor rural farmers providing a vital protein source, income, manure and is important in a number of social functions for gifts, sacrifice, medicinal value, etc). This enterprise is however, largely managed under subsistence farming, although a number of birds exchange hands in a marketing arrangement. The current national chicken population is estimated at 39 million, the bulk (87.7%) of which is constituted by the indigenous chicken (UBOS 2010), mostly kept in rural settings.

Indigenous chickens are also increasingly becoming important in niche markets, given their organic way of being raised (Angel 2010). In rural settings birds are kept under traditional systems which are highly extensive. Farmers do not gain adequately enough from chicken rearing partly because there are no standards for determining the economic value of chicken. There are no weighing scales in poultry markets and/or villages.

The marketing system is generally, informal and haphazard (Emuron et al 2010). Birds are sold on face value and not by actual weight which reduces the farmers' bargaining power for premium price. The aim of this study was to explore the possibility of applying body measurements to determine live body weight of indigenous Ugandan chicken with accuracy.

Materials and methods

Location

Data were collected from indigenous rural chickens in the districts of Mpigi and Mubende, which are located in the Lake Victoria Crescent Agro-ecological Zone in Uganda. The districts were chosen on the basis of their high populations of indigenous chickens. In each district, two Sub-counties were selected for the study (i.e. Kassanda and Kalwana in Mubende district and Muduuma and Mpigi Town Council in Mpigi district).

Data collection

Two studies were conducted; the initial one was to develop the model for prediction of live body weight based on linear body measurements while the second involved the validation of the model. In the first study, data were collected during on-farm visits between April and June 2010. The weight of each bird was individually taken using a 25 kg weighing scale (Dahongying, Model No ATZ-A2, Huaying weighing apparatus Co. Ltd., Zhejiang, China) while body dimensions were measured, using a common tailors' measuring tape. Information collected included; Live Body Weight (LBW), Corpus Length (CL), Chest Circumference (G), Femur Length (FL), Femur Circumference (FC), Shank Length (SL) and Keel Length (KL). Measurements were carried using a modification of the method described by Salomon (1996). Parameter descriptions were:

CL: Length between the first thoracic vertebrae and the base of the pygostyle;
FL: Length between the mid region of the *Coxa* (hip bone) and that of the *Genu* (knee) taken on the right limb;
FC: Circumference of the drumstick at the *Coxa* region, taken on the right limb;
G: Circumference of the body measured at the tip of the *Pectus* (hind breast);
SL: Length between the *Genu* and the *Regiotarsalis*, taken on the right limb; and
KL: Length between the anterior and the caudal end of the keel.

A two-month' difference was used to categorize the chickens into age groups based on information from the owners. Hens in lay were not included in this experiment and all measurements were taken in the morning before birds were released to feed. Sex and plumage color were determined by visual examination.

In another study to test the model data were collected from chicken keeping households and village markets in each of the Sub-counties above. Farmers 'and/or seller's visual judgment, weigh scale and the model based on heart girth (G) as described in the first study were used. Markets were chosen on basis of high numbers of indigenous chickens available at these places. Birds are sold by vendors at stationed stalls to consumers regularly. Also traders usually come to buy chickens in markets and/or from village farmers and/or from middlemen and resell them in markets of big cities, like those of Mityana and Kampala.

Statistical analysis

The data were analysed using Generalised Linear Model procedure of SAS, version 9.1 (SAS 2003). Data were classified according to age and sex. The statistical model used took the following form:

$$Y_{ij} = \mu + A_i + B_j + AB_{ij} + e_{ij}$$

Where, Y_{ij} = vector value for measurement; μ = population mean; A_i = fixed effect of age group; B_j = fixed effect of sex; AB_{ij} = interaction between age and sex effects; e_{ij} = random error

No effect of plumage was observed ($P > 0.05$) thus ruled out of the model. Pearson's correlation coefficients between body weight and all body measurements were calculated. Measurements of parameters that were found to be significantly correlated with body weight were then subjected to regression procedures for development of prediction equations.

