2014

Prediction of live body weight using various body measurements in Ugandan village pigs

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Four body measurements; body length, heart girth, height and body width were strongly predictive (R^2 = 0.92) of live body weight for the ≥ 40 kg pigs with the prediction equation; Weight = -108.198 + 0.228 (body length) + 1.094 (heart girth) + 0.267 (height) + 0.922 (body width). The flank-to-flank measurement did not affect model prediction ($p > 0.05$) and quadratic terms also did not improve accuracy and were not included in any prediction models. These results suggest that live weight could be accurately estimated using two or more pig body measurements.

It was concluded that this weight estimation tool would empower Ugandan small scale pig farmers by providing them with an accurate estimate for the animal's live weight and giving them better bargaining power when selling their pigs.

Keywords

body length, body width, heart girth, height, weight prediction model

Disciplines

Agriculture | Animal Sciences

Comments

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Livestock Research for Rural Development 26 (5) 2014 | Guide for preparation of papers | LRRD Newsletter | Citation of this paper

Prediction of live body weight using various body measurements in Ugandan village pigs

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Abstract

A study to develop body weight prediction equations based on various body measurements was conducted in rural Kamuli district, Uganda. Body weight (kg) and body measurement data (cm) were collected from 411 pigs between 15 and 127 kg from both local and exotic (mainly crossbreds) pigs. Five body measurements; body length, heart girth, height, body width and flank-to-flank were taken from each pig. Prediction models were developed by regressing weight on pig body measurements. The models were developed for pigs categorized as < 40kg, = 40 kg and an overall single prediction model. Mean weights of < 40 kg and = 40 kg were 27 ± 6.5 kg and 63 ± 19.6 kg, respectively. Body length and heart girth were used to predict (R^2 = 0.89) weight for the < 40 kg pigs with the prediction equation; Weight = -41.814 + 0.296 (body length) + 0.654 (heart girth).

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It was concluded that this weight estimation tool would empower Ugandan small scale pig farmers by providing them with an accurate estimate for the animal’s live weight and giving them better bargaining power when selling their pigs.

Keywords: *body length, body width, heart girth, height, weight prediction model*

Introduction

Most Ugandan smallholder farmers do not have access to a scale to weigh their livestock and this creates both management and sales problems. Without scales farmers may have to travel large distances to weigh their livestock, but most commonly traders buy livestock based on visual weight estimates, and almost always underestimate it, which adversely affects farmers because they receive less money for their animals than they are really worth.

Live weight estimations predicted using body measurements have been used in different animal species (Enevoldsen et al 1997; Thiruvenkadan 2005). In the case of pigs, backyard farmers in the Philippines used body measurements such as body length and heart girth to predict weight, because they could not afford to purchase weighing scales (Murillo and Valdez 2004). Previous work by McGlone et al (2004) individually weighed and obtained several body dimensions including sow body length, height, body width (lateral body length, left to right from the mid-line) and depth were also determined. Prediction equations were used to estimate live body weight and size relations in these different pigs. This information is vital to provide accurate live body weight estimates for the pigs when marketed. Other research has reported a strong correlation between live body weight and heart girth in finishing pigs (Groesbeck et al 2004). In a recent study conducted in Western Kenya, Mutua et al (2011) reported accuracy of weight prediction using body length and heart girth for pigs from different age categories.

The Uganda commercial swine industry is mostly made up of very small scale farmers, many of them poor women and pig production is critical to provide food and help raise money for their families (Tatwangire 2013; Ouma et al 2014). The producers/small scale pig farmers do not have means for transporting pigs to an organized market so they must rely on traders to come to their farms and buy the pigs. Often they are given lower prices because the pigs' live body weights are poorly estimated at the time the sales transaction is occurring. Since the breed types may be quite different in Uganda, than in other places, data must be collected to develop prediction equations for local and improved pigs (cross between the local and exotic breeds). Limited peer review work has addressed the weights and dimensions for market pigs and sows in Uganda and at present, no reliable data exits that could be used to develop a body weight prediction tool for pigs raised by smallholders in Uganda. Additionally, using body weight prediction information from other locations might not be accurate. It is critical that the Ugandan local pig producers have accurate live body weight information at the time any sales transaction occurs in order to establish some “true” total body weight estimate and hence establish a fair market value for each animal. Such information will be vital to the Ugandan smallholder and medium size pig farmers who cannot afford scales and need fair prices for their pigs. The objective of this study was to develop prediction models for determining pig weight using various body measurements.

Materials and Methods

All animal procedures were approved by the Institutional Animal Care and Use Committee (IACUC Log#8-13-7614-S) of Iowa State University before the start of the research project.

