**International Journal of Research in Agriculture and Forestry**
**Volume 5, Issue 4, 2018, PP 7-12**
**ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)**

# Repeatability Estimates and Principal Component Analysis of Birth and Weaning Traits in Domestic Rabbits

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## ABSTRACT

*Records on birth and weaning traits of 280 kittens born in 54 litters were collected to estimate repeatability (R2) and to describe objectively the interdependence among these traits in domestic rabbits. Gestation Length (GL), Litter Size at Birth (LSW), Neonatal Survival Rate (NSR), Litter Birth Weight (LBW), Litter Size at Weaning (LSW) and Litter Weaning Weight (LWW) were the traits investigated. Data were analysed using the General Linear Mixed Model Procedure of SAS via Restricted Maximum Likelihood Method and were also subjected to Principal Component Analysis using SPSS. Repeatability estimates were calculated using standard expressions. Mean GL, LSB, NSR, LBW, LSW and LWW were; 32.26 ± 0.26, 5.19 ± 0.30, 87.63 ± 4.07, 244.90 ± 15.58, 2.83 ± 0.30 and 2120.00 ± 222.30 respectively. The repeatability estimates obtained for GL, LBW, LSW and LWW (0.44, 0.50, 0.56 and 0.79 respectively) were high whereas moderate estimates were obtained for LSB and NSR (0.27 and 0.26). The estimate of high repeatability indicates certainty of repeating these traits in subsequent lifetime of the animal and renders reliability for retaining such animal. From the factor analysis after varimax rotation of the inter correlated traits, three principal components accruing for 91.32% of the total variation were extracted. Principal components 1, 2 and 3 were good descriptors of weaning traits, birth traits and gestation length respectively. The high values of communalities (0.831-0.950) were indicative of a large number of variance to have been accounted for by the factor solution. Because of erroneous inferences incurred from multicollinearity of interdependent explanatory variables, the extracted principal components could be used as factor scores for predicting litter sizes and weights, and gestation lengths in domestic rabbits.*

**Keywords:** *Repeatability, Principal component, Birth traits, Weaning traits, Rabbits.*

## INTRODUCTION

Rabbits have been found endowed with production of high quality protein needed to satisfy the rural people for animal protein (Fielding and Matheron, 1991). This is due to their characteristic short generation interval, efficiency at converting feed material into meat and a high prolificacy and fecundity (Beaumont *et al.*, 2003). The reproductive performance of rabbits is an important aspect in determining the profitability of commercial rabbit breeding. Repeatability in its simplest form is the tendency for performance in the same animal to be similarly repeated. It tells how an animal will repeat its performance in a given trait during its lifetime, hence, calculation of the repeatability of reproductive traits will indicate the extent at which selection will influence future animal reproductive performance (Ibe, 1995). Thus, it would be possible by selection, breed diversity and genetic parameter estimates to make rapid improvement in rabbit performance (Chineke and Raheem, 2009). More so, apart from the use of repeatability as an index of the reliability of early measurements in evaluating and selecting animals for future performance, it also enables farmer to calculate his future financial returns (Dalton, 1985). A litter trait at birth, weaning and other ages as it affects dam reproductive traits has been studied by many authors (Kabir *et al.*, 2014; El-Maghawry *et al.*, 1993; Rajapandi *et al.*, 2015; Fayeye and Ayorinde, 2016). Most results and estimates available have been obtained from experimental populations established for various types of selection study (Odubote and Somade, 1992). In animal breeding, large number of data is required, which makes it presumably complex to handle and interpret. Such difficulty in data handling can be curbed using principal component analysis (PCA). PCA is a multivariate technique that analyses a data table in which observations are described by several inter-correlated quantitative dependent variables (Abdi *et al.*, 2010) and had been used in quantifying size and morphological indices of domestic rabbits (Yakubu and Ayoade, 2009). Consequently, multivariate approach is employed to analyse growth and reproductive data in rabbits and other domestic animals. This study, therefore, was conducted to determine the estimates of repeatability for birth and weaning traits and to provide an objective description of these traits using principal components in domestic rabbits.

## MATERIALS AND METHODS

### Study Location

The study was carried out in the Rabbit Research Unit of the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika – Zaria, which is located between latitude 11˚12'42"N and 7˚ 33' 14" E on an altitude of 691m above sea level (Ovimaps, 2012). The area falls within the Northern-Guinea Savannah zone having an average annual rainfall of 1100mm which starts from late April to mid-October. The mean minimum and maximum daily temperatures are14˚C and 24˚C, respectively during the cool season and 19˚ C and 36˚ C, respectively during the hot season.

