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Determination of grasscutter age (*Thryonomys swinderianus,* Temminck 1827) based on morphometric characters

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ABSTRACT

Objectives: In order to determine the grasscutter (*Thryonomys swinderianus* TEMMINCK, 1827) age, in Benin, a study was conducted on some of its morphometric characters such as Body Length (LTC), Tail Length (LQ), Ear Length (LO), Hind leg Length without Claws (LPPG), the Neck Perimeter (PC), Head Perimeter (PT), Chest Perimeter (Pth) and Body Weight (BW).

Methodology and Results: In this study, 202 male grasscutters aged from 2 weeks to 12 months were used. A strong correlation was obtained firstly between the different characters with a determination coefficient ranging between 0.764 and 0.968 andalso between the animal age and these characters with a determination coefficient ranging between 0.858 and 0.98. The best age prediction equation in males with a single character, given by Simple Linear Model (SLM) was: Age = 1.094 + 0.013 PV, with R^2 = 0.96; with two characters is: Age = - 10.162 + 0.078 LQ + 0.009 PV, with R^2 = 0.98; with three characters is: Age = - 9.981 + 0.006 LTC + 0.072 LQ + 0.009 PV with R^2 = 0.98. The best obtained by Generalized Linear Model (GLM) with a single character was: Age = exp (-2.069 + 0.020 Pth) with AIC = 1053.2; with two characters is: Age = exp (- 1.458 + 0.006 LQ + 0.011 Pth), with AIC = 1016.6; with three characters is: Age = exp (- 1.170 + 0.001 LTC + 0.006 LQ + 0.010 Pth) with AIC = 1017.

Conclusions and application of findings: Prediction equations developed can be used to estimate grasscutter age based on linear body measurements (LTC, LQ, LO, LPPG, PC, PT, Pth) and body weight (PV). The classification of equations in order of reliability for the two models used appears that the more equation expresses age based on several characters, the more reliable it is.Breeders, veterinarians and rural supervisors can use the equations found in this study to determine grasscutter age for better breeding, monitoring and management.Researchers can also use these equations to determine the age of game and for rearing grasscutter

Keywords: Grasscutter, morphometric characters, Age Estimation, Correlation, Regression Model, Prediction equations, Benin

INTRODUCTION

Grasscutter (*Thryonomys swinderianus*), a rodent as aguti (*Dasyprocta aguti* or *Dasyprocta punctata*), is found in Africa from south of Sahara to the Cape through the Center of Namibia (Mensah et al., 2007). In West Africa, game meat, including that of the grasscutter, plays a leading role in balanced diets (Annor and Kusi, 2005). Years of research led to the domestication of the grasscutter named grasscutter farming, which is now popular in countries of Africa (Mensah, 2000) and in which the grasscutter's breeding became an income generating activity (Fantodji and Mensah, 2000). Beyond its interest as a source of animal protein, the major importance of the grasscutter is that its meat is popular and it is not forbidden by any religion contrary to pork meat for example, which is, in Benin to Muslims. It is also a part of West and Central Africa food culture (Mensah et al., 2007).The amount of grasscutter's meat consumed in Benin comes not only from rearing grasscutter but grasscutter game which is the largest source of meat production traditionally consumed in parts of Benin (Brüntup and Aina, 1999). Grasscutter meat undergoes various transformations before consumption. The carcass is either smoked or fried, dried or fresh prepared in a sauce or fried "Apkèssè". The famous desired taste or praised by some gourmets and consumers in the grasscutter game is just the aftertaste left after the meat preparation (Mensah *et* al., 2007). Unfortunately, there isn't at present any criteria for determining the age of the grasscutter (*Thryonomys swinderianus*), which shows the relevance of this work whose overarching aim is to determine grasscutter age (*Thryonomys swinderianus* TEMMINCK, 1827) from some morphometric characters.

Photo1: Grasscutter (*Thryonomys swinderianus* TEMMINK, 1827)

MATERIALS AND METHODS

Study Area: The Borough of Tatonoukon, in the municipality of Adja Ouèrè (South-East of Benin), in the center of the Plateau's department houses grasscutter farming, with a herd of more than 2500 heads. This provided the framework for this study.

Materials: 202 grasscutters were used in this study. They ranged in age from 2 weeks to 12 months (Table 1). Females (66) grasscutters were eliminated from the study due to possible cases of undetected pregnancy. Animals received a balanced diet, in line with that consumed in the nature and water *ad libitum*.

