Genetic and Non-Genetic Factors Affecting Litter Size and Birth Weight of Rabbit in Minna, Niger State, Nigeria

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Abstract. Genetic and non-genetic factors influencing litter size and birth weight of rabbit was evaluated using New Zealand White and Chinchilla breeds. Parameters measured were total number of kittens born per litter, number of litter born alive, live litter birth weight and average litter birth weight. Results of the experiment revealed that dam breed had no significant affect on total number of kittens born per litter, number of litter born alive and average litter birth weight while live litter birth weight were affected. Sire breed and month of birth did not significantly influenced all the parameters measured. Heritability estimates were low to moderate for all the traits (0.27 to 0.44), while repeatability estimates were observed to be low (0.17 to 0.26). No heritability and repeatability values were estimated for average litter birth weight of kittens due to negative genetic variance. Significant correlations were found between litter size traits and birth weight. Correlation between litter size traits and average litter birth weight, as well as live litter birth weight and average litter birth weight were observed to be non-significant.

Keywords: rabbit, litter size, birth weight, genetic, non-genetic

Abstrak. Faktor-faktor genetis dan non-genetis yang mempengaruhi litter size dan bobot lahir kelinci diteliti menggunakan kelinci bangsa New Zealand White and Chinchilla. Parameter yang diukur adalah jumlah anak sekelahiran, jumlah anak sekelahiran hidup, bobot lahir anak sekelahiran hidup, dan rataan bobot lahir anak sekelahiran. Hasilnya menunjukkan bahwa bangsa dari induk tidak berpengaruh secara nyata terhadap jumlah anak sekelahiran, jumlah anak sekelahiran hidup, rataan bobot lahir anak sekelahiran, sedangkan pengaruhnya terhadap bobot lahir anak sekelahiran hidup adalah nyata. Bangsa dari pejantan dan bulan saat kelahiran tidak berpengaruh pada semua peubah yang diukur. Taksiran heritabilitas pada semua peubah adalah rendah hingga sedang (0,27 - 0,44), sedangkan taksiran nilai repitabilitas adalah rendah (0,17 - 0,26). Nilai heritabilitas dan repitabilitas tidak diperoleh pada peubah rataan bobot lahir anak sekelahiran karena variansi genetisnya negatif. Korelasi yang nyata diperoleh pada jumlah anak sekelahiran dan bobot lahir. Korelasi yang tidak nyata diperoleh antara jumlah anak sekelahiran dengan rataan bobot lahir anak sekelahiran, serta bobot lahir anak sekelahiran hidup dengan rataan bobot lahir anak sekelahiran.

Kata kunci: kelinci, jumlah anak sekelahiran, bobot lahir, genetis, non-genetis

Introduction

Rabbit litter size and birth weight are traits of economic importance which should be given prominence in rabbit breeding programmes or enterprise. Litter size at birth has been identified as one of the main traits affecting the profit function in a rabbit farm (Eady and Prayaga, 2000). According to AbouKhadiga (2004), Belhadi (2004) and Nofal et al. (2005), litter size is the most important economic character in rabbit production. Litter size is controlled by two different sets of factors; those of inherited nature and the environment. Since it is controlled by heredity, it can be improved by crossbreeding between breeds or lines within breeds (AbouKhadiga, 2004; Nofal et al., 2005). While the inherited characters affect the buck and doe, the environmental factors are most likely to affect the doe more. Nutrition, age of doe, parity and disease have an effect on litter size and by implication, on birth weight. The environment plays a great role in determining heritability values. Low heritability estimates of preweaning litter size at different ages have been reported by many investigators (Rastogiet al., 2000; Baselga and Garcia, 2002; Garcia and Baselga, 2002 a,b). Studies have identified the factors influencing litter traits as breed (Lukefahr et al., 1983; Khalil, 1999), year of birth (Ferraz et al., 1991), season of birth (Khalil et al., 1995; Khalil, 1999; Prayaga and Eady, 2003) and parity (Khalil, 1999). The factors listed above most likely also affect birth weight traits in rabbit. The genotype of both mother and foetuses play a vital role in determining birth weight, while the consequent litter weights basically depend on the foetuses' genotype and the suckled milk from the dam (Abdel-Azeem, 2006). Litter weight at weaning is controlled by the number of kittens that survived to weaning (Risamet al., 2005). The objective of this study therefore, is to identify both genetic and non-genetic factors influencing the size and weight of rabbit litters in Minna, Niger State, Nigeria.

