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Comparative estimation of repeatability of birth weight in four rabbit breeds

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ABSTRACT

The study involved 89 kits from ten primiparous Does of four rabbit breeds (Hyla, Dutch, Checkered and Chestnut) which were evaluated for their birth weight. There was two Hyla Does with 12 kits, three Dutch Does with 36 kits, three Checkered Does with 24 kits and 2 Chestnut Does with17 kits. The mean birth weight in the entire study ranged between 25.0g and 80.0g, the mean birth weight in the entire study was 49.17 ± 1.29g, while the mean birth weight across the breeds was 48.08 ± 4.96g, 47.47 ± 2.01g, 56.88 ± 1.80g and 42.65 ± 1.51g respectively for Hyla, Dutch, Checkered and Chestnut. The experiment was a Completely Randomized Design where breed was the single factor studied. There was statistical (P<0.05) difference in birth weight due to breeds, with the Checkered breed having significantly higher birth weight than the Dutch and Chestnut, while there was no significant difference between Hyla and the three other breeds. A one-way analysis of variance of between Does within breed revealed that of the four breeds, it was only the Chestnut breed that Doe effect was not significant (P>0.05). The largest Doe effect on birth weight was recorded in the Hyla breed (54.04%) while it was 44.74%, 33.16% and 12.02% respectively for Dutch, Checkered and Chestnut. Repeatability is the proportion of total variation in a set of measurements resulting from differences among individuals. These values were estimated from the variance components as Intraclass coefficient, and repeatability and standard errors obtained in the study was 0.65 ± 0.30, 0.52 ± 0.24, 0.35 ± 0.33 and 0.11 ± 0.12 for the Hyla, Dutch, Checkered and Chestnut respectively, which indicated the potentials for early selection and breeding plan for the breeds with moderate to high repeatability values.

Keywords: Rabbit breeds, birth weight, repeatability estimates, variance components

INTRODUCTION

The proportion of total variation in a set of measurements resulting from variation among individuals is repeatability, which is most frequently estimated as the intraclass correlation coefficient (ICC). It is a useful estimate in a variety of biological, ecological and animal breeding studies, and it can be obtained from repeated measurements on a number of individuals (Wolak *et al*., 2012). Repeatability estimates the proportion of the total variation in a trait that is due to permanent differences among individuals, rather than measurement error or temporary environmental effects, and it can also be used to optimize breeding strategies and improve reproductive efficiency (Akporhuarho and Obodoagwu, 2020).

Birth weight is an essential parameter for evaluating the future growth and reproductive performances of rabbits, as an early indicator of the genetic potential of a rabbit breed for its growth and reproductive traits (Ayo-Ajasa *et al*., 2020 and Badr *et al*., 2019). It also reflects the maternal environment's effect on the offspring, which could impact the rabbit's growth and survival. The repeatability of birth weight in rabbit breeds is of significant importance in rabbit breeding programs as it helps rabbit breeders to reliably predict the performance of the offspring in terms of growth rate and carcass quality (North *et al*., 2019). A consistent birth weight repeatability ensures that the breed maintains its desired characteristics such as size, meat quality, and reproductive performance (Simek *et al*., 2019).

The birth weight of rabbits is affected by various genetic and non-genetic factors such as genotype (breed), gestation length, litter size and maternal environment. Maternal effects have been observed to be significant factors in determining egg size and subsequently the birth weight of rabbits. Thus, mother's nutritional status before and after birth has also been reported to have a direct impact on the offspring's birth weight (Olateju and Chineke, 2022 and Piles *et al*., 2021). Studies have shown that there is significant difference in birth weight among different rabbit breeds and Genetic factors play a crucial role in birth weight variability in rabbit breeds, and genetic diversity and population structure of different rabbit breeds determine their birth weight (Allam and Mahrous, 2021; Boucher *et al*., 2021 and Ren *et al*., 2019).

Different statistical procedures have been used in estimating repeatability, it is however suggested that a repeatability model that accounts for random effects and fixed effects, such as breed, litter size, and parity, would provide more accurate estimates (Yuldasheva and Khabibjonova, 2021). It is also emphasized that the importance of selecting suitable exterior traits can serve as indicators of birth weight repeatability in different rabbit breeds (Zigo *et al*., 2020). Understanding the repeatability of birth weight in different rabbit breeds can also help to improve breeding strategies and management practices, while the evaluation of exterior faults in rabbit breeds could also be a useful tool in selecting for desirable traits related to birth weight (Mojcherová *et al*., 2022).