Table 1: Distribution of animal material by age

Age (month)	Number of animals
½	15
1	16
2	18
3	17
4	15
5	20
6	17
7	13
8	17
9	14
10	11
11	14
12	15
Total	202

Materials for restraint: The restraint equipment that was used in this study were the mesh crates in which animals were put before anesthesia and jute bags in which animals were put before weighing. Anesthetic materials included latex gloves and gown; 2 ml syringes and disposable needles and two anesthetics: Xylazine hydrochloride (ROMPUNND) and Ketamine hydrochloride (IMALGENEND) that were a dose of 0.1 ml / kg of body weight. The measuring equipment were an ordinary load cell capacity of 10 kg (50g scale) for measurement of body weight; a caliper precision 1/1000 mm and a tape measure for linear body measurements of grasscutters and sheets recording the measured data. The manual restraint was done as suggested by Mensah and Ekué, 2003 and Mensah *et* al., 2007. The animals were seized almost at the base of the tail; hindquarters raised so that only the front legs rested on the floor of the cage. Once the animal was stable, it was introduced into the burlap bag and hung on the spring scale for weighing. The weight values were then recorded on the collection sheet.

Method of anesthesia of the grasscutter: Once the weighing was completed, grasscutters were taken out of the burlap bag and then introduced into the restraining cage where they were anesthetized. Using a 2 ml syringe, a mixture of equal volumes of xylaxine hydrochloride (Rompun 2% ND) and ketamine hydrochloride (Imalgene 1000ND) was injected at a dose of 0.1 ml / kg body weight. This operation was indicated by Adjanohoun (1986) and Farougou (1992) to anesthetize the grasscutter because the two products used separately are poorly tolerated by this rodent (Adjanohoun, 1988). On the basis of body weight of the grasscutter, the dose to be injected in each animal was calculated. This mixture, injected intramuscularly (IM) at the base of the tail, yielded a good sedation with excellent muscle relaxation at low doses. Anesthesia was effective after 5 to 10 minutes and grasscutters slept for 30 to 60 minutes before its effect wore off. This time was sufficient to take all linear measurements on the animal. All measurements were taken early morning before feeding to avoid skewing the data and at a frequency of once a week

The measurement was inspired by the method carried out by Rosevear (1969) and used by Sicard *et* al. (1995), measurements of morphometric characters in grasscutters were taken as follows:

- Head-body length (CTL): from anal orifice of the grasscutter to the muzzle;
- Tail's Length (LQ): from anal orifice of the grasscutter to the last caudal vertebra;
- Ear's Length (LO): from the base to the farthest walking from the flag;
- Posterior Left Foot Length (LPPG): from heel to longest finger without claws;
- Chest Circumference (Pth): wrap the tape measure around the chest by passing between the forelegs
- Head Circumference (PT) and neck (PC): around the head and then around the neck.

Statistical analyses of data: The collected data were entered, coded and recorded using Excel 2007 before being processed. Descriptive statistics were performed. The pairwise comparisons of means were performed using Student's test. The relationship between ages and various body measurements and weight were determined by calculating the correlation matrix between variables. This correlation has provided guidance on the simultaneous evolution of the variables taken in pairs. The coefficients of determination (R^2) for the MLS and the Akaike Information Criterion (AIC) for MLG were used to identify the best equation models. For establishing prediction equations, it is the simple linear model (SLM) and the generalized linear model (GLM) that was used. In general, a predictive model is any equation that can be put in the form: $y = ax + b$, with y= dependent variable, b the value of y when x = 0; a change of y for any change in a unit of x, and x is the independent variable. Once developed, these models were used from independent samples. For data processing, the software R 2.10.0 with lots of packages (MASS, FactoMineR) was used

RESULTS AND DISCUSSION

Age determination from equation models (Simple Linear Model (SLM)): Equations for estimating age based on morphometric characters and their coefficient of determination R^2 (%).

Table 2: Equations of age estimates based on PV, PC, PT, LTC, LQ, Pth and LPPG

Equations	R^2 (%)
Age = 1.094 + 0.013 PV	96
Age = - 44.951 + 0.409 PC	93
Age = - 42.798 + 0.367 PT	93
Age = - 37.775 + 0.360 LTC	90
Age = - 33.116 + 0.258 LQ	89
Age = - 55.363 + 0.320 Pth	85
Age = -24.348 + 0.675 LPPG	85

PV: Live Weight; PC: Neck Circumference; PT: Head Circumference; LTC: Length Head Body; LQ: Tail's Length; Pth: Circumference thoracic LPPG: left hind leg length.