Materials and Methods

Data on litter size and birth weight of rabbit were collected over a six month period (from June to November).The rabbits used for the experiment were strains of New Zealand White (NZW) and Chinchilla (CH). The foundation animals were comprised of six bucks (three per breed) and eighteen does (nine per breed). The rabbits were housed in individual hutches spacious enough to accommodate the doe, a kindling box and the kittens. Each cage or hutch measured 75 x 75 x 50 cm. The hutches were raised on wooden stilts about 60 cm above the ground level. Feed (16 % CP; 2776 Kcal/Kg ME formulated concentrate, Mango leaves, *Tridaxprocumbens* as well as legume hay supplement) and water were given *ad libitum* throughout the experimental period. Other routine management practices observed included cleaning of the hutches, administration of anti-stress (Vitalyte®) as well as prophylactic treatment of Coccidiosis (using Amprolium®).

The experiment was conducted at the Rabbitry section of the Teaching and Research Farm of the Department of Animal Production, Federal University of Technology, Minna, Niger State, Nigeria. Minna is located between latitude 9^0 37’ North and longitude 6^0 32’ East of the equator. The altitude is 853 feet (260 m) above sea level. Annual precipitation averages 1312 mm with a mean temperature between 19^0C and 37^0C. The mean relative humidity is between 21 – 73% (Climatetemp, 2011). Mating began when the animals were between 4-5 months of age (i.e. 120-150 days) and weighing between 1.45-1.50 kg. The does were introduced to the bucks for mating. They were allowed to remain with the bucks until mating was assured. The does were monitored for pregnancy first by attempting to mate them 14 days post mating, and through palpation of the abdominal region between the thighs after 14 days. Five days to kindling, nesting boxes were placed in the doe’s hutch. Parameters measured were total number of kittens born per litter (TNB), number of litter born alive (NLBA), live litter birth weight (LLBWT) and average litter birth weight (ALBWT). Data on dam breed, sire breed and effect of months of birth were analyzed using the General Linear Model (ProcGLM) procedure of SAS (1993). The model used was :

$$Y_{ijkl} = \mu + B_i + D_j + BD_{ij} + Mk + P_l + e_{ijkl}$$

Where Y_{ijkl}= the observation of the $_{ijkl}{}^{th}$litter size and birth weight traits; μ = overall mean; B_i= fixed effect of the $_i{}^{th}$ buck (i =1, 2); D_j= fixed effect of the $_j{}^{th}$ doe(j = 1, 2); BD_{ij}= interaction between buck and doe; M_k = fixed effect of month of kindling (k = 1, 2.., and 6); P_l = fixed effect of parity (l= 1, 2); e_{ijkl}= random error effect.

Phenotypic correlation between TNB, NLBA, LLBWT and ALBWT wasalsoestimated to study the degree of relationship between them. Phenotypic variances and repeatability estimates were calculated for TNB, NLBA, LLBWT and ABWT. Heritability was estimated from variance component using the formula:

$$h^2 = \frac{\sigma_g^2}{\sigma_p^2}$$

Where σ^2_g = genetic variance and σ^2_p = phenotypic variance.

Repeatability (R) was estimated using the expression given by Kabir et al. (2010) as shown below:

$$R = \frac{\sigma_i^2}{\sigma_i^2 + \sigma_e^2}$$

Where σ^2_g = individual's variance component; σ^2_e = error; $\sigma^2_g + \sigma^2_e$ = total phenotypic variance.

