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Full Length Research Paper

Determination of body weight from morphometric characteristics of guinea pigs (*Cavia porcellus*) reared in southern Benin

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In animal production, body weight is an important parameter for management, health and marketing decisions. This study is undertaken to determine the relationships between body weight and linear body measurements of guinea pigs. 120 guinea pigs (60 males and 60 females) were used. Body weight (BW), head-body length (HBL), chest circumference (CC), head circumference (HC), neck circumference (NC), left hind foot length (FL), and left ear length (EL) were the measured traits. The collected data were evaluated using multiple regression analysis. The obtained models of regression are : BW= - 397.374 + 10.817HBL + 16.440CC + 12.433NC - 19.039EL - 12.011FL + 12.458HC ; BW = - 560.601 + 4.531HBL + 21.649CC + 6.556NC -6.632EL – 2.086FL + 34.370HC ; BW = - 477.178 + 7.941HBL + 17.672CC + 8.758NC – 10.383EL – 1.951FL + 22.884HC, respectively for males, females and both sexes. In the regression model obtained for both sexes, the coefficients of HBL, CC and HC were significant (p < 0.01). The HC and CC coefficients for males and the CC and HC coefficients for females were also significant (p < 0.01). It was concluded that BW of guinea pigs was significantly influenced by CC, HBL, HC using multiple linear regression.

Key words: Body weight, morphometric traits, equation, multiple regression, guinea pigs.

INTRODUCTION

In developing countries such as Benin, the population explosion observed in recent years has led to food insufficiency and thus to a higher demand in animal protein. This situation exposes the population to protein-energy malnutrition (PSDAN, 2009). Conventional livestock such as cattle, goat, sheep, pig and poultry cannot fill this need for protein. One solution is the breeding of unconventional animal species such as

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snails, grasscutters and guinea pigs. The guinea pig (*Cavia porcellus*) is a rodent considered as a microlivestock species that hold great promise for rural development because it requires little capital, equipment, space and labor (NR International, 2006). Caviaculture is according to Nkidiaka (2004), a solution to nutritional needs in general and proteins in particular. High prolificacy and diet flexibility, as well as a great adaptability to the wide range of housing and management approaches, are critical traits of guinea pig reared for meat production (Lammers et al., 2009).

The animal has a body weight ranging between 700-1200 g and can measure between 20-25 cm long (Vanderlip, 2003). Information on the weight of the animal is important for different management practices such as breeding, medication and supplementation. However, in rural zone where access to animal weighing is difficult, the most common methods for estimating the weight of the animal are the use of a regression equation developed from linear body measurements (Melesse et al., 2013). According to Khan et al. (2006), linear body measurements can be used as indirect selection criteria in the absence of weighing scale. Several studies have shown that there is a relationship between age and morphometric characters of animal (Chineke et al., 2006; Jayeola et al., 2009; Sacramento et al., 2013). Ozoje and Mbere (2002) reported on the use of skeletal dimensions such as shoulder width, heart girth and height at withers as good indicators of live weight. Heart girth was considered as the best indicator of live weight (Villiers et al., 2009).

The purpose of the present study is to attempt a prediction of live body weight of guinea pig from linear measurements namely head-body length (HBL), the chest circumference (CC), the head circumference (HC), the neck circumference (NC), the left hind foot length (FL) and the left ear length (EL) of guinea pigs.

MATERIALS AND METHODS

Study site

The study was conducted at the Application, Exploitation and Production Farm of the Faculty of Agronomic Sciences of the University of Abomey-Calavi in the south of Benin. The commune of Abomey-Calavi is located in the region where the sub-equatorial climate zone is marked by two rainy seasons and two dry seasons. The annual rainfall is 1,200 mm and the monthly temperatures mean vary between 27 and 31°C (INSAE, 2004).

Experimental animals

One hundred and twenty (120) guinea pigs composed of 60 males and 60 females were used for this study. These animals were bought on farms in the commune of Aplahoué and Allada. They belonged to different age categories, reflecting a variety in body weight values.

Once on the farm, the guinea pigs purchased were housed in cages made of wood with a grid bottom of 100 x 100 x 100 cm raised 30 cm from the ground. The adult guinea pigs were put in groups of 10 while the young were put in groups of 15. They were fed *ad libitum Panicum maximum* supplemented with maize bran. Clean water was given *ad libitum*.