Results and Discussion

Chickens in rural areas have not been subjected to extensive selection, have low introgression and hence less genetic dilution. They are managed under extensive/free range systems with occasional feed supplementation. Because of their nature of production (organic farming), local chicken currently have widespread market acceptability as more affluent consumers prefer such birds to those produced under intensive systems.

Effect of age and sex

Mean values for live body weight and body measurements with respect to age groups are presented in Tables 1 and 2. Live body weights and body measurements for mature chickens (i.e. above eight months) across sex are shown in Table 3. All linear body measurements increased with increasing age and stagnated above eight months of age. Linear measurements reflect structure growth, thus are not expected to change much after maturity is attained. However, body weight and other non-linear measurements such as girth depend on changes in muscular and fat deposition.

Table 1. Live body weight (kg) and body measurements (cm) of female chicken

Age (months)	Measurements						
	BL (cm)	G (cm)	FL (cm)	FC (cm)	SL (cm)	KL (cm)	LBW (kg)
2-4 (n = 26)	14.80[a]	18.0[a]	9.51[a]	7.13[a]	5.40[a]	7.40[a]	0.43[a]
4-6 (n = 56)	15.90[b]	19.4[b]	9.84[b]	7.80[c]	5.50[b]	7.90[b]	0.75[b]
6-8 (n = 64)	18.20[c]	23.80[c]	11.3[c]	8.90[c]	6.10[c]	9.70[c]	1.16[c]
8-10 (n = 46)	18.90[d]	25.69[d]	11.60[c]	9.40[d]	6.30[c]	10.30[d]	1.46[d]
≥10 (n = 150)	19.40[d]	25.70[d]	11.70[c]	9.70[d]	6.30[c]	10.60[d]	1.58[e]
LSD	1.01	1.57	0.80	1.41	0.69	0.65	0.13
CV%	8.52	10.21	10.48	10.63	14.92	10.03	21.84

[abcde] *Means with the same superscript within a column are not different*

Table 2. Live body weight (kg) and body measurements (cm) of male chicken

Age (months)	Measurements						
	BL (cm)	G (cm)	FL (cm)	FC (cm)	SL (cm)	KL (cm)	LBW (kg)
2-4 (n = 45)	12.90^{d}	16.09^{d}	8.28^{d}	9.14^{c}	4.57^{c}	6.30^{d}	0.6^{d}
4-6 (n = 21)	18.10^{c}	22.66^{c}	11.56^{c}	9.26^{c}	6.91^{b}	9.09^{c}	1.08^{c}
6-8 (n = 30)	19.33^{b}	24.32^{b}	12.38^{b}	10.89^{b}	7.15^{b}	10.19^{b}	1.42^{b}
8-10 (n = 22)	20.94^{a}	27.78^{a}	13.62^{a}	12.05^{a}	7.60^{ab}	11.86^{a}	1.95^{a}
≥10 (n = 33)	21.50^{a}	29.23^{a}	14.11^{a}	12.74^{a}	7.98^{a}	12.43^{a}	2.32^{a}
LSD	1.01	1.57	0.8	1.4	0.69	0.65	0.4
CV%	8.5	10.2	10.48	10.6	15.9	10	22.6

^{abcd} *Means with the same superscript within a column are not different*

Due to maintenance of sex ratio, and/or negative selection of males for selling, slaughter, give away and other functions more females were available for sampling than males. In Senegal more males were reportedly sold than females in 1998 (Guèye et al 1998). In our current study, males were superior ($P < 0.01$) to females in all body measurements (Table 3). The findings are in line with those of Olawunmi et al (2008) and Guèye et al (1998) for mature chickens. On average, a mature male bird weighed 2.11 ± 0.27 kg while a female one weighed 1.48 ± 0.15 kg. These weights are in line with those reported by Ssewannyana et al (2003) and Kyarisiima et al (2004). The existing sexual dimorphism is explained by the differences in levels of male sex hormone which is responsible for greater muscle development in males than in females.