Table 3: Equations of age estimates with two morphometric characters

Equations	R^2 (%)
Age = -10.162 + 0.078 LQ + 0.009 PV	98
Age = - 16.306 + 0.149 PC + 0.008 PV	98
Age = - 16.50 + 0.142 PT + 0.008 PV	98
Age = - 1.753 + 0.025 LTC + 0.010 PV	97
Age = - 13.45 + 0.077 Pth + 0.010 PV	97
Age = - 32.332 + 0.048 LTC + 0.249 PC	95
Age = - 33.205 + 0.037 LTC + 0.253 PT	94
Age = - 41.645 + 0.055 LQ + 0.293 PT	94
Age = - 44.367 + 0.167 PC + 0.220 PT	94
Age = - 40.832 + 0.403 PT – 0.034 Pth	94
Age = - 46.388 + 0.377 PC + 0.027 Pth	93
Age = - 42.829 + 0.074 LQ + 0.298 PC	93
Age = - 21.519 + 0.086 LTC + 0.080 Pth	91
Age = - 38.514 + 0.207 LQ + 0.067 Pth	89

Table 4: Equations of age estimates with three morphometric characters

Equations	R^2 (%)
Age = - 9.981 + 0.006 LTC + 0.072 LQ + 0.009 PV	98
Age = - 16.75 + 0.135 PT + 0.006 Pth + 0.008 PV	98
Age = - 16.01 + 0.045 LQ + 0.091 PC + 0.008 PV	98
Age = - 18.24 + 0.072 PC + 0.087 PT + 0.008 PV	98
Age = - 32.456 + 0.046 LTC + 0.012 LQ + 0.236 PC	95
Age = - 33.280 + 0.034 LTC + 0.036 LQ + 0.215 PT	95
Age = - 43.385 + 0.037 LQ + 0.145 PC + 0.189 PT	94
Age = - 41.609 + 0.179 PC + 0.263 PT – 0.050 Pth	94
Age = - 40.036 + 0.095 LQ + 0.316 PC – 0.042 Pth	93
Age = - 13.279 + 0.073 LTC + 0.163 LQ – 0.083 Pth	93

Table 5: Equations of age estimates with four morphometric characters

Equations	R^2 (%)
Age = - 15.98 + 0.008 LTC + 0.035 LQ + 0.094 PC + 0.008 PV	98
Age = - 17.39 + 0.034 LQ + 0.052 PC + 0.059 PT + 0.008 PV	98
Age = - 18.16 + 0.073 PC + 0.089 PT – 0.002 Pth + 0.008 PV	98
Age = - 17.698 + 0.064 LTC + 0.069 LQ + 0.282 PC – 0.162 Pth	96
Age = - 36.864 + 0.077 LQ + 0.146 PC + 0.242 PT – 0.101 Pth	95
Age = - 33.813 + 0.041 LTC + 0.007 LQ + 0.194 PC + 0.061 PT	95

Table 6: Equations of age estimates with five morphometric characters

Equations	R^2 (%)
Age = - 17.15 + 0.004 LTC + 0.031 LQ + 0.060 PC + 0.049 PT + 0.008 PV	98
Age = - 15.88 + 0.049 LQ + 0.055 PC + 0.082 PT – 0.035 Pth + 0.008 PV	98
Age = - 19.008 + 0.057 LTC + 0.064 LQ + 0.214 PC + 0.102 PT – 0.173 Pth	97

Morphometric parameters were in millimeters, weight in grams and age in weeks.

Among studied characters, LQ, PC, Pth and PV were the most highly significant (P <0.001); characters LTC and PT were moderately significant (P <0.01) and the characters LO and LPPG were non-significant (P> 0.05).Equations developed with these characters had very high coefficients of determination R^2. These R^2 ranged from 85-96% for equations with a single character (Table 2); 89-98% for equations with two characters (Table 3); 93-98% for equations with three characters (Table 4); 95-98% for equations with four (Table 5) and 97-98% for equations with five characters (Table 6). It should be noted that the higher the coefficient of determination is, the higher the equation is reliable.

Generalized linear model (GLM): Equations for estimating age based on morphometric and Akaike Information Criterion (AIC).

