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Diallel Crossing of Three Rabbit Breeds in Northern Guinea Savannah Zone of Nigeria: 1. Genetic Parameter Estimates for Litter Traits

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Target Audience: Animal/Rabbit breeders, Rabbit farmers and Animal scientists.

Abstract

Data on litter traits of 202 progeny from purebred population of Chinchilla (CHC), New Zealand White (NZW) and California White (CAW) breeds of rabbits were used to estimate heritability and repeatability for litter traits. The litter traits considered were gestation length (GL), litter size (LS) and litter weight (LW) from birth to weaning. The variance components used for estimation of heritability were obtained through VARCOMP Procedure of SAS. Repeated records of dams were used to estimate repeatability. Heritability estimates for litter size from birth to weaning were high (0.49–0.64) in the CHC breed, while the estimates for litter weight were moderate to high (0.34–0.52). In the NZW and CAW breeds, moderate to high heritability estimates for litter size and litter weight (0.33–0.46 and 0.28–0.41); (0.31–0.42 and 0.32–0.41) were observed from birth to weaning. Estimates of repeatability for all traits observed in this study for all breeds were moderate to high. Traits with moderate to high repeatability observed in this study imply that great reliability can be put on selection or culling of does and bucks for such trait, based on one or two records. Lowly heritable traits obtained can be improved upon by crossbreeding. Moderately heritable traits on the other hand could be improved upon by combining pedigree and individual selection. While individual selection can be adopted to improve the highly heritable characters observed.

Keywords: Diallel cross, Genetic parameters, Rabbits, Litter traits, Zaria

Desscription of Problem

Genetic improvement of rabbit is important in order to increase their contribution to the much needed animal protein. One of the pre-requisite for genetic improvement is the knowledge of genetic parameters for important economic traits (1). The genetic parameters would influence breeder's decision on the selection methods to employ so as to achieve rapid genetic progress. The ratio of the additive genetic variance over the phenotypic variance is called heritability (in the narrow sense) and can take on values from 0 to 1. The potential for genetic improvement of a particular trait is largely dependent on the heritability, repeatability and its genetic relationship with other traits of economic importance (2). Reports from Ghana (3), Tanzania (4), Brazil (5) Hawa2 (6) and Nigeria (7, 8) indicated higher heritability for production traits than is generally reported from temperate environments. Heritability estimates reported by (5) for body weight was 0.03 (6 weeks), 0.19 (9 weeks) and 0.26 (11 weeks). Patras (9) reported a heritability estimate for body weight at 60 days to be 54%. Kalil and Soleman (10) reported that the heritability estimate for doe reproductive traits (number of service per conception and gestation length) were low in magnitude in Bouscat and Giza White rabbits.

Estimates of heritability from paternal half-sibs obtained by (8) at 9 weeks of age were 0.30, 0.18, 0.45, 0.56 and 0.43 and at 12 weeks of age the estimates were 0.09, 0.35, 0.67, 0.06 and 0.03, for body width, body length, head-to-shoulder, shoulder-to-tail and length of leg, respectively. This indicates that, some of the body measurements are governed by genes with additive effects, while others are governed by genes with non-additive effects. Moderate heritability estimates reported by (7) for litter size at birth, litter birth weight and litter weaning weight were 38.0, 32.0 and 16.0%, respectively. Productive traits that are related to fertility, litter performance as well as those related to health and/or survival rate are lowly heritable (11). This suggests that these traits are basically under the control of genes, which have non-additive effects. Lukefahr *et al* (3) estimated the heritability of body weight at 90 day of age in rabbit from tropical Ghana to be 0.42.

Chineke and Raheem (12) reported low heritability estimates for withers weight (0.17) and length of ear (0.11) at 42 days of age, and stated that crossbreeding might be a better option (to make use of heterosis) for the improvement of these traits, since strong non-additive gene action is playing a major role. The authors also gave a moderate heritability estimates for nose-to-shoulder (0.28) and length of ear (0.24) at 49 days and for nose-to-shoulder (0.24), shoulder-to-tail pin bone (0.31) and trunk length (0.24) at 56 days of age. Gestation length, average daily gain at 56 days and individual weaning weight showed little or no heterosis, ranging from –1.4% for gestation length to 2.6% for average daily gain (13).

With the difficulty in the acquisition of pure breeds of rabbits in Nigeria, breeds such as Chinchilla, New Zealand White and California White remain the most commonly available, which have peculiar characteristics that distinguish them from other breeds.

