ESTIMATION OF GENETIC PARAMETERS, BREEDING VALUES AND EXPECTED GENETIC GAIN FOR BODY WEIGHT IN REARED GRASSCUTTERS

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ABSTRACT
Body weight is a critical economic trait in grasscutter production, influencing market value, reproductive performance, and meat yield. A total of 266 grasscutters were evaluated at the Delta State University Teaching and Research farm, Abraka, South-South, Nigeria. Data on bodyweight were collected at 2, 4, 6, and 8 months of age for 6 months and were analyzed using restricted maximum likelihood and best linear unbiased prediction in the WOMBAT statistical program written by Meyer (2007). The maternal animal model was used to appropriately partition phenotypic variance into variance components and account for the maternal effect of the dam. High (0.49-0.71) and moderate (0.20-0.40) heritability was obtained for direct and material, respectively. Estimated breeding values for body weights of the top 30%genetically superior grasscutters ranged from (0.024-0.096)kg, (0.08-0.58)kg, (0.05-0.37kg), and (0.045-0.18)kg at 2,4, 6, and 8 months, respectively. Expected genetic gain (EGG) per generation at 2, 4, 6, and 8 months was 0.13kg, 0.21kg, 0.22kg, and 0.11kg, respectively. In conclusion, these values provides a foundation for monitoring genetic progress in subsequent generations and show the feasibility of selective breeding in this species for the sustainability of animal agriculture.
Keywords: Bodyweight, Breeding values, Genetic gains, Grasscutter, and Selection programs

INTRODUCTION

The grasscutter, also known as the bigger cane rat (*Thryonomys swinderianus*), is a member of two surviving cane rats found only in Sub-Saharan Africa (Woods and Kilpatrick, 2005; Hoffmann, 2008). Grasscutter and smaller cane rat (*T. gregorianus*) are the only living members of the Thryonomys genus and family (Merwe, 2015). Phiomorpha is made up of the Thrynomidae, Petromuridae, and Bathyergidae families, which were among the first to colonize Africa with Hystricognaths and even rodents. According to fossil data, Phiomorpha may have included numerous extinct species (Sallam and Seiffert, 2016; Sallam and Seiffert, 2020).
The grasscutter and smaller cane rats have distinct morphological characteristics, including body size. The grasscutter may measure up to 6kg (Merwe, 2015), but the lesser cane rat weighs less. Grasscutter is a popular source of animal protein in West Africa because of its larger body weight, distinct meat flavor, and numbers, particularly in rural areas. Grasscutter is a popular game animal with high meat quality (Yisau *et al.,* 2019; Teye *et al.,* 2020), which has sparked scientific attention (Yisau *et al.,* 2019; Durowaye *et al.,* 2021). Several Initiatives are currently underway to advance its domestication as micro-livestock, although natural populations continue to be killed for human food.
Larger animals tend to have fewer litter numbers (Babarinde and Saitou, 2020). The typical litter size for grasscutter is 2.9, and females can have up to two litters each year (Adu *et al.,* 2017). An earlier author reported that grasscutter is considered a vulnerable or threatened wildlife species due to poor reproduction rates and high hunting activity without limitations (Yisau *et al.,* 2019; Teye *et al.,* 2020; Aluko *et al.,* 2015). Improving the genetic potential of grasscutter for growth is crucial for increasing the production efficiency and meeting the rising demands for improved grasscutters. Among the morphometric characteristics, body weight is a key economic trait in grasscutter production, directly influencing the amount of meat produced and consequently its profitability (Adebayo and Akinmoladum, 2021). The income and their livelihood are often improved based on the weight of the animals reared (Rajkumar *et al.,* 2020).
The knowledge of genetic parameters of this trait can help to develop effective breeding programs aimed at enhancing growth performance. The estimation of genetic parameters and breeding values (EBV) is are essential step in modern animal breeding programs, which helps in providing valuable tools for selecting superior animals and improving the genetic merit of future generation (Eze *et al.*, 2019). This study, therefore, aimed to estimate variance components, heritability, genetic correlation, as well as breeding values to predict genetic gain for body weight at 2,4,6 and 8 months of old in grasscutters. These age points are important as they represent key stages in the growth and development of grasscutters, and understanding the genetic control of body weight at these stages can inform optimal selection strategies. The body weight at 2 months could indicate early growth potential, while body weight at 8 months reflects on the normal animal's size at marketing age.

Materials and Methods

Study Area

The study was conducted at the Teaching and Research Farm of Delta State University, Abraka (latitude $6^0$12N, and longitude 6^0 °60E) in the Southern Region of Nigeria, having average annual rainfall of 2599mm and mean temperature of 29^0C.

Experimental Animals and Management

The study used a total of 266 grasscutters *(Thryonomy swindenarus)* produced from 80 dams of the university's breeding stock. The animals were managed intensively with individual records kept for each animal and were housed in standard cages measuring 75cm x 60cmx 40cm for six (6) months.