Data collection

Linear, curvilinear, weight, and other measurements were made on guinea pigs. These measurements were made following the method used by Sacramento et al. (2013). The different parameters measured are the head-body length (HBL), the chest circumference (CC), the head circumference (HC), the neck circumference (NC), the left hind foot length (FL), and the left ear length (EL). Linear measurements were taken using the tape measure while body weight was measured using a 10 kg measuring scale. The measurements were made as next described:

1. Head-body length (HBL): Length from the tip of the nose to the rump;
2. Left ear length (EL): Length from the point of attachment of the ear to the tip of the ear;
3. Left hind foot length (FL): Length from the heel to the longer finger without the claws;
4. Chest circumference (CC): Chest circumference taken by wrapping the tape around the chest just behind the fore legs;
5. Head circumference (HC): Head circumference by wrapping the tape around the head;
6 Neck circumference (NC): Circumference by wrapping the tape around the neck.

Statistical analysis of data

Data obtained were subjected to descriptive statistics (mean, standard deviation, minimum and maximum values). The inferential statistics (Student'st-test) were performed after checking the conditions of normality and homogeneity of the data respectively by the tests of Shapiro-Wilk and Leven. Multiple linear regressions were subsequently performed to model the body weight based on the explanatory variables of head-body length (HBL), the chest circumference (CC), the head circumference (HC), the neck circumference (NC), the left hind foot length (FL) and the left ear length (EL). For validation of the model, the following tests were carried out:

The Shapiro-Wilk test to check the normality of the residues; The Student's t-test to verify the nullity of the residues; The Breush Pargan test to verify the independence of the residues; The Dubin Waston test to verify the homocedaticity of the residues; Analysis of variance (ANOVA) to verify the significance of the coefficients.

All these analyses were realized in the R version 3.5.0. Software. Regression test was carried out using with ime4 package. Analysis of variance realized during the test of regression was considered significant at the 5% level.

RESULTS

Characteristics of the physical measurements of guinea pigs according to the sex

Table 1 presents the mean values of body weight and morphometric parameters in relation to sex of the guinea pigs. For all traits considered, the mean values obtained

Table 1. Main morphometric parameters of guinea pigs.

Sex	Parameters : mean ± standard deviation (min ; max)						
	BW (g)	HBL (cm)	CC (cm)	NC (cm)	EL (cm)	FL (cm)	HC (cm)
Male	310.19±132.75 (41 ; 511)	25.26± 4.96 (12 ; 36.5)	14.57±2.86 (8 ; 23)	10.89± 2.09 (8 ; 16.4)	2.34±0.28* (1.7 ; 3.2)	3.42±0.51* (2.3 ; 4.2)	11.63±1.37 (8 ; 14)
Female	285.54±106.29 (62 ; 513)	24.61±3.91 (15 ; 31.3)	13.70±1.99 (8.8 ; 18)	10.75±1.84 (8 ; 14.5)	2.19±0.29* (1.5 ; 2.9)	3.35±0.41* (2.8 ; 4.2)	11.32±0.99 (8.5 ; 12.8)

BW, body weight; HBL, head-body length; CC, chest circumference; NC, neck circmference; EL, left ear length; FL, left hind foot length; HC, head circumference. * = statistically significant at 5% level.

Table 2. Results of the regression model coupled with variance analysis results.

Factors	Male		Female		Group (Male and female)	
	Coefficient	Standard errors	Coefficient	Standard errors	Coefficient	Standard errors
Constant	-397.374	59.946***	-560.601	75.048***	-477.178	43.971***
Head-body lenght	10.817	2.361***	4.531	3.790	7.941	1.977***
Chest circumference	16.440	3.003***	21.649	5.013***	17.672	2.604***
Neck circumference	12.433	4.790*	6.556	6.759	8.758	3.722*
Left ear lenght	-19.039	18.046	-6.632	21.626	-10.383	13.206
left hind foot length	-12.011	13.105	-2.086	1.505	-1.951	1.397
Head circumference	12.458	9.670	34.370	12.876**	22.844	7.572**
Degrees of freedom	57		57		120	
Adjusted R-squared	0.9255		0.8545		0.8993	
F-statistic	131.4***		62.66***		188.6***	

Signif. codes: 0; '***'0.001; '**'0.01, '*'0.05, '.' 0.1, ' '1.

in males were higher than those found in females.

The results of inferential tests indicate that variables (EL and FL) are statistically significant at the 5% level.

Modeling: Equations of body weight prediction of guinea pigs

For males, the variations of the explained variable are explained by 92.55% of the variations of the explanatory variables. Three explanatory variables presented in the model are significant after the variance test. These variables are head-body length (HBL), chest circumference (CC) and neck circumference (NC). The estimation coefficients reveal that when the weight of the guinea pig increases by 1 kg, the head-body length (HBL) of the guinea pig increases by 10.81 cm, the chest circumference (CC) increases by 16.44 cm and the neck circumference (NC) by 12.43 cm (Table 2).