### Animal Management

The rabbits were housed in a well-constructed building within which they were kept above the ground in a wire – mesh cage for ease of handling, protection and proper management. Only one doe or buck was housed per compartment, each of which is large enough for one doe and its litter (about 10 to 15 kits) until weaning time. A nest box that provides shelter and protection of newly born rabbits and seclusion of the doe when it kindles (gives birth) was usually kept for a doe few days to its time of kidding until weaning. Few cages were kept in a separate area for isolation of new or sick rabbits. Containers used for feed and water were made from clay and are about 3 to 4 inches deep, 6 to 8 inches in diameter, easy to clean, and heavy enough to prevent the rabbits from tipping them over. All the rabbits were fed *ad libitum* with mash diets containing 16.5% crude protein and 2884 Kcal ME/Kg. *Brachiaria decumbens* (Signal Grass), tops of *Arachis hypogea*was also fed as supplementary ration. The does were fed 300 to 400g and 150 to 350ml of the mash diet and water per day, respectively. There was an organised health care provision by the Institute in terms of vaccination, deworming and among other medications. Ear tattoos with unique numbers provided a good means of permanent identification of individual rabbit.

### Animals used and Breeding Plan

The breeding flock included 19 bucks and 35 does all raised in the Rabbit Research Unit. The bucks and does comprised of New Zealand White, Chinchilla, Grey, Dutch and Californian rabbits of varying purity. Prior to mating, the weight of individual doe was taken as an initial weight in order to suspect pregnancy as a result of apparent increase in weight. The does were mated to intact bucks by introducing them to the bucks and allowed to remain until mating was assured, after which the does were returned to their pens and observed for pregnancy. Pregnancy and its progressions were determined by palpating the abdominal region of the does 14 days post mating and visual observation of the abdomen which gets enlarged as pregnancy progressed. Non – pregnant does were put up for mating again until conception occurred. All matings were carried out in the morning and the mating dates were also recorded. Ten days to kindling, nest-boxes were provided and placed into individual hutch in preparation for kindling. All pregnant does were allowed to kindle without any interference.

### Parameters Measured

The traits investigated in this study include; Gestation length, Litter size at birth, Neonatal survival rate, Litter birth weight, Litter size at weaning and Litter weaning weight. The Records of 280 kits that were born in 54 litters from the breeding flock (composed of 19 bucks and 35 does) were analysed.

### Statistical Analysis

The data obtained were corrected for the sire and dam effect using the following model;

$$Y_{ijk} = \mu + \alpha_i + \beta_{ij} + \varepsilon_{ijk}$$

Where;

$Y_{ijk}$ = Records of $k^{th}$ litter by the $j^{th}$ dam mated to the $i^{th}$ buck.

$\mu$ = Common mean

$\alpha_i$ = Effect of $i^{th}$ sire

$\beta_{ij}$ = Effect of $j^{th}$ dam mated to $i^{th}$ sire

$\varepsilon_{ijk}$ =Uncontrolled environmental and genetic deviations attributable to individuals.

All effects were assumed normally, identically and independently distributed around equal means and zero variance. Data were analysed using the General Linear Mixed Model Procedure of SAS (2004) following the Restricted Maximum Likelihood (REML) method and were further subjected to principal component analysis using SPSS version 20.0 (SPSS, 2011). The variance components generated were used to estimate repeatability as the ratio of the sum of additive genetic and permanent effects to total phenotypic variance using the formula given by Iraqi, (2008);

$$R^2 = \frac{\delta_a^{\ 2} + \delta_p^{\ 2}}{\delta_t^{\ 2}} = \frac{\delta_a^{\ 2} + \delta_p^{\ 2}}{\delta_a^{\ 2} + \delta_p^{\ 2} + \delta_e^{\ 2}}$$

Where

$R^2$ =Repeatability estimate

$\delta_t^2$ = Total phenotypic variance.

$\delta_a^{\ 2}$ =Additive genetic variance.

$\delta_p^{\ 2}$ =Variance component due to permanent effects.

$\delta_e^{\ 2}$ = Environmental variance component.