The animals were fed with a combination of grasses such as elephant grass (*Pennisetum purpureum*), Guinea grass (*Pennisetum maximum*), Pumpkin leaf (*Telferia occidentals*) stem supplemented with 14% concentrated pelleted feeds twice daily. Water was given *ad-libitum* and routine health care practices were strictly adhered.

Data Collection

Body weight data were collected at four distinct age points; 2, 4, 6, and 8 months of age. The weighing of the animals were carried out early in the morning before feeding, using a digital animal weighing scale with sensitivity of 0.01kg to ensure accuracy. Pedigree information of the animals were taken from the farm record and each animal was individually identified using ear tags.

Ethical standards

The Department of Animal Science Committee on Animal Welfare approved the procedures and guidelines for handling this animal during the experiment.

Statistical Analysis

Genetic evaluation was performed using a maternal animal model that incorporated both genetic and environmental sources of variation influencing body weight traits. The model accounted for direct additive genetic effects, material genetic effect and residual effect. The below showed maternal animal model fitting fixed and random effect.

$$Y = X_b + Z_a + W_m + Spe + e$$

where

Y = Vector of observed phenotypic values (body weight)

b = Vector of fixed effect (sex and farm)

a = Vector of random direct genetic effect (animal's own gene).

m = Vector (dam's genetic influence)

pe = Vector of random permanent environmental effects

e = Vector of random residual effects constructed variability)

X, Z, W, S are the corresponding incidence matrices relating observations to each effect.

Variance components, direct, and maternal heritability as well as breeding values were estimated using Restricted maximum likelihood (REML) and best linear unbiased prediction of WOBAT *(*Meyer, 2007). The expected genetic gain per generation (EGG) was computed as product of direct heritability (h^2) and selection differential (S); and expected percentage improvement as

$\frac{EGG}{X}$ x 100%Wherex = sample mean

Blup is a widely used method in animal breeding for estimating the genetic merit of individual. It combines phenotypic information with pedigree information to provide more accurate prediction of an individual's breeding values by considering both the animals own performance and performance of the relatives.

Results and Discussion

The descriptive means body weight of grasscutter at 2, 4, 6 and 8 months were0.50kg, 1.05kg, 1.65kg and 2.16kg Table 1. This finding was in consistent with 0.53kg, 1.00kg, 1.40kg mean body weight at 2,4 and 6 reported by Annor *et al.,*(2002) and 0.61kg, 1.10kg, 1.63kg and 2.08kg reported by Ekpeze *et al.,*(2008) for 2, 4, 6 and 8 months respectively.

However, these mean body weights reported were high than 0.79kg, 1.04kg and 1.78kg reported by Udeh, (2017) but lower than the range of (0.66 - 2.51kg) reported by Ikpeze and Ebenebe, (2004) for body weight of graasscutter at 5 months. Udeh and Okonta, (2013) reported an average body weight of 3.00kg for grasscutter at five months of age. Annor *et al.,* (2011) reported range of 0.69-1.94kg for female and male grasscutter at 4-5 months of age. The differences observed in mean body weight across these reports and our study may be due to different method of estimation of mean values and species of grasscutters used in their studies, which has not been given proper attention. The variability as judged by standard deviation at 2, 4 were similar but higher at 6 month of age.

Table 1: Descriptive statistics of bodyweight of grasscutte rat 2,4,6,8 month of age

Trait (age)	Mean ± SE	SD	Min	Max
2 Bodyweight (kg)	0.50 ± 0.02	0.20	0.11	0.84
4 Bodyweight (kg)	1.05 ± 0.02	0.21	0.62	1.49
6 Bodyweight (kg)	1.65 ± 0.04	0.24	0.97	2.11
8 Bodyweight (kg)	2.16 ± 0.03	0.34	1.35	2.76

SE= Standard Error. SD= Standard Deviation

The estimate of variance components and direct heritability (h^2) of body weight of grasscutter obtained in this study were 0.52, 0.49, 0.71 and 0.55 at 2, 4, 6 and 8 months of age Table 2. These values reported were higher than the heritability values of 0.14, 0.10 and 0.12 for body weight of grasscutter at 4, 6 and 8 months respectively reported by Udeh, (2017). The difference in these heritability estimate may be due to method of estimation, sex, sample size and species of grasscutters. The high heritability values (0.49-0.71) found in this study were comparable to the report of Adenyo *e tal.,*(2012) who reported direct heritability for body weight ranging from 0.40-0.60; and wasalso inconsistency with Annor *et al.,* (2022)who reported 0.55, 0.48, 0.66 and 0.84 values for body weight at 2, 4, 6 and 8 month. However, Udeh, (2020) also reported 0.62 and 0.68 direct heritability for body weight in grasscutter at 4 and 6 months old.