This study was therefore, conducted to estimate the heritability and repeatability for some litter traits under a 3 x 3 diallel crossing of three rabbit breeds.

Materials and Methods

Description of study area

This study was carried out at the Rabbitry Unit of the Animal Science Department

Teaching and Research Farm, Ahmadu Bello University, Zaria, located between latitude 11^0 and 12^0N and on altitude of 640m above sea level (14). The area falls within the Northern-Guinea Savannah zone having an average annual rainfall of 1100mm which starts from late April to mid October. Detailed description of Zaria was given elsewhere by (15).

Experimental animals and mating

The stock of rabbit used (New Zealand White (NZW), Chinchilla (CHC) and the California White (CAW) breeds) was purchased from the National Veterinary Research Institute (NVRI), Vom near Jos, Plateau State. They were housed in well ventilated pens and small metallic ear-tags were used for their identification and proper record keeping. Feed and clean drinking water were provided *ad libitum* throughout the period of acclimatization and adaptation. They were raised on a mixed feeding regime and fed twice daily at 8:00am and 4:00pm. Concentrates were first given in the morning and forage (*Panicum maximum* grass and *Centrosema pubescence* legume) in the evening to enhance intake.

The animals were raised to sexual maturity and mating started when they were 5 months of age (150 days). The does were mated to bucks by introducing them to the bucks and allowed them to remain with the bucks until mating is successful after which does were returned to their pens and observed for pregnancy. The mating ratio adopted was 1 buck to 3 does. Pregnancy was diagnosed 14 days post coitus by palpation of the abdominal region between the thighs as well as through observation of the abdomen which got enlarged as pregnancy progressed (due to the growth of the developing embryos). Ten days to kindling, nest-boxes were provided and placed into individual hutch in preparation for kindling. The kindling dates, litter size and litter weight were recorded immediately after kindling. Weaning of kits was done at 35 days and dry does were remated within 7 days after weaning their kits.

Data collection and traits measured

Data on litter traits of 202 purebred kits, comprised of 54 Chinchilla (CHC), 66 New Zealand White (NZW) and 82 California White (CAW) progeny of 12 sires and 36 dams were used for this study. The litter traits considered were gestation length, litter size and litter weight at birth and at weekly intervals up to weaning. Litter size was obtained by counting the number of kits kindled while litter weights were measured in grammes (g) using a digital sensitive scale.

Experimental design and statistical analysis

The data was subjected to analysis of variance (ANOVA) using the GLM procedure of SAS (16). The design of the experiment was Nested or Hierarchical type (17), in which a sire was mated to several dams with each mating producing several offspring. Significantly different means were separated using Duncan's Multiple Range Test (18). There were three parities and the model adopted is shown below:

$Y_{ijklm} = \mu + P_i + X_j + S_k + D_{kl} + E_{ijklm}$

Where; Y_{ijklm} = Observation on the m^{th} progeny of the l^{th} doe mated to the k^{th} sire belonging to the j^{th} sex and the i^{th} parity; μ = overall mean; P_i = Fixed effect of parity; X_j = Fixed effect of sex; S_k = Random effect of sire; D_{kl} = Random effect of dam within sire; E_{ijklm} = Random error, independently, and identically normally distributed with zero mean and constant variance (2nd (0, σ^2).

Heritability estimates

Variance components were estimated using Method 3 of Henderson (19). Variance component for sire (σ^2_S) and error (σ^2_E) were calculated by equating computed mean squared of each random effect to its expectations and solving the components. These estimates were used to compute heritability and repeatability. Heritability was then obtained using the standard expression given by (20) as follows:

$$= \frac{4\sigma^2 S}{\sigma^2 S + \sigma^2 E}$$

Where; h^2_S = heritability based on sire variance component; h^2_D = heritability based on dam variance component. The standard errors for heritability estimates were calculated using the formula described by (20).

Repeatability estimates

The breeding value of the individual upon which selection can be based, particularly for traits which can be measured more than once in life-time, depends on repeatability estimates of the traits. The repeatability (R) which indicates the extent to which selection will influence future performance of the rabbits was therefore calculated using the following formula described by (20).

$$R = \frac{\sigma^2 I}{\sigma^2 I + \sigma^2 e}$$

Where; σ^2_I = fixed effect of each animal and $\sigma^2 e$ = within individual records' variance.