This study aims to assess the birth weight of four different breeds of rabbits, estimate the repeatability of the birth weight across the breeds and evaluate the differences in the repeatability estimates within and among breeds.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Lagos State University Teaching and Research Farm of the School of Agriculture, Epe Campus, Lagos, lying at latitude 6.35'34.7°N and longitude 3.59'55.5°E. The experimental area is in the lowland humid tropics agroecological zone, with an average annual rainfall of 1,165.0 mm and average annual temperature of around 26.9°C.

This experiment was conducted in strict compliance with the animal research ethics guidelines of the Lagos State University.

Experimental Units

The experimental units comprised of four pure breeds of Chestnut, Checkered, Dutch and Hyla of the same age, which had never been mated nor previously engaged in kindling (nulliparous). Each breed unit was composed of three Does and two bucks, that are individually housed in cages prior to mating. The rabbits were given identification numbers depicting its breed and serial number within breed.

Management and Breeding Practices

The rabbits were reared in galvanized iron cages with feeders and drinkers. Grasses and legumes (*Panicum maximum, Centrosema pubescens, Tridax procumbens* and *Talinum triangulare*) were fed to the rabbits, with supplementation by commercially formulated grower pellets with proximate composition displayed in Table 1. Routinely, the feeders and drinkers are cleaned before adding fresh feed. Water was also given to the rabbits *ad libitum*. Feeding was done twice daily in the morning (07.00am) and evening (04.00pm) based on 10 percent of the rabbits' individual body weight divided into two feeding portions for the morning and evening feeding.

Table 1. Proximate composition of Grower 1 Crumble feed used in the study*

Content	Proportion
Crude Protein (Min)	15.00%
Crude Fat (Min)	4.00%
Crude Fibre (Max)	6.00%
Calcium (Min)	1.00%
Av. Phosphorus (Min)	0.45%
Lysine (Min)	0.70%
Methionine (Min)	0.35%
Metabolizable Energy (Min)	2600Kcal/kg

*Chikun Grower Crumble

Mating was done by taking the Doe to the buck and watched for its receptiveness. The date of mating and identification numbers of both the buck and Doe are recorded. Pregnant Does are identified by palpation and prepared for parturition by taking them to the cages with kindling boxes few days before the expected due date.

Experimental Design

The experiment was a completely randomized design, whereby the breeds of the rabbits were used as the factor in the first analyses and the Does used as factors in the repeatability estimation.

A total of ten pregnant Does from the four breeds comprising Hyla (2), Dutch (3), Checkered (7) and Chestnut (2) were evaluated for the birth weight of their kits. In all, 89 kits were kindled during the study period and details about the kits and the parents were recorded appropriately. There was 12 Hyla, 36 Dutch, 24 Checkered and 17 Chestnut kits recorded in this study.

Measurements and Data Collection

Measurements of all the kits were taken within 24 hours of birth, after being carefully tagged one after the other using indelible permanent markers with unique colour codes on different ears of the kits for easy identification.

The measurement was taken using Digital Scale with a sensitivity of 0.00g, and information such as kit, dam and sire IDs, litter size was also recorded along with the kit's weight.

Statistical Analyses

Preliminary statistical analyses were conducted using basic descriptive statistics (mean, standard deviation, standard error), test of normality within dam, exploratory tools (box plots) tests were conducted for validation and correctness of the collected data.

Further statistical analyses included one way analysis of variance (ANOVA), multiple comparison using post-hoc test of honestly significant difference (HSD) of Tukey after a significant ANOVA, and the variance components were estimated from the ANOVA table.

The statistical model describing the study was $Y_{ij} = \mu + \alpha_i + \epsilon_{ij}$ where Y_{ij} is the measured birth weight of the j^{th} kit within the i^{th} dam, α_i is the effect of i^{th} dam and ϵ^{ij} is the residual random effect, assumed to be normal, independent and random.

The post-hoc test was done with the Tukey formula $q_k = \frac{(\bar{X}_{i\prime} - \bar{X}_{k\prime})}{\sqrt{\frac{MS_{error}}{n}}}$ where q_k is the quotient of the difference between dam means, $\bar{X}_{i\prime}$ is the larger mean of the pair, $\bar{X}_{k\prime}$ is the smaller mean of the pair, MS_{error} is the mean square error derived from the ANOVA table. This calculated value is compared to the q table using the number of treatments as numerator and degrees of freedom for error as denominator. A significant difference is declared if the calculated value is equal or greater than the value on the table.

Repeatability estimate was derived from the variance components using the Intraclass Correlation Coefficient (Sokal and Rohlf, 1995), $ICC = \frac{\sigma_B^2}{\sigma_B^2 + \sigma_W^2}$ where σ_B^2 is the variance component among dams and σ_W^2 is the variance component within dams.