Table 7: Equations of age estimates based LTC, LQ, LPPG, PC and Pth

Equations	AIC
Age = exp (3.383 + 0.015 PV)	1053.2
Age = exp (- 0.274 + 0.019 PC)	1200.4
Age = exp (-35.984 + 0.349 PT)	1154.6
Age = exp (1.193 + 0.005 LTC)	1154.6
Age = exp (- 0.291 + 0.014 LQ)	1081.2
Age = exp (-2.069 + 0.020 Pth)	1053.2
Age = exp (0.594 + 0.034 LPPG)	1267.3

Table 8: Equations of age estimates with two morphometric characters

Equations	AIC
Age = exp (-1.458 + 0.006 LQ + 0.011 Pth)	1016.6
Age = exp (-1.769 + 0.005 PC + 0.015 Pth)	1032.3
Age = exp (0.71 + 0.002 LTC + 0.009 LQ)	1043.3
Age = exp (-1.502 + 0.001 LTC + 0.016 Pth	1050.1
Age = exp (-1.917 + 0.002 LPPG + 0.018 Pth)	1054.2
Age = exp (-0.431 + 0.010 LQ + 0.006 PC)	1058.3
Age = exp (-0.187 + 0.011 LQ + 0.008 LPPG)	1064.8
Age = exp (0.337 + 0.003 LTC + 0.009 PC)	1069.5
Age = exp (-0.083 + 0.015 LPPG + 0.011 PC)	1141.5
Age = exp (1.263 + 0.006 LTC – 0.003 LPPG)	1155.9

Table 9: Equations of age estimates with three morphometric characters

Equations	AIC
Age = exp (-1.170 + 0.001 LTC + 0.006 LQ + 0.010 Pth)	1017
Age = exp (0.0004 + 0.002 LTC + 0.006 LQ + 0.004 PC)	1031.1
Age = exp (- 1.809 – 0.001 LPPG + 0.005 PC + 0.015 Pth)	1034.2
Age = exp (0.287 + 0.003 LTC + 0.009 LQ – 0.006 LPPG)	1042.4
Age = exp (-0.332 + 0.009 LQ + 0.005 LPPG + 0.004 PC)	1053.6

Table 10: Equations of age estimates with four morphometric characters

Equations	AIC
Age = exp (-1.489 + 0.005 LQ – 0.001 LPPG + 0.003 PC + 0.01 Pth)	1014.8
Age = exp (-1,058 + 0,001 LTC + 0,006 LQ - 0,005 LPPG + 0,010)	1016,5
Age = exp (0,176 + 0,004 LTC + 0,006 LQ - 0,013 LPPG + 0,006 PC)	1022

Table 11: Equation for estimating age with five morphometric characters

Equation	AIC
Age = exp (- 0,856 + 0,002 LTC + 0,004 LQ - 0,010 LPPG + 0,004 PC + 0,008Pth)	1008,1

Also note that LTC, LQ, LO, LPPG, PC, PT and Pth were in millimeters , the weight in grams and age in weeks

Among the characters studied, LQ was the most highly significant (P <0.001); characters LTC and Pth were moderately significant (P <0.01), and PC, LPPG characters were weakly significant (P <0.05) and characters not significant (P> 0.05) were LO, PT and PV. Equations developed with these characters had Akaike Information Criteria (AIC) higher or lower. These ranged from 1053.2 to 1267.3 for equations with a single character, from 1016.6 to 1155.9 for equations with two characters, from 1017 to 1053.6 for equations with three characters, from 1014.8 to 1022 for equations with four characters and 1008.1 for the equation with five characters. It should be noted that as the Akaike Information Criterion (AIC) is small, the equation is more reliable. The more an equation has multiple characters, it is more reliable. Therefore, this equation is the five-character which is the most reliable.

DISCUSSION

Measurements of morphometric characters in the grasscutter: Linear and body measurements, the averages of LTC at 12 months (432.06 mm) obtained in this study belong to the range 230-440 mm respectively reported by Anonymous (1999), Schrage *et* al. (1999), De Visser *et* al. (2001) and Jayeola *et* al. (2009). Similarly, the averages of the LTC at 6 months (380.58 mm) obtained are in the range 350-610 mm for both sexes reported by Nowak (1999), against the average by the LTC to 2 months (154.11 mm) and 6 months (380.58 mm) obtained are less than 370 mm to 572 mm and 2 months to 6 months reported by Annor *et* al. (2011). The difference in these two studies compared to this study, is due to the inclusion by these authors, of tail's length in the measurement of the head and body length. Averages of LQ at 2 months (166.22 mm) and 6 months (220.65 mm) obtained are in the range 65-260 mm for both sexes reported by Nowak (1999). Similarly the average of LO at 3 months (181.23 mm) obtained in this study belong to the range 180-192 mm reported by Granjon *et* al. (2009), by the middle against the LO at 6 months (220.65 mm) values obtained are greater than 160 mm reported by Annor et al. (2011). The difference is related to the measurement. In fact, in their study, these authors had taken from the measurement of tail length from the base, while in this study we had taken from the anus to the end of the tail. Averages of LO to 5 months (32.1 mm) obtained are in the range 30-35 mm reported by Granjon *et* al. (2009). Similarly, the ranges 34-41 mm obtained in this study between 5 and 12 months are similar to the range 34-43 mm reported by Jayeola *et* al. (2009) for both sexes. Averages of LPPG to 6 months (81.12 mm) are obtained in the range 80-100 mm reported by Granjon et al. (2009). The averages of LPPG (95.06 mm) obtained 12 months are below the range 128-197 mm for both sexes reported by Jayeola *et* al. (2009). This difference is due to the fact that these authors took into account the entire paw, claws included. Averages of Pth to 5 months (245.5 mm) and 265.82 mm to 6 months are similar to those