Results and Discussion

Heritability estimates for litter traits

The estimates of heritability (h^2) from sire variance component for reproductive and litter traits from birth to weaning in the 3 breeds of rabbits are shown in Table 1. The h^2 estimates in the CHC breed from birth to weaning for gestation length (GL) ranged between 0.18±0.27 and 0.26±0.27, respectively.

The corresponding h^2 values in the NZW breed from birth to weaning ranged between 0.11±0.24 and 0.15±0.27. The CAW had the corresponding h^2 that ranged between 0.11±0.24 and 0.17±0.24, respectively.

Moderate to high heritability estimates for litter size at birth (LS) and litter birth weight (LW) as well as litter size at weaning and litter weaning weight were observed in the CHC, NZW and CAW breeds, respectively. The highest h^2 in the CHC breed for LS was 0.64 at 7 days of age and the lowest estimate was 0.49 at 21 days of age. For LW in the same breed, the highest h^2 was 0.52 at weaning and the lowest h^2 was 0.34 at 7 days of age. In the New Zealand White breed, 0.46 was obtained as the highest h^2 estimate for LS at 21 days of age, while the lowest h^2 was 0.30 at 28 days of age. For LW in the same breed, the highest value was 0.41 at 21 days of age and the lowest value was 0.28 at 14 days of age. In the CAW breed the highest and lowest estimates of h^2 for LS were 0.42 and 0.31 at 42 and 21 days of age respectively. The highest and lowest estimates for LW in this breed were 0.41 and 0.32 obtained at birth and weaning, respectively.

Table 1: Estimates of heritability (h^2±SE) from sire variance component for gestation length and litter traits at various ages

		Age (days)					
Breed	Trait	Birth	7	14	21	28	35
CHC	Gestation length	0.23±0.21	NA	0.26±0.27	NA	NA	0.18±0.27
	Litter size	0.53±0.35	0.64±0.31	0.53±0.27	0.49±0.31	0.60±0.23	0.58±0.34
	Litter weight	0.41±0.27	0.34±0.32	0.49±0.31	0.47±0.34	0.43±0.31	0.52±0.28
NZW	Gestation length	0.11±0.24	0.15±0.27	NA	NA	NA	NA
	Litter size	0.44±0.37	0.37±0.41	0.33±0.41	0.46±0.37	0.30±0.41	0.43±0.41
	Litter weight	0.37±0.33	0.29±0.21	0.28±0.28	0.41±0.24	0.34±0.21	0.39±0.33
CAW	Gestation length	0.17±0.24	NA	NA	NA	0.11±0.27	NA
	Litter size	0.32±0.40	0.42±0.36	0.38±0.44	0.31±0.40	0.36±0.36	0.40±0.44
	Litter weight	0.41±0.37	0.34±0.31	NA	0.36±0.31	0.40±0.33	0.32±0.31

CHC=Chinchilla; NZW=New Zealand white; CAW=California white; SE = Standard error; NA = Not available.

The low to moderate heritability values observed for reproductive traits in all the breeds (Table 1) was an indication that non-additive and additive gene action operates for the expression of these traits. Characters that are lowly heritable can be improved upon by crossbreeding, considering the strong non-additive gene action which determined the expression of such characters (8). Moderately heritable traits on the other hand would be improved upon by combining pedigree and individual selection. The heritability estimates for gestation length at birth reported herein were lower than 0.59±0.26 reported by (12). In the CHC breed, heritability estimates for LS from birth to weaning (Table 1) were high, while the estimates for litter weight were moderate to high. Similarly in the NZW and CAW breeds, estimates of heritability from birth to weaning for litter size and weight were observed to be moderate to high. Odubute and Somaile (7) obtained heritability estimate of 0.33±0.08 for litter birth weight in different breeds (Chinchilla, California, New Zealand) of rabbits and their crosses. The estimates previously reported by (7) were lower than the values obtained in this study, which could be due to differences in the breeds of rabbits used.

For litter size, the estimates observed in this study were in conformity with other reports in literature (21; 13). (21) reported an estimate of 0.24±0.15 in Bouscat breed of rabbit. Similar values for litter traits had been reported by other workers (13). The high heritable characters can be improved upon by individual selection. Differences in estimates of heritability could arise from differences in breeds, environment, management as well as method used in data analysis.