The standard error for the repeatability was derived using the formula for unequal subclass numbers (Swiger *et al*., 1964) as where r is repeatability, n is number of dams and k_1 is the number of measurements within dam.

$$SE_r \cong \sqrt{\frac{2(m_{.}-1)^2(1-r)(1+(k_1-1)r)^2}{k_1^2(m_{.}-n)(n-1)}}$$

RESULTS AND DISCUSSION

Descriptive statistics of the birth weight of kits

A total of 89 kits were kindled during the period of study with birth weight ranging between 25.0g and 80.0g (Table 2). The overall mean birth weight in the study was 49.17 ± 1.29g, with the Checkered breed recording the highest value (56.88) and the Chestnut breed had the lowest birth weight (42.65). Birth weight ranged from 25.0g to 80.0g in the entire study. However, the shortest range was recorded in the Chestnut breed (Figure 1) with a value of 18g, while largest range of 55g was recorded in the Hyla breed. The median birth weight value was close to the middle of the boxplot for all the breeds except for the Chestnut that had its median close to the first quartile, which further exacerbate the spread or dispersion of birth weight within the breed and magnify the skewness in the data.

Table 2: Basic descriptive and repeatability estimates for birth weight (g) by breeds of rabbits

Breed	No. of Dams	No. Of Kits	Mean Birth weight (g) ± SE	Repeatability ± SE
Hyla	2	12	48.08 ± 4.96^{ab}	0.65 ± 0.30
Dutch	3	36	47.47 ± 2.01^{b}	0.52 ± 0.24
Checkered	3	24	56.88 ± 1.80^{a}	0.35 ± 0.33
Chestnut	2	17	42.65 ± 1.51^{b}	0.11 ± 0.12
Overall	10	89	49.17 ± 1.29	0.51 ± 0.11

Means with different superscript within the same column differs significantly ($P<0.05$).

Almost 40.5 percent of kits in the study were from the Dutch breed, while the Hyla breed had the least proportion (13.48%) which represent just one third of birth recorded in the Dutch. Despite the smaller litter size within the Hyla, it had a lower birth weight compared to the Checkered that had higher litter size with considerably heaviest kits. This observation contradicts relationship between litter size, birth weight and breed effects (Yakubets and Bochkov, 2018) in rabbits.

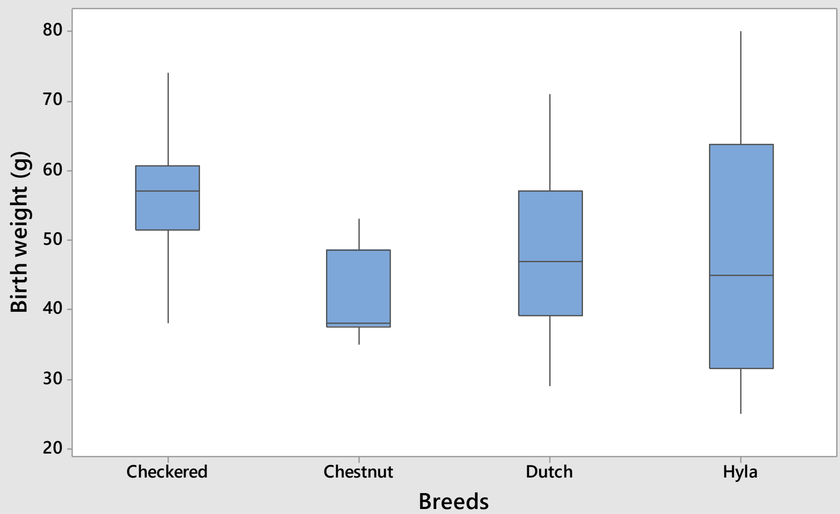

Figure 1: Boxplot of birth weight (g) of rabbits by breed

Breed effect on birth weight of rabbits

The statistical difference in the birth weight of the kits due to breed can be explained by the fact that genetics play a prominent role in the birth weight of rabbits, as a consequence of differences in their genetic composition and also differences in dam's abilities for nutrient uptake during pregnancy, and egg sizes at fertilization (Olateju and Chineke, 2022 and Piles *et al*., 2021). This observation supports earlier reports of influence of genetics on birth weight of rabbits (Llobat and Marín-García, 2022; Olateju and Chineke, 2022 and Raslan *et al*., 2020).

The Checkered breed had the highest weight at birth (Table 2), and was 18.30 percent heavier than the next heavier breed (Hyla). Despite the large difference in the Checkered breed birth weight compared to others, it had the second lowest range of values in the distribution, indicating that the birth weights for the breed were fairly close. The Hyla breed birth weight though not statistically different ($P>0.05$) from the Checkered breed, was intermediate between the Checkered and the other two breeds (Dutch and Chestnut).

Dam effect on birth weight of rabbits

Differences in birth weight of kits due to differences in dam was highly significant ($P<0.001$) across all breeds studied (Table 3). This difference in birth weight accounted for 53.51 percent of the total variation in birth weight of kits.