Study location

The study was conducted in Eastern Uganda, Kamuli district, in Kakindu, Kabalira, Buburiki, Bugulumira A and B, Buweryo, Bukaaya, Buyengere, Bususwa, Bunabiryo, and Kabaganda villages. The project focused on small holder pig farms (less than 10 pigs) and medium scale commercial farmers (less than 50 pigs). The district veterinary officer and community based mobilizers working with a local non-governmental organization (Volunteer Efforts for Development Concerns, VEDCO) guided the researchers in locating the pig farmers, and in ensuring a good relationship among researchers, pig farmers and the community at large.

Weighing and measuring pigs

Farms were visited, pigs weighed, and live body measurements were taken at each location using an electronic digital scale and a wire cage to hold pigs steady for measurement purposes. A picture of each pig was taken to phenotypically characterize the pigs by breed and to maintain for future reference. A total of 411 pigs that ranged between 15 and 127 kg were evaluated and the corresponding measurements, in centimeters (cm) were then taken twice and included heart girth, height, body width, body length and flank-to-flank. Data were not collected from pregnant females and very aggressive pigs that could not be reasonably restrained in the cage.

For every farm visited, the farmer or a member of the household was asked to estimate the weight and age of the pig(s) measured. Prior to each pig's entry on the scale, researchers zeroed-out the scale to be sure an accurate weight for each animal was obtained. A small amount of commercial feed was placed at one end of the cage floor; the animal was directed towards the cage for weighing from the opposite side of the cage. The cage was designed such that it would accommodate both small and larger pigs. A cloth measuring tape was used to determine the heart girth, height, body width and body length in centimeters. Heart girth was measured just behind the front legs. A string was wrapped around the heart girth of the pigs and the intersection of the string was then used to transfer the heart girth circumference to a cloth tape for the measurement. A modified caliper made with Poly Vinyl Chloride (PVC) pipe was used to determine height directly behind the front legs of the pig. The caliper was adjusted so that the upper PVC pipe touched the back of the pig. The height and the corresponding body width were noted and recorded. Body length was measured with a cloth tape from the mid-point of the ears (crown) to the tail head. Flank-to-flank was measured with a cloth tape being placed over the top of the tip, from the bottom of the flank on one side of the pit to the bottom of the flank on the other side of the pig (Figure 1). The pig's sex was noted and recorded after weight and pig body measurements.

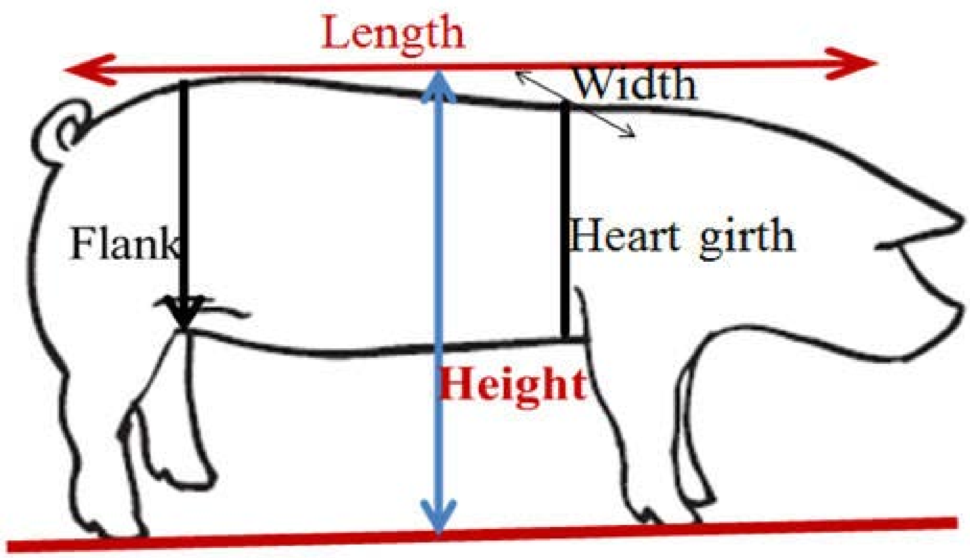

Figure 1. A graphical depiction showing the location where various body dimensional measurements were obtained that were utilized to predict live body weight in pigs from Uganda

Categorization of pigs

Pigs were categorized into two groups based on body weight: young or below market age (< 40 kg) and market weight pigs (= 40 kg). In Uganda, pigs are sold for slaughtering beginning at an average weight of 40 kg.