Table 3. Effect of sex on body measurements of chicken above six months of age

Measurement (cm)	Sex		LSD	CV%
	Male (n= 260)	Female (n = 85)		
BL	20.78^{a}	19.11^{b}	0.4	8.1
G	27.13^{a}	25.36^{b}	0.68	10.4
FL	13.40^{a}	11.62^{b}	0.3	9.79
FC	11.04^{a}	9.48^{b}	0.4	15.9
SL	7.60^{a}	6.26^{b}	0.24	14.6
KL	11.43^{a}	10.37^{b}	0.31	11.3
BW	1.92^{a}	1.48^{b}	0.11	26

^{abcd} *Means with the same superscript within a row are not different*

Like most tropical breeds, indigenous chicken ecotypes in the study area, have a small stature which explains their adaptability to production stress in their environment. This perhaps means that their persistent existence in the tropics was made possible by perpetual reductions in live weight and body over a long period of time (Yeasmin and Howlider, 1998; Broady et al 1984). The environment has been greatly linked with the phenotypic appearance of individual chickens in the tropics (Badubai et al 2006). A smaller body size is said to be vital in reducing the maintenance feed requirements and increase feed efficiency. This is essential for survival in the scavenging system due to scarcity and uncertainty surrounding feed supply.

Relationship between live body weight and zoometrical measurements

The correlation coefficient between live body weight and body measurements for all age groups and sex are presented in Table 4. All coefficients were significant and positive. In males all measurements were strongly correlated to the BW of chicken ($P < 0.01$), while in females all measurements were significant except BL and FC in 6 - 8 months old chickens. The relationship did not vary much with age, indicating that a single weight estimation model could be adopted across age. The highest correlation coefficient was G (0.88), and closely followed by BL (0.81) and FL (0.80) in both males and females. In mature indigenous chickens in Senegal, Guèye et al (1998) also found that body length and chest girth were strongly and significantly correlated to body weight.

Table 4. Correlation coefficient of live body weight and body measurements in chickens

Age group (months)	Sex	Body Measurement (cm)					
		BL	**G**	**FL**	**FC**	**SL**	**KL**
2-4	F (n = 26)	0.36	0.29	0.25	0.17	0.26	0.36
	M (n = 45)	0.90	0.60	0.76	0.45	0.08	0.57
	F+M	0.69	0.79	0.76	0.62	0.63	0.71
4-6	F (n = 56)	0.81	0.70	0.70	0.68	0.72	0.79
	M (n = 21)	0.49	0.67	0.44	0.46	0.35	0.21
	F+M	0.78	0.85	0.75	0.82	0.76	0.73
6-8	F (n = 64)	0.06	0.06	0.15	0.01	0.03	0.16
	M (n = 30)	0.69	0.86	0.88	0.78	0.39	0.81
	F+M	0.53	0.71	0.77	0.76	0.50	0.56
8-10	F (n = 46)	0.16	0.24	0.19	0.07	0.38	0.38
	M (n = 22)	0.25	0.43	0.59	0.64	0.37	0.53
	F+M	0.57	0.70	0.73	0.70	0.53	0.73
≥10	F (n = 150)	0.34	0.28	0.44	0.07	0.32	0.40
	M (n = 33)	0.57	0.78	0.68	0.52	0.51	0.54
	F+M	0.67	0.77	0.73	0.68	0.66	0.6

Table 5 gives a summary of the various models developed for live weight determination in chicken. Girth (G) having showed the highest correlation to body weight would thus be the best body weight estimator. It was plotted against LBW to study the nature of their relationship. The power model (Figure 1) was the most suitable while simple linear regression showed the least suitable predictor model. The figure shows that the nature of the relationship between G and LBW would best be demonstrated using non linear regression models.