Except for Chestnut breed where dam difference was not statistically significant ($P>0.05$), influence of dams was significant (P<0.0%) in all other three breeds investigated. The dam effect was most pronounced in the Hyla breed accounting for 54.04 percent of the total variation in birth weight, then the Dutch breed (44.94%), the Checkered breed (33.16%) while the Chestnut breed had the lowest eta squared (R^2) of 12.02 percent.

The lowest value in eta squared obtained in the Chestnut breed further corroborated the lowest mean birth weight of Chestnut kits and the lowest range of 18g (35.0 – 53.0g) recorded in the breed.

The reason that can be adduced to these differences could be as a result of the differences in the genetic make-up of the different breeds, which also affect their physiological state during pregnancy, which is inclusive but not limited to genetics, nutrition and resistance to diseases, which all impacted the birth weight of kits (Llobat and Marín-García, 2022; Fontanesi, 2021; Garreau, 2021; Raslan *et al*., 2020 and Szendrő *et al*, 2019).

Table 3: Analysis of variance of dam effect on birth weight among breeds

	Hyla		Dutch		Checkered		Chestnut		Overall	
Source	**df**	**MS**	**df**	**MS**	**df**	**MS**	**df**	**MS**	**df**	**MS**
Dam	1	1756.9***	2	1142.82***	2	295.88*	1	75.01^{ns}	9	775.04***
Error	10	149.4	33	85.56	21	56.80	15	548.87	79	76.70
R^2 (%)	54.04		44.74		33.16		12.02		53.51	

^{ns} = P > 0.05 * = P < 0.05 ** = P < 0.01 *** = P < 0.001

Repeatability of birth weight in rabbits

Genetic diversity is an important factor that affects repeatability of birth weight in different breeds of rabbits, and it was reported that genetic variation among rabbit breeds affects their growth rates and reproductive performance (Allam and Mahrous, 2021). Therefore, the selection of breeding animals with desirable genetic traits is crucial for achieving consistent birth weights in different breeds of rabbits, because maintaining the genetic diversity of rabbit breeds is essential for their long-term survival and sustainable development (Boucher *et al*., 2021).

It must be noted that reproductive traits such as litter size, age at first litter, and gestation length are all heritable and can affect birth weight of kits, thus selecting rabbits with desirable reproductive traits can improve offspring birth weight and overall reproductive health of the dam (Piles *et al*., 2021).

There was moderate overall repeatability in the entire study across all dams (0.51±0.11), while the highest value was obtained from the Hyla breed, followed by the Dutch and Checkered breeds, and the least repeatability was from the Chestnut breed (Table 2). It is noteworthy that the standard error for the Chestnut breed was greater than the repeatability, which may be indicative of some inherent disparity between its dams beyond differences in genetic make-up.

Aside from genetic differences among the breeds, some environmental factors, such as temperature, humidity, and lighting, also influence the birth weight of rabbits (Madkour, *et al* 2023). This study ensured that breeds were provided with optimal environmental conditions during pregnancy to ensure the health and productivity of their offspring. In order to minimize extraneous sources of variation aside from the breeds that were being investigated, the rabbits were supplemented with formulated diets rich in protein and energy to ensure optimal birth weight at kindling as earlier reported (Belabbas *et al*., 2022 and Mugnier *et al*., 2022).

Much of the differences in birth weight that could arise due to nutritional status of the Does during pregnancy was taken care of by the feed supplementation for all breeds which was kept constant throughout the study in line with earlier reports (Kishk, 2022 and Svoradová *et al*., 2022), and age also by ensuring that Does of the same age across the breeds were studied (Rödel, 2022 and Rouillon *et al*., 2022).

The standard error obtained for the repeatability of birth weight in the Chestnut breed could be explained with the relatively low repeatability value (0.11) and the marginal difference between the lowest and the highest birth weight. The difference in birth weight values due to Does differences within the Chestnut breed was also the least (12.02%) when compared to other breeds.

CONCLUSIONS

Birth weight in the four rabbit breeds evaluated had values between 25.0g and 80.0g. Breed was a significant ($P<0.05$) source of variation among the breeds. The Checkered had the highest birth weight while the Chestnut had the least birth weight.

Dam effect was significant ($P<0.05$) among three of the breeds (Hyla, Dutch and Checkered), while the influence of dam within the Chestnut breed was not significant ($P>0.05$).

Repeatability values ranged between 0.11 and 0.65 among the four breeds evaluated. The Hyla breed had the highest repeatability, while the Chestnut had the least repeatability.

The repeatability values obtained indicated potentials for early selection of the Hyla and Dutch Does for successive breeding programs.

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