Estimation of heritability and repeatability for pre-weaning body weights of domestic rabbits raised in the humid tropics

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Abstract

Heritability and repeatability estimates are needed for the genetic evaluation of livestock populations and consequently for the purpose of upgrading or improvement. Pooled data on 302 progenies from three consecutive parities of purebred rabbit breeds (Chinchilla, Dutch and New Zealand white) raised in Derived Savanna Zone of Nigeria were used to estimate heritability and repeatability for pre-weaning body weights between 1st and 8th week of age. The experiment was carried out at the Rabbitry Unit of the Teaching and Research Farm of the Ebonyi State University, Abakaliki. Traits studied include: Kit Weight at birth (KWB), 2nd week (K2W), 4th week (K4W), 6th week (K6W) and 8th week (K8W). Nested random effects analysis of (Co) variance as described by Statistical Analysis system (SAS) were employed in the estimations. Respective heritability estimates from the sire component (h^2) and repeatability (R) as intra-class correlations of repeated measurements from the three parities for KWB, K2W, K4W and K8W were 0.59 ± 0.24 , 0.55 ± 0.24 , 0.93 ± 0.31 , 0.28 ± 0.17 , 0.64 ± 0.26 and 0.12 ± 0.14 , 0.05 ± 0.14 , 0.58 ± 0.02 , 0.60 ± 0.11 , 0.20 ± 0.14 . Heritability and repeatability (except R for KWB and K2W) estimates are moderate to high. In conclusion, since pre-weaning body weights in the present study tended to be moderately to highly heritable and repeatable, hence, improvement of rabbits raised in derived savanna zone can be realized through genetic selection criterions.

Keywords: Heritability, Nested design, Parity, Pooled data, Repeatability

Introduction

Genetic improvement remains a veritable option for the development of the Nigerian livestock industry. Ibe (1998) reported that genetic improvement of animals requires a good understanding of basic concepts of genetics and animal breeding and this includes information on genetic parameters of economic traits. Genetic parameters (e.g. heritability, repeatability, genetic and phenotypic correlations) are ratios of (co)variances and their estimates are needed for the genetic evaluation of livestock populations and consequently for the purpose of upgrading or improvement. Magnitude of heritability for important

economic traits enables the rabbit breeder/farmer to decide on the type of selection that will lead to rapid genetic progress. Traits with high heritability may be improved by individual selection, while those with low heritability may be improved genetically by family selection. Obasi and Ibe (2008) opined that traits of low heritability can also be improved by exploiting heterosis through crossbreeding and non-genetically by improving the environment. Repeatability estimate also gives useful information in selection for future performance. The estimate can be used in determining Most Probable Producing Ability (MPPA) which adjusts

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the records of individuals to the same base for the purpose of ranking and selection, based on their ability to repeat their performance in subsequent records. Information on (co)variances estimates, correlation among traits and heritability and repeatability of body weight and reproductive traits of rabbit in sub-Sahara Africa using sire and dam models had been documented (Odubote and Somade, 1992; Ndjon and Nwakalor 1998; Akanno *et al.*, 2004). However, such information on rabbit breeds, including three of the most common raised in derived savannah of Nigeria (Dutch, Chinchilla and New Zealand White) is not widespread as in poultry; hence, more studies are needed. The study therefore, attempt to address this dearth of information in rabbit enterprise by means of providing the base line for research in the humid tropics.

Materials and methods

Study location and experimental animals

The study was conducted in the Rabbitry Unit of the Teaching and Research Farm of the Ebonyi State University, Abakaliki. Animals used in this study consisted of three (3) rabbit breeds [Dutch (DUT), Chinchilla (CHI) and New Zealand White (NZW)]. Three bucks and nine does (between 8 – 10 weeks of age) of each breed were used in the experiment. These were obtained from random-bred selected population of male and female (parent stock) of each breed from Emmipina Livestock Farms and Goddy Veterinary Services, Uyo, Akwa-Ibom State. All animals were managed, treated and given medication throughout the study period under the same managerial and climatic conditions. The experiment was a nested (hierarchical) design with nine (9) sires mated to twenty-seven (27) does at maturity (6-7 months). Each of the 3 sires of a breed was mated to 3 dams of the same breed.

Data analysis

To estimate the observable (co)variance components for pre-weaning body weight, data obtained were subjected to Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) for unequal subclass numbers (unbalanced data) using Henderson's Method III (Henderson, 1984) of “fitting constants”, as described in general m-stage nested procedures of SAS (SAS, 2013) Version 9.4 for Windows x64 based system according to Montgomery (2001). The statistical model is as presented in expression (1).

$$Y_{ijklm} = \mu + P_i + B_{j(i)} + S_{k(ij)} + D_{l(ijk)} + \epsilon_{ijklm} \quad (1)$$

Where: Parentheses denote which factor it's nested within;

Y_{ijklm} = observation on the m^{th} progeny of the l^{th} doe mated to the k^{th} sire and belonging to the j^{th} breed and i^{th} parity;

μ = overall mean;

P_i = fixed effect of i^{th} parity ($i=1, 2, 3$);

B_j = fixed effect of j^{th} breed ($j=1, 2, 3$)

$S_{k(ij)}$ = random effect of k^{th} sire;

$D_{l(ijk)}$ = random effect of the l^{th} dam mated to the k^{th} sire;

ϵ_{ijklm} = random error, assumed to be independently and identically normally distributed with zero mean and constant variance [$iind(0, \sigma^2)$]

By equating the mean square of each random effect to its expectation, variance component for sire (σ_s^2), dam (σ_d^2), and error (σ_e^2) were obtained. Similarly, by equating mean cross products for pairs of traits to their expectations, covariance components for sire (COV_s), dam (COV_d) and error (COV_e) were also obtained. These were used to estimate heritability and repeatability of pre-weaning body weight.