Table 5 Prediction equations for live body weight determination based on heart girth (G) in mature chicken

Model	Equation	R^2	Significance
Power	$0.001G^{2.417}$	0.83	***
Exponential	$0.100e^{0.105G}$	0.80	***
Polynomial	0.002G2 + 0.038G - 0.6214	0.77	***
Linear	0.123G -1.60	0.76	***

**** Significant at P < 0.01*

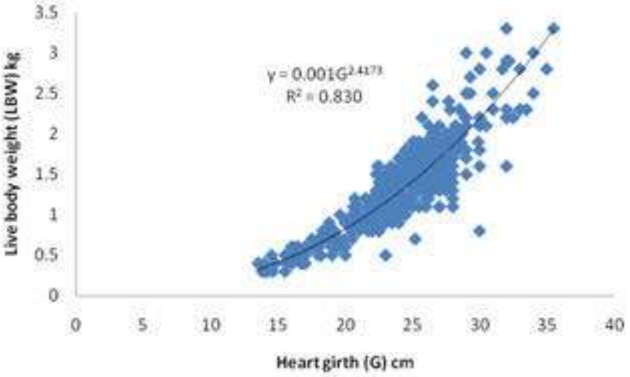

Figure 1: A power-model graph of live body weight against chest circumference

Economic value implications

Indigenous chickens are regularly traded throughout the year. Table 6 shows mature chicken mean weights with associated error of mean by different methods of determination and selling points with corresponding average prices per bird. It was noted that, visual judgment/estimation was the basis for chicken value determination both on farm and in markets.

A mature cock of about 2 kg live body weight was sold at $7.0 and $9.4 while a hen of about 1.6 kg went at $4.3 and $6.2 as farm gate and market prices respectively. It was noted that by visual judgment, sellers at farms lost between $0.6 and $0.65 per kilogram live body weight of chicken sold while buyers in markets paid between $0.1 and $0.2 more per kilogram live body weight.

Table 6. Means with their standard errors for weights (kg) of mature chicken determined by different methods from the selling points and the average prices per bird sold

Selling point	Method of weight determination	Weight (kg)	Price/bird ($)
Hen (n=40)			
Farm	Model prediction	1.54 ± 0.06	4.3
Farm	Visual judgment	1.20 ± 0.05	
Farm	weighing scale	1.51 ± 0.06	
Cock (n=30)			
Farm	Model prediction	1.97 ± 0.15	7
Farm	Visual judgment	1.57 ± 0.13	
Farm	weighing scale	2.07 ± 0.14	
Hen (n=40)			
Market	Model prediction	1.60 ± 0.09	6.2
Market	Visual judgment	1.78 ± 0.09	
Market	Weighing scale	1.61 ± 0.06	
Cock (n=25)			
Market	Model prediction	2.05 ± 0.08	9.4
Market	Visual judgment	2.10 ± 0.07	
Market	Weighing scale	2.03 ± 0.05	

Using a carcass dressing percentage of 80%, mature dressed birds sold by both farmers and market vendors were estimated to fetch $4.83 and 5.89 for a hen and rooster, respectively on per kg basis.

Compared with the commercial chicken prices, these offers translated into premiums of about 13.76% for hens and 21.7% for roosters in markets. Those in search of niche and affluent markets seem willing to pay more in order to get indigenous chicken meat raised organically (Emuron et al 2010). Similar findings have been reported by Guèye et al (1998) in indigenous mature chickens in Senegal.

Conclusions

From the findings it can be concluded that;

- The use of a common tailor's measuring tape gives an accurate estimate of body weight and is sufficient. Chest circumference produced the most accurate estimate, though BL and FL could also be used. Farmers could use the readily available tapes to determine the value of their birds.
- Famers can gain more value for their chicken if their sales were based on body weight in live birds or even better with carcass sales.
- The study has revealed phenotypic variability which is affected by both genetic and environmental factors

Recommendations

Use of calibrated tape measures to determine live body weights of live birds could provide an informed basis for negotiation by farmers' for better prices from buyers on farm and save consumers from exploitation by market vendors. Local chicken traders need to be trained and equipped with skills in chicken economic value determination as a useful tool in chicken trade.

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