reported by Ikpeze *et* al. (2004). Live weights means (1124.75 g) obtained in males at 5 months, 1000-5000 g belong to the ranges reported by Anonymous (1999) and De Visser et al. (2001). Similarly, the weight of 3453.32 g obtained in our study belongs to the ranges 3000-5000 g for males reported by Yéwadan *et* al. (1995). At 9 months, the weight of 2248.09 g obtained in this study for males is similar to that reported by Ikpeze *et* al. (2004).No studies have been so far performed on the circumference of the neck and head. In this study, the ranges of 93-239 mm and 100-246 mm respectively were found for around the neck and the head of both sexes. In males, the average 109.53 mm to 2 weeks and 237 mm at 12 months are obtained for the perimeter of the head. For the circumference of the neck, averages from 100 mm to 225.26 mm 2 weeks and 12 months are obtained in males.

Effect of age and sex on weight and linear measurements: All linear measurements and weight carried increased with age. At two weeks old, linear measurements and weight of all characters in males are slightly higher than in females although there is no significant difference (P> 0.05). These results are similar to those reported by Annor *et* al. in 2011. However, from the third month, the males have the measurements of characters LTC, LQ, PC, PT, Pth significantly higher (p <0.05) than females. It is the same for the body weight from 6 months.

Correlation between morphometric characters studied: The values of the high correlation coefficients ranging between 0.764 and 0.968 obtained between morphometric characters of the grasscutter showed a correlation. These coefficients between PV, LTC and Pth vary between 0.88 and 0.90. Similar results are reported in the grasscutter by Ikpeze *et* al. in 2004.The strong correlation between age, variables LTC, PC, PT and the body weight (PV) with correlation coefficients ranging between 0.934 and 0.954, Pth and LPPG variables with r = 0.90 and variables LQ and LO with r = 0.858, helped establish equations for predicting the age against these characters.

Prediction of age according to morphometric: High correlation coefficients obtained in this study between age and morphometric characters have permitted, with two models, to develop equations for predicting the age of the grasscutter based on these characters. All equations derived from MLS in males with R^2 (85-98) were better. They can be used to determine the age of farming grasscutter and game grasscutter. Nevertheless among the equations with a single character for age determination in males, we recommend the equation Age = 1.094 + 0.013 PV has held its R^2 = 96% (Table 2), as the equation Age = -10.162 + 0.078 LQ + 0.009 PV with R^2 = 98% among the equations involving two characters. The one we recommend one of the equations containing three characters is Age = - 9.981 + 0.006 LTC + 0.072 LQ + 0.009 PV with R^2 = 98%.

Among the equations derived from the Generalized Linear Model, based on Akaike Information Criteria (AIC), the equations age = exp (3.383 + 0.015 PV) with an AIC = 1053.2 (Table 7); Age = exp (-1.458 + 0.006 LQ + 0.011 Pth) with an AIC = 1016.6 (Table 8) and Age = exp (-1.170 + 0.001 LTC + 0.006 LQ + 0.010 Pth) with AIC = 1017 are those we recommend in the male. The two models used for the determination of equations, more the equation has several characters, more reliable it is and vice versa. All the equations found in this study can be used to determine the age of grasscutters. By replacing the linear measurements and weight of grasscutters taken in the equations obtained in this study, the age of the animal will be found.

CONCLUSION

This study showed that all linear and weight measurements increased with age. At two weeks old, linear and weight measurements of all characters in males are slightly higher. The characters used in determining the age of grasscutters are correlated. In addition, age is strongly correlated with all characters LTC, LQ, PC, PT, Pth and PV. This correlation between age and the character was established from the simple linear model and generalized linear model prediction equations that can help determine the age of the grasscutter based on these characters. And from the rank order of reliability equations for both models used, it appears that more equation expresses age based on several characters, more reliable it is and vice versa.

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