Heritability estimates due to sire, dam and sire and dam components were obtained with expressions (2), (3) and (4), respectively:

$$h_s^2 = 4^2_s / ^2_p$$

(2)

$$h^2_d = 4^2_d / ^2_p$$

(3)

$$h^2_{s+d} = 2(^2_s + ^2_d) / ^2_p \quad (4)$$

where: h_s^2 ; h_d^2 and h_{s+d}^2 = respective heritability estimate from sire, dam and sire and dam components

σ_p^2 = total variance component ($\sigma_s^2 + \sigma_d^2 + \sigma_e^2$) and

σ_s^2 ; σ_d^2 and σ_e^2 = respective sire, dam and error variance component.

The standard errors (SE) of heritabilities (for unbalanced data) were calculated using the formulae described by Becker (1992).

Repeatability, R estimates were computed as intra-class correlations of repeated measurements for three parities on each doe, thus:

$$R = \frac{\sigma^2_I}{\sigma^2_I + \sigma^2_E} \quad (5)$$

Where; R = repeatability estimates;

$$\sigma^2_I = MS_I - MS_E / k_I$$

MS_I = mean square for the individual dams and MS_E = mean square error

Table 1: Heritability estimates for pre-weaning growth traits of rabbit

Growth Traits	h_s^2	h_d^2	h^2_{s+d}
KWB	0.59±0.24	1.56±1.31	1.07±0.23
K2W	0.55±0.24	1.31±0.36	0.93±0.22
K4W	0.93±0.31	0.86±0.30	0.90±0.22
K6W	0.28±0.17	0.21±0.15	0.25±0.12
K8W	0.64±0.26	0.48±0.23	0.56±0.17

$$k_I = \frac{1}{N-1} \left[\frac{m - m_k^2}{m} \right] \quad (6)$$

h_s^2 = heritability due from sire component; h_d^2 = heritability due from dam component

h^2_{s+d} = heritability due from both sire and dam components; KWB, K2W, K4W, K6W and K8W = kit weight at birth, 2nd, 4th, 6th and 8th week respectively.

N = number of dams

m. = total number of measurements

m_k = number of measurements taken on the k^{th} dam

$$\sigma^2_E = MS_E$$

Becker (1992) also gives expression for the approximation of standard error (SE) for R in unequal numbers of measurements per individual.

Results and discussion

Heritability estimates for pre-weaning body weight of rabbits

Heritability estimates for pre-weaning from sire component, dam component and both sire and dam components are presented in Table 1. Except for moderate heritability estimates (0.21±0.15 to 0.28±0.17) obtained for K6W, high estimates of heritability were observed in all pre-weaning body weight studied. Moderate to high heritability estimates (0.28±0.17 to

0.93±0.31) from the sire component for pre-weaning body weight are consistent with those estimates obtained in some studies in Egypt (Khalil *et al.*, 2000; Iraqi *et al.*, 2002), Spain (Estany *et al.*, 1992; Gomez *et al.*, 2000), Brazil (Fereaz and Eler, 1996) and Nigeria (Okoro *et al.*, 2011; Oludayo, 2012). The results obtained in the present study indicate the strong influence of additive factors in the expression of these traits and at the same time suggest possible improvement of the rabbits through individual selection method.

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Table 2: Estimates of repeatability (R± SE) for pre-weaning body weight of rabbit

Pre-weaning body weight	R± SE
KWB	0.12±0.14
K2W	0.05±0.14
K4W	0.58±0.02
K6W	0.60±0.11
K8W	0.20±0.14

KWB, K2W, K4W, K6W and K8W = Kit Weight at birth, 2nd, 4th, 6th and 8th week respectively;
SE = Standard error for R

Moderate to high repeatability that was obtained for IK4W, IK6W and IK8W were similar to the reports of Chineke *et al.* (2001) and Ndjor and Nwakalor (1998). Moderate to high repeatability required fewer (2 to 3 parities) records before selecting a doe for these traits. While, the low repeatability result implies that many measurements from several parities are needed to correctly evaluate the consistency of the doe's performance in any experimental population.

Conclusion

Moderate to high heritability estimate [$h^2_{(s)}$] for pre-weaning body weight indicates the usefulness of these traits as a guide to selection in any programme aiming at improvement of rabbit enterprise in the tropics. In the same vein, high repeatability estimates for K4W and K6W indicate that selection for improvement at these pre-weaning ages will result in increased growth performance.

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