In a separate study, Henry *et al.,* (2014), reported direct heritability values of 0.56 and 0.66 on litter weight at birth and weaning weight. The moderate to high heritability reported by several authors for body weight in grasscutter validates the high heritability estimates of 0.49-0.71 found in this study, indicating that opportunity exist for genetic improvement of body weight (Udeh and Isiorho 2016); Udeh (2020). The implication of this range of heritability (0.49-0.71) is that the body weight in grasscutter is highly heritable. Thus, breeding strategies aimed at selection of animals with superior estimated genetic values (selective breeding) will lead to faster genetic improvement in growth and body weight traits.

Table 2: Estimate of variance components and heritability in grasscutter at various age

Trait (age)	$\sigma^2 a$	$\sigma^2 m$	$\sigma^2 p$	$h^2 d$ ± SE	$h^2 m$ ± SE
2 Bodyweight	0.018	0.014	0.035	0. 52±0.01	0.40±0.12
4 Bodyweight	0.044	0.031	0.090	0.49±0.08	0.34±0.03
6 Bodyweight	0.060	0.025	0.084	0.71±0.04	0.30±0.02
8 Bodyweight	0.034	0.013	0.064	0.55±0.05	0.20±0.03

*Note: $\sigma^2 a$= additive genetic variance. $\sigma^2 m$=maternal additive genetic variance. $\sigma^2 p$= total phenotypic variance $h^2 d$= direct heritability. $h^2 m$= maternal heritability

The estimated breeding value is essential in predicting selection differential. Selection differential refers to the difference between the mean trait value of the selected individuals and the overall sample mean of the same traits. Accurate prediction of selection differentials is essential for assessing the expected genetic gain in subsequent generation. Estimated breeding values (*EBVs*) reflect on the additive genetic value of individuals and identification, and the selection of animals based on their *EBVs*, which serves as a reliable basis for selecting superior animals. When selection is based on *EBVs* rather than phenotypic values, the selection differential is more accurately represents the true genetic potential of the selected animals and thus is more reliable and accurate in the predicted genetic gain. The top twenty genetically superior animals for each age were selected, which represent 30% of the herd. The estimated breeding value of the animals in each age ranged from 0.024- 0.096kg, 0.08kg-0.5kg, 0.05 kg-0.37 kg, and 0.045kg 0.18kg at 2,4,6, and 8 months, respectively Table 3 - 6. These results emphasize the potential of quantitative genetic tools in improving grasscutter productivity and advocate the integration of genetic evaluation and selective breeding systems into breeding programs in grasscutter farming.

Table 3: Estimated Breeding Values for Body Weight at 2 Months (Above Mean EBVs)

Ani ID	EBVs(kg)	Ranking	Ani ID	EBVs(kg)	Ranking
128	0.096	1	127	0.045	9
104	0.096	1	141	0.042	10
125	0.093	2	132	0.042	10
120	0.090	3	109	0.039	11
134	0.087	3	150	0.035	12
142	0.078	4	96	0.032	13
136	0.069	5	111	0.030	14
124	0.059	6	121	0.029	15
83	0.051	8	118	0.029	15
110	0.045	9	130	0.024	16

Ani ID = Animal Identification Number, EBVS = Estimated Breeding Values

Table 4: Estimated Breeding Values for Body Weight at 4 Months (Above Mean EBVs)

Ani ID	4BWT	Ranking	Ani ID	4BWT	Ranking
179	**0.58**	**1**	**181**	**0.19**	**10**
181	**0.50**	**3**	**185**	**0.19**	**10**
186	**0.48**	**4**	**182**	**0.19**	**10**
206	**0.47**	**5**	**187**	**0.19**	**10**
196	**0.46**	**6**	**184**	**0.19**	**10**
177	**0.46**	**6**	**208**	**0.17**	**11**
195	**0.46**	**6**	**206**	**0.15**	**12**
175	**0.40**	**7**	**216**	**0.14**	**13**
196	**0.30**	**8**	**204**	**0.09**	**15**
109	**0.24**	**9**	**169**	**0.08**	**16**

Ani ID = Animal Identification Number, EBVs = Estimated Breeding Values

Table 5: Estimated Breeding Values for Body Weight at 6 Months (Above Mean EBVs)

Ani ID	**6BWT**	**Ranking**	**Ani ID**	**6 BWT**	**Ranking**
255	**0.37**	**1**	**261**	**0.19**	**7**
271	**0.32**	**2**	**285**	**0.16**	**8**
230	**0.3**	**3**	**259**	**0.16**	**8**
257	**0.28**	**3**	**254**	**0.13**	**9**
234	**0.25**	**4**	**231**	**0.13**	**9**
266	**0.23**	**5**	**274**	**0.11**	**10**
262	**0.23**	**5**	**265**	**0.1**	**11**
245	**0.23**	**5**	**233**	**0.08**	**12**
235	**0.22**	**6**	**280**	**0.06**	**13**
241	**0.22**	**6**	**268**	**0.05**	**14**