The suitability of the data to principal component analysis (PCA) was tested using Barlett's test of sphericity and further tested by Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy. During the evaluation, factors were rotated with varimax rotation of Kaiser. Everitt *et al.*, (2001) defined principal component analysis as a method of transforming variables in a multivariate data set $X_1, X_2, \ldots X_p$ into new uncorrelated variables $Y_1$, $Y_2, \ldots\ldots Y_p$ which account for decreasing proportions of the total variance in the original variables defined as;

$$Y_1 = a_{11}X_1 + a_{12}X_2 + \ldots\ldots + a_{1p}X_p$$

$$Y_2 = a_{21}X_1 + a_{22}X_2 + \ldots\ldots + a_{2p}X_p$$

$$Y_p = a_{p1}X_1 + a_{p2}X_2 + \ldots\ldots + a_{pp}X_p$$

## Results and Discussions

### Mean Performance

Means (±SE), Coefficient of variation, minimum and maximum values for all the traits studied are presented in Table 1. Litter size and Litter weight at weaning were more variable (62.71% and 62.04% respectively) while gestation length indicates the lowest level of variability (5.97%). The mean value of gestation length (32.26±0.26) reported here was slightly higher than 29.7 to 30.3 days reported by Olowofeso *et al.*, (2012) in their work on different breeds of rabbits although lower in other literatures (Odeyinka *et al.*, 2008; Akpa and Alphonsus, 2008). Moderate to high values of coefficient of variability of the litter traits confirms that these traits are subjected to many effects such as genetic makeup of the does, non – genetic effects (year – season, parity and management of the herd). The values of LSB, LBW and LWW observed in this study were higher than the reports of Fayeye and Ayorinde, (2016), but were lower than the submissions of Kabir *et al.*, (2016).

**Table1.** *Least square means and Coefficient of variation of some birth and weaning traits in domestic rabbits*

| Traits | Mean ± S.E | Coefficient of variation | Minimum | Maximum |
|---|---|---|---|---|
| Gestation Length | 32.26 ± 0.26 | 5.97 | 27.00 | 36.00 |
| Litter Size at Birth | 5.19 ± 0.30 | 41.90 | 1.00 | 10.00 |
| Neonatal Survival Rate | 87.63 ± 4.07 | 34.12 | 0.00 | 100.00 |
| Litter Birth Weight | 244.90 ± 15.58 | 44.55 | 50.00 | 700.00 |
| Litter Size at Weaning | 2.83 ± 0.30 | 62.71 | 1.00 | 8.00 |
| Litter Weaning Weight | 2120.00 ± 222.30 | 62.04 | 450.00 | 5100.00 |

*S.E = Standard error*

### Repeatability Estimates

The estimates of repeatability for the studied birth and weaning traits are presented in Table 2. The values of repeatability estimated for the birth and weaning traits measured moderate to high values (0.26-0.79) which is in conformity with the submissions of Kabir*et al.*, (2014) in their study on pure and crossbred rabbit does in Nigeria. However, most literatures reported a range of 0.001 to 0.27 for litter size traits (Iraqi *et al.*, 2008; Garcia *et al.*, 1982; Baselga*et al.*, 1992; Khalil, 1994; Lukefahr and Hamilton 1997). Akpa and Alphonsus (2008) reported a much higher $R^2$ value of 0.80 for gestation length than the value obtained herein (0.44), although Chineke and Raheem (2009) reported a lower value of 0.17. Furthermore, Repeatability estimates for neonatal survival of 0.26 was higher than the findings of Lukefahr and Hamilton (1997) and Kabir *et al.*, (2014). Similarly, the repeatability estimates for litter size at birth (0.27), litter size at weaning (0.56), litter birth weight (0.50) and litter weaning weight (0.79) were higher than 0.23 and 0.31 reported by Fayeye and Ayorinde, (2016).

According to Lukefahr *et al.*, (1983), the high estimates of repeatability for some litter traits may be an indicative of the considerable additive genetic variation among other permanent effects for these characters. For traits which display wide variation, estimates obtained from a small sample might be subject to considerable error, hence, large sized data is required for a reliable estimate of repeatability.