The prediction equation for male body weight is:
BW = - 397.374 + 10.817 HBL + 16.440 CC + 12.433 NC - 19.039 EL - 12.011 FL + 12.458 HC

For females, 85.45% of the variations of the explanatory variables presented in the model explain the variations in the explained variable. The significant explanatory variables after the analysis of the variance are the chest circumference (CC) and the head circumference (HC). The estimated model for predicting body weight of females is as follows:

BW = - 560.601 + 4.531 HBL + 21.649 CC + 6.556

NC -6.632 EL - 2.086 FL + 34.370 HC

According to this model a weight gain of 1 kg to the female would produce an increase of 21.649 cm of the chest circumference and an increase of 34.37 cm of the head circumference (Table 2).

In a general way without sex distinction, 85.45% of the variations in the explanatory variables presented in the model explain variations in the explained variable. The prediction equation for body weight of the animal (both sexes) is as follows:

BW = - 477.178 + 7.941 HBL + 17.672 CC + 8.758 NC – 10.383EL – 1.951 FL + 22.884 HC

The significant explanatory variables after analysis of variance in this model are the head-body length (HBL), the chest circumference (CC), neck circumference (NC) and the head circumference (HC). So a 1 kg increase in the animal weight would produce an increase in head-body length of 7.941 cm, an increase in chest circumference of 17.672 cm, an increase in neck circumference of 8.758 cm and an increase in head circumference of 22.884 cm (Table 2).

The Fischer F-values are high for the three established regression models. However, the higher values of F for the models estimated for males (131.4) and for the group (males + females) (188.6) prove the good reliability of these two models of prediction (Table 2).

DISCUSSION

From the study results, the mean values obtained in males were higher than those found in females for all traits considered. These results are similar to those reported in guinea pigs by Egena et al*.* (2010) except for length of ear. The observed difference between sexes cannot be attributed to the sexual dimorphism because ages of animal were not known. According to Mavule et al*.* (2013), the effect of ear length with body weight might be because ear length is determined by non-additive genetic effects and less affected by the environment.

The regression equations suggest that animal's weights are correlated differently with linear body measurements by sex. Similar results are reported by Egena et al*.* (2010) in guinea pigs, by Taye et al*.* (2016) in sheep and by Otoikhian and Kperegbeyi (2014) in goat. Heart girth was not the best variable for estimating body weight for female sheep, it was the height at rump and body length that were used to estimate weight for female sheep. In goats, the best predictors of body live weight for male and female is heart girth (Asefa et al*.*, 2017).

The better association of body weight with heart girth was possibly due to relatively larger contribution of this parameter to body weight, which consists of bones, muscles and viscera (Thiruvenkadan, 2005). Likewise, heart girth is least affected by the posture of the animal (Asefa et al*.,* 2017).

Egena et al*.* (2010) reported in guinea pigs high and significant correlation between body weight and body length, body weight and heart girth, and between body weight and trunk length. These morphometric parameters would be suggested as good for predicting live body weights in guinea pigs.

In females, Fisher's F value (F = 62.66) indicates that the equation model is not better and that it would be better to use the equation for the group (male + female) for easy prediction of weight. Sex dimorphism observed in guinea pig can explain the bad quality of the predicting model for female. Others linear body measurements such as width of the buttocks and pelvic width must be considered and included in regression model for the best predicting body weight equation for female. Pelvic width is an important trait affecting the productivity of the female through its effect on reproductive performances (Aliyari et al., 2012; Van Rooyen et al., 2012).

The body weight of the guinea pig is significantly influenced by HBL, CC, NC and HC. These parameters can be considered as good predictors of body weight. Parameters such as the EL and FL had a negative impact on the weight which leads to say that the light guinea pigs are characterized by large ears and long feet.

In the present study, the age of experimental animals was unknown and so the best predictors of body weight according to the age would not be defined with precision. However, Egena (2010) reports that in young guinea pigs aged 8 to 10 weeks, the best predictors of body weight are body length, trunk length and heart girth. Morphometric characters such as head-body length, tail length, ear length, left hind foot length without claws, neck circumference, head circumference, chest circumference and physical body weight are also used for age determination as reported by Sacramento et al*.* (2013) on grasscutters. The different predicting equations found by these authors could not be used for guinea pig which has no tail. In rabbits, the length between the nose and the shoulder, the length between the shoulder and the base of tail, chest circumference, height at wither, trunk length and ear length are used to predict live weight (Egena et al., 2012; Sakthivel et al., 2013). Donaldio et al. (2005) found that another parameter such as hind food length has a good linear relationship with log-transformed weight of rabbits.

Conclusion

Significant relationship was observed between body weight and body morphometric measurements in guinea pigs. The prediction of body weight could be estimated from measurements of head-body length, chest circumference and head circumference using a multiple regression predictive equation. Except for chest circumference, morphometric characteristics significantly influencing body weight in different regression models differ from sex to sex. Other studies may include guinea pigs whose ages will be controlled to better appreciate the effect of sex on the morphometric characteristics of the latter and thus on models of body weight prediction.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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