Ani ID = Animal Identification Number, EBVs = Estimated Breeding Values

Table 6: Estimated Breeding Values for Body Weight at 8 Months (Above Mean EBVs)

Ani ID	8WHT EBVs (kg)	Ranking	Ani ID	8WHT EBVs (kg)	Ranking
301	0.18	1	324	0.081	6
308	0.18	1	330	0.081	6
320	0.140	2	319	0.069	7
310	0.140	2	325	0.064	8
318	0.110	3	351	0.062	9
309	0.10	4	301	0.060	10
312	0.100	4	345	0.054	11
322	0.100	4	329	0.054	11
315	0.084	5	319	0.047	13
313	0.084	5	314	0.045	14

Ani ID = Animal Identification Number, EBVS = Estimated Breeding Values

The expected genetic gain of body weight per generation is presented in Table 7. This illustrates the predicted improvement in the weight that can be achieved per generation because of selective breeding, attributed to the heritability of the traits and the selection differentials. The expected genetic gains for body weight traits in the selected grasscutter at 2, 4, 6, and 8 months old were 0.13 kg, 0.21kg, 0.32kg, and 0.19kg, respectively, representing 26%, 20%, 19% and 9% improvement over the body weight average of the population. These observed trends showed a progressive increase and absolute genetic gain up to 6 months. This finding implies that selecting breeding animals at 6 months could lead to more substantial and consistent improvements in future generations. Although genetic gain was also high at 4 months (0.21 kg), the accuracy of the estimated breeding value was lower in comparison with the estimated breeding value at 6 months due to greater developmental environmental variability and lower heritability. The pattern suggests that selection pressure is more effective during the earlier growth phases, particularly from (weaning) 2 - 6 months of age, where the physiological and metabolic rates are typically higher in growing grasscutter (Adu *et al.,* 2005). The highest heritability estimate (0.71) and genetic gain at 6 months (0.22kg, 19%) showed this stage as optimal for selective breeding due to the higher additive genetic variance and better environmental stability. These findings are in conformity with the earlier studies in small herbivores (rabbits), where earlier growth stages exhibited higher heritability and stronger response to selection (Yakubu, 2010). Furthermore, the percentage genetic gain recorded in this study was within the range reported for other non-conventional livestock species (rabbit, guinea pig) undergoing selective breeding in tropical climates (Abdulmalik *et al.,* 2018; Oseni *et al.,* 2014; Nwakpu *et al*., 2017). These reports underscore the urgent need for a structured selective breeding program in captive-reared grasscutter populations and emphasize the genetic potential of this species for meat production, food security, and job creation. However, early selection at 4 months, despite higher relative expected genetic gains, may be affected by greater developmental variability and less stable expression of genetic potential (Yakub *et al*., 2019). The reduced genetic gain at 8 months (0.19kg,9%) reflects increased influence of non-additive genetic effects or diminishing returns from selection at a later growth stage (Okeyoyin and Adedibu 2019; Babarinde *et al.,* 2023).

Table 7: Expected Genetic Gain per Generation (EGG)

Ages	Heritability (h^2)	S	(EGG) (Kg)	%EGG
2	0.52	0.25	0.13	26
4	0.49	0.42	0.21	20
6	0.71	0.31	0.22	19
8	0.55	0.19	0.11	9

h^2 = direct heritability. S = selection differential. EGG = expected genetic gain

CONCLUSION

This study assessed the estimated breeding values, heritability, and expected genetic gains in grasscutters at 2, 4, 6, and 8 months of age, focusing on body weight as a key economic trait. The results revealed that genetic gains of 0.13 kg, 0.21 kg, 0.22 kg, and 0.11 kg were achieved at 2, 4, 6, and 8 months, respectively, indicating the presence of considerable additive genetic variation for growth traits in the grasscutter population studied. The highest genetic gain observed at 6 months (0.22 kg) showed that this age is the most responsive period for selection of grasscutters aimed at improving growth performance. The relatively lower genetic gain at 8 months (0.11 kg) reflects a decline in additive genetic variance for body weight trait as the animal matures, resulting in reduced response to selection, which underscores the importance of early and mid-stage evaluation of traits for more efficient genetic improvement. The ranking of individual animals based on their estimated breeding values (EBVs) provided a clear framework for selecting superior breeding stock and facilitating targeted mating decisions. It is therefore recommended that selective breeding in grasscutters, especially around 6 months of age, can significantly enhance growth performance, provide breeding strategies that can boost meat yield, improve economic returns for farmers, and contribute to the sustainability of animal agriculture in Nigeria and sub-Saharan African countries.

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