**Table2.** *Variance components and repeatability estimates for some birth and weaning traits in domestic rabbits.*

| Traits | Additive Genetic Variance | Phenotypic Variance | Permanent Effects Variance | $R^2$ |
|---|---|---|---|---|
| Gestation Length | 1.75 | 7.92 | 1.73 | 0.44 |
| Litter Size at Birth | 1.03 | 7.14 | 0.90 | 0.27 |
| Neonatal Survival Rate | 1.42 | 17.94 | 3.24 | 0.26 |
| Litter Birth Weight | 2.50 | 12.98 | 3.99 | 0.50 |
| Litter Size at Weaning | 2.75 | 13.27 | 4.68 | 0.56 |
| Litter Weaning Weight | 2.27 | 4.44 | 1.24 | 0.79 |

## Principal Component Matrix

After varimax rotation, three principal components (factors) extracted are presented in Table 3. According to Yakubu and Ayoade, (2009), these coefficients show the relative contribution of each trait to a particular principal component. A scree plot of the Eigen values against their principal components is shown in figure 1. The suitability of the data to principal component analysis was highly significant from Barlett's test (chi square = 141.153, P = 0.00). The three factors extracted contributed 91.32% of the total variability of the studied traits, with the first factor (PC1) explaining 37.74%, second factor 33.67% and the third factor 19.92% of the total variance. PC1, PC2 and PC3 had Eigen values of 2.26, 2.02 and 1.20 respectively. PC1 was characterized by high positive loadings (correlations between the components and the variables) on LSW (0.944) and LWW (0.899) which indicates the traits themselves as good descriptors of weaning traits. PC2 on the other hand had high positive loadings on LSB (0.801) and LBW (0.849) while NSR showed a negative loading (-0.657) indicating that an increase in litter size at birth and/or litter birth weight will result to a corresponding decrease in neonatal survival rate. The second factor however, is a good estimator of the birth traits. Exclusively, PC3 was primarily related to gestation length, hence, this factor could be regarded as a gestation length factor. The high range of communalities (0.831 – 0.950) observed imply that the birth and weaning traits are strong in explaining the total variation in the factor solution. This justifies the use of indices of the measured traits, referred to as principal components for prediction, since they are orthogonal to each other.

**Table3.** *Rotated component matrix, Communalities, Eigen values and Percentage of total variance of some birth and weaning traits in domestic rabbits.*

| Traits | Components | | | Communalities |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Gestation Length | -0.317 | -0.278 | 0.851 | 0.901 |
| Litter Size at Birth | 0.473 | 0.801 | 0.256 | 0.930 |
| Neonatal Survival Rate | 0.391 | -0.657 | 0.496 | 0.831 |
| Litter Birth Weight | 0.294 | 0.849 | 0.379 | 0.950 |
| Litter Size at Weaning | 0.944 | -0.145 | -0.117 | 0.927 |
| Litter Weaning Weight | 0.899 | -0.358 | -0.051 | 0.940 |
| Percentage Variance (%) | 37.74 | 33.67 | 19.92 | |
| Eigen Values | 2.26 | 2.02 | 1.20 | |

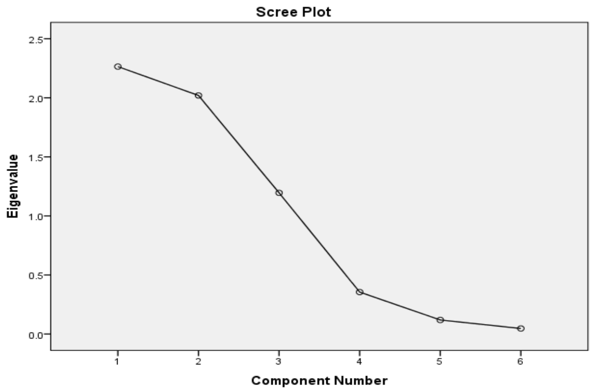


**Figure1.** *Scree Plot*

## CONCLUSIONS

Apparently, the high estimates of repeatability for traits of GL, LBW, LSW and LWW indicates certainty of repeating these traits in subsequent generation, however assessment of several parities before selecting parents for these studied traits is necessary for effectiveness since LSB and NSR showed moderate repeatability estimates from the same population. More so, the principal component analysis presents a more reliable approach in predicting desired characteristics compared to the use of original measured traits as predictors because of erroneous inferences from multicollinearity of interdependent explanatory variables. Thus, the components could be used as factor scores for predicting litter sizes and weights, and gestation lengths in domestic rabbits

## ACKNOWLEDGEMENT

The authors duly appreciate the efforts of the staff in the Rabbitry Unit, NAPRI for their technical assistance and seeing the light of this research.

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**Citation:** *Zaharaddeen M.M and Kabir M. (2018). Repeatability Estimates and Principal Component Analysis of Birth and Weaning Traits in Domestic Rabbits. International Journal of Research in Agriculture and Forestry, 5(4), pp 7-12.*