Repeatability for litter traits

The repeatability estimates for litter traits from birth to weaning are presented in Table 2. The values obtained from the CHC breed for GL, LS and LW from birth to weaning ranged from 0.59±0.32 to 0.67±0.30, 0.54±0.30 to 0.75±0.33 and 0.52±0.28 to 0.86±0.37, respectively. The corresponding values obtained from the NZW breed ranged from 0.47±0.28 to 0.51±0.29, 0.46±0.30 to 0.66±0.30 and 0.41±0.27 to 0.74±0.32, for GL, LS and LW, respectively. While estimates of repeatability from CAW breed ranged from 0.43±0.27 to 0.59±0.32, 0.37±0.40 to 0.70±0.33 and 0.38±0.20 to 0.69±0.30 for GL, LS and LW, respectively. Generally, the estimates of repeatability obtained for the CHC breed were high in all the traits while the values for the NZW and CAW were moderate to high.

Table 2: Estimates of repeatability (±SE) for gestation length and litter traits for different breeds of rabbits at various ages

		Age (days)					
Breed	Trait	Birth	7	14	21	28	35
CHC	Gestation length	0.67±0.30	NA	0.59±0.32	NA	NA	0.63±0.30
	Litter size	0.72±0.32	0.64±0.31	0.75±0.33	0.69±0.31	0.54±0.30	0.68±0.34
	Litter weight	0.86±0.37	0.54±0.32	0.80±0.34	0.67±0.30	0.56±0.30	0.52±0.28
NZW	Gestation length	0.51±0.29	NA	0.47±0.28	NA	NA	NA
	Litter size	0.50±0.28	0.58±0.31	0.66±0.30	0.48±0.30	0.46±0.30	0.58±0.30
	Litter weight	0.74±0.32	0.41±0.27	0.54±0.29	0.59±0.32	0.56±0.30	NA
CAW	Gestation length	0.59±0.32	NA	NA	0.43±0.27	NA	NA
	Litter size	0.70±0.33	0.52±0.31	0.47±0.30	0.37±0.40	NA	0.54±0.30
	Litter weight	0.69±0.30	0.50±0.31	0.38±0.20	NA	0.54±0.30	0.47±0.31

SE = Standard error; NA = Not available CHC=Chinchilla; NZW=New Zealand white; CAW=California white;

The results obtained from this study for GL at birth was higher than the values (0.17±1.24) reported by (12). Similarly, the estimates of repeatability obtained from this study for LS and LW at birth in the CHC breed (0.72±0.32 and 0.86±0.37), NZW breed (0.50±0.28 and 0.74±0.32) and CAW breed (0.70±0.33

and 0.69±0.30) were higher than (0.22±2.42) and (0.12±1.12) reported by (4). Repeatability value of 0.67 and 0.80 for LS at birth and GL respectively, was reported by (22).

In a study conducted on non-descript rabbits in the South-Eastern part of Nigeria, Okero *et al.* (23) reported estimates of repeatability of 24% and 34% for LS and LW at birth, which were lower than estimates of repeatability observed herein. In their report on Chinchilla rabbits, (24) gave an estimate of 3.7% for litter birth weight, while (25) obtained a high repeatability estimate of 45% for LS in locally adapted breeds of rabbits in Shika-Nigeria. Moderate to high estimates of repeatability for LW at weaning was reported by (13). Traits with moderate to high repeatability imply that great reliability can be put on selection or culling of does and bucks for that trait, based on 1 or 2 records. According to (22) moderate to high estimates of repeatability for litter size and gestation length as well as high correlated relationship amongst them suggests that, selection of rabbit for increased litter size and shorter gestation length can be done using the first or second record of the rabbits.

Conclusion and Application

1. Heritability values observed for reproductive traits in the three breeds were low to moderate. Estimates for litter size from birth to weaning were high (0.49–0.64) in the CHC breed, while those for litter weight were moderate to high (0.34–0.52). In the NZW and CAW breeds moderate to high estimates of heritability for litter size and litter weight (0.33–0.46 and 0.28–0.41); (0.31–0.42 and 0.32–0.41) were observed from birth to weaning.
2. Lowly heritable traits can be improved upon by crossbreeding. Moderately heritable traits on the other hand could be improved upon by combining pedigree and individual selection. While individual selection can be adopted to improve highly heritable characters.
3. Estimates of repeatability for all traits observed in this study in the three breeds were moderate to high. Moderate to high repeatability imply that great reliability can be put on selection or culling of does and bucks for that trait, based on one or two records.

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