Data analyses

Prediction equations to estimate pig weight using heart girth, height, body width, and body length measurements were developed using GLM procedures (SAS 9.3 2012). Analyses were performed by stepwise regression using PROC REG to determine the change in R square when additional body measurements were included in the model. Data from two pigs from the heaviest weight class (167 and 180 kg) were not included in the analyses as they were identified as statistical outliers based on standard deviations. Both pig breed and sex were included in the model to determine whether they significantly influenced body weight in this study. Three prediction equations were developed in the course of the analyses. Equation 1 was computed for the young pigs below market weight, equation 2 was computed for the market weight pigs, and equation 3, the single prediction model was developed to assess the overall effect of body length, heart girth, height and body width on the pig's body weight. A body measurement parameter was considered significant and included in the prediction model at $p < 0.05$. Quadratic terms were also tested and only included if they significantly improved prediction.

Results

The model data sets included 411 pig observations, of which 202 pigs weighed less than 40 kg and the remaining 209 pigs' body weight was greater or equal to 40 kg. The mean body weights of pigs < 40 kg and = 40 kg were 27 kg (SD = 6.5; 95% confidence interval, 26.3 - 28.1) and 63 kg (SD = 19.6; 95% Confidence interval, 60.3 - 65.6), respectively Pigs were classified into one of five breeds that included; Large White, Landrace, Camborough, Local Black and a crossbred among Local Black and the other breeds. Crossbred pigs were the most prevalent in the study. When examining the data by breed classification, there were 150 crossbred pigs, 86 Large White and 79 Camborough, 62 Local Black and 34 Landrace. Breed and sex were not significant sources of variation when predicting pig weights in any of the pig categories ($p > 0.05$, Table 1).

Table 1. Model effects, prediction values and their significance for live body weight using analysis of variance from a study of Ugandan market pigs

Weight[2] (kg)		**Parameter**						
		Height[1]	**body width[1]**	**Height girth[1]**	**Flank[1]**	**body length[1]**	**Breed**	**Sex**
< 40	Mean Square	0.0273	1.74	391	1.078	295	10.2	1.96
	Estimate	- 0.006	0.103	0.654	- 0.0265	0.296		
	p value	0.94	0.55	< 0.0001	0.64	< 0.0001	0.08	0.52
= 40	Mean Square	171	332	2814	68.6	749	39.6	0.162
	Estimate	0.266	0.922	1.094	0.167	0.228		
	p value	0.02	0.0023	< 0.0001	0.15	<0.0001	0.31	0.94
All weights	Mean Square	6.45	570	3684	0.208	1168	52.5	6.520
	Estimation	0.0437	1.016	1.024	- 0.0068	0.251		
	p value	0.63	< 0.0001	<0.0001	0.93	<0.0001	0.12	0.63

N= 202 for pigs < 40 kg and N= 209 kg for pigs = 40 kg

[1] *Body measurements*

[2] *Pig categories*

The heart girth was the most important pig weight predictor with $R^2 > 0.84$ in the three pig categories. Limited additional contribution to the overall R^2 in the three pig categories was observed when other body dimensional measurements were included in the model (Table 2).

Body length and heart girth measurements explained a substantial portion of the variation in pig body weight ($R^2 = 0.89$; $p < 0.05$) for the pigs that were in the < 40 kg weight class from the present study. The prediction equation, equation 1 for this data is as follows:

$$\text{Weight} = -41.814 + 0.296(\text{body length}) + 0.654(\text{heart girth})$$

The model that included all significant effects was observed for the = 40 kg pigs when weight was regressed on all the four parameters of body length, heart girth, height and body width

($R^2 = 0.92$; $p < 0.05$). The prediction model (equation2) developed was:

$$\text{Weight} = -108.198 + 0.228(\text{body length}) + 1.094(\text{heart girth}) + 0.267(\text{height}) + 0.922(\text{body width})$$

Only three parameters; body length, heart girth and body width were identified as significant sources of variation when trying to predict live body weight ($p < 0.05$) in a single prediction model from the current data. The most predictive ($R^2 = 0.95$) model using the three parameters and weight was:

$$\text{Weight} = -80.261 + 0.251(\text{body length}) + 1.024(\text{heart girth}) + 1.016(\text{body width})$$

Flank-to-flank was not included in any of the three prediction models ($p > 0.05$). Quadratic terms were not significant and were not included in any of the models (data not shown)

Table 2. Change in R Square with inclusion of each additional body measurement using stepwise regression when predicting live body weight by three weight classes of pigs raised by smallholders in Uganda

Weights[2] (kg)	Parameter[1]	R Square
< 40	Heart girth	0.84
	Heart girth, Body length	0.89
	Heart girth, Body length, Body width	0.89
	Heart girth, Body length, Body width, Height	0.89
	Heart girth, Body length, Body width, Height, Flank	0.89
= 40	Heart girth	0.90
	Heart girth, Body length	0.91
	Heart girth, Body length, Body width	0.91
	Heart girth, Body length, Body width, Height	0.92
	Heart girth, Body length, Body width, Height, Flank	0.92
All	Heart girth	0.94
	Heart girth, Body length	0.94
	Heart girth, Body length, Body width	0.95
	Heart girth, Body length, Body width, Height	0.95
	Heart girth, Body length, Body width, Height, Flank	0.95

N=202 pigs for <40kg, N=209pgs for = 40kg

[1] Pig categories

[2] Body measurements

Discussion

The average pig market weight is relatively low in the villages in Kamuli district. This is in agreement with previous reports in Africa (Mutua et al 2011) where pigs were sold at <10 months of age due to lack of available food that typically occurs on a seasonal basis. In addition, farmers tend to sell their pigs to provide food and help raise money for their families

(Tatwangire 2013). Some farmers do not have shelter for their pigs, but instead tether pigs on pastures to graze or provide them with leftover food and do not follow regular vaccination schedules or disease/parasite control measures (Waiswa 2005; Katongole et al 2012; Mutua et al 2011). This ultimately negatively impacts the pigs' market weight. Sex did not significantly affect prediction of pig weights in the present study. This is consistent with recently published findings in rural western Kenya for young, market-age and breeding pigs (Mutua et al 2011). Other well-designed experiments have reported that sex was a significant source of variation when predicting the pigs' average daily gain (Latorre et al 2004). The possible explanation for the differing results when compared to the current experiment is that pigs managed in small scale poor subsistence farmers cannot express their genetic potential for growth due to the feeding regimes, in which kitchen leftovers, forages and crop residues are the main components of the diet as was the case in the present study (Katongole et al 2012; Tatwangire 2013;). Breed did not significantly influence the pig weight in the current experiment which is in line with previous research (McLaren et al 1987). Although breed may not affect the pig weight, it does affect the carcass and meat quality measures (Edwards et al 2003). The lack of breed significance could be a result of the fact that the genetic potential from the improved group animals is not that high and that the feeding regimes do not allow improved animals to express their potential. Most farmers mate their gilts or sows with any readily available boars from the neighborhood.

All three prediction models from the present study indicate that heart girth and body length are important prediction measurements when estimating the pigs' live body weight. Heart girth could as well provide an accurate live body weight prediction when used alone (Groesbeck et al 2004). The importance of both heart girth and body length for weight prediction agrees with previous reports conducted in Western Kenya where live body weight was predicted using body length and heart girth for young, market-age and breeding age pigs (Mutua et al 2011). Farmers in rural western Kenya and those in rural Kamuli district likely use similar management practices. However, the results for the young pigs in the study conducted in the Philippines are dissimilar to the findings from the present study and may not be applicable to Kamuli (Murillo and Valdez, 2004). This is attributed to the fact that all the pigs involved in the Murillo and Valdez, (2004) study were from improved breeds (three way crosses from purebred Landrace, Large White and Duroc), that were raised under confinement conditions and had ad libitum access to a diet that more closely matched its nutritional needs (NRC, 2012) when compared to the present study. But these findings could be extrapolated to Uganda pigs in better managed farms.

The three prediction models could provide better weight estimation tools, but problems may occur when taking pig measurements. Pigs tend to move around and often moved their heads which may have caused variations in measurements (Groesbeck et al 2004). Therefore, it is recommended to take at least two body measurements, as was done in the current study, and use the computed average for prediction. Pigs should be properly restrained prior to measurement and muddy areas must be avoided so the pigs do not become coated with mud which would bias live body weight measures. A cage was most effective in the current study in restraining pigs and in obtaining all measures utilized in this study.

This research is intended to enable farmers to compute pig weights using simple devices like calculators and mobile phones. The ultimate goal is to eventually develop a cell phone application that will allow farmers to predict the weights from simple body measurements of body length, heart girth, body width and height.

Acknowledgements

Funding for this research project "Catalysing the emerging smallholder pig value chains in Uganda to increase rural incomes and assets" with grant Number COFIN-ECG-63-ILRI was provided by the International Fund for Agricultural Development (IFAD) and the European Union (EU) land ed by the International Livestock Research Institute (ILRI). The first author was also supported by the Ensminger Endowment, College of Agriculture and Life Sciences, Iowa State University, State of Iowa and Hatch funds. The authors would also like to acknowledge the Volunteer Efforts for Development Concerns staff for their assistance, before and during the course of the research. No benefits in any form from any commercial party related directly or indirectly to the subject of this manuscript were derived from this activity. The authors declare that they have no conflict of interest.

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Received 22 March 2014; Accepted 21 April 2014; Published 1 May 2014

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