Results and Discussion

The least square means of litter size and birth weight of rabbits by dam, sire and month of birth is presented in Table 1. Dam breed significantly (P<0.05) influenced live litter body weight while total number of kittens born per litter, number of litter born aliveand average litter birth weight were not significantly (P>0.05) affected. Interactions of doe and buck breed were not significant for all the traits either. The non-significant nature of TNB, NLBA and ABWT could be explained with the observation of Prayaga and Eady (2001) who reported that high within-breed variability disallowed the means from being different significantly. The result obtained however disagrees with earlier reports (Gad Alla et al., 2005; Pannu et al., 2005).

Rashwan et al. (1995) reported that differences in litter size at birth could be due to differences in ovulation rate, and pre-implantation viability as well as maternal effects determined by the number of matured, fertilized and established ova. Interaction between doe and buck resulted in a significantly (P<0.05) higher LLBWT as was observed for kittens resulting from CH x NZW mating. This is at variance with the observation of Prayaga and Eady (2001) who reported non significant doe and buck interactions in mating involving NZW, Californian and Flemish Giant rabbits.

Sire breed did not influence (P>0.05) all the traits studied although kittens born to Chinchilla sires were observed to have better values for TNB, NLBA and LLBWT. The non-significant nature of the result is in agreement with the findings of Prayaga and Eady (2001). Month of birth had no significant effect (P>0.05) on all the litter size and birth weight traits of kittens. Differences between doe were therefore not influenced by the month of birth of the kittens. No particular trend was observed in theeffect of month of birth on the traits studied. The non-significant nature of the result is supported by earlier findings (Such et al., 1978; Ibrahim, 1985). Garcia et al. (2000), Zaky (2001), Zerrouki et al. (2005) and Abdel-Azeem et al. (2007) however all reported significant effects of month of kindling on litter size at birth. The non-significant nature of ABWT contradicts the report of Prayaga and Eady (2001) who reported significant effect of month of birth on average birth weight of kittens. Khalil et al. (1995) also observed significantly heavier birth weights in winter kindlings than in other seasons. This they tied to between doe differences, an indication of the existence of genetic variability; a raw material to be exploited for selection. The ABWT observed for kittens in this study falls within the 35-45 g reported by Onifade et al. (1999) for rabbit kittens in Nigeria.

Estimates of heritability for the traits were observed to be low to moderate (Table 2) ranging from 0.27 (LLBWT) to 0.44 (TNB). However, no estimate of heritability was obtained for ABWT. The heritability estimates were higher than values earlier reported for rabbits (Krogmeier et al., 1994; Gomez et al., 1996; Rochambeau, 1997). Higher values of heritability estimate, represents greater propensity of the parental generation passing

Table 1. Least square means (standard error) of litter size and birth weight traits of rabbit by dam, sire and month of birth

Parameter	N	TNB	NLBA	LLBWT	ABWT
Dam breed					P<0.05
Chinchilla (CH)	36	12.00	11.67	475.00[ab]	41.18
		(2.21)	(2.20)	(10.98)	(3.39)
New Zealand White (NZW)	35	8.33	8.33	256.67[b]	40.65
		(2.13)	(2.21)	(4.98)	(5.30)
CH x NZW	47	15.67	15.00	603.33[a]	39.07
		(2.26)	(2.00)	(10.98)	(7.09)
NZW x CH	43	14.33	13.00	517.33[ab]	39.61
		(1.98)	(2.12)	(4.06)	(3.45)
Sire breed					
CH	84	5.40	5.20	215.67	43.10
		(0.46)	(0.36)	(4.49)	(2.87)
NZW	81	4.80	4.53	181.47	43.01
		(0.37)	0.31)	(3.44)	(2.87)
Month of birth					
June	49	4.90	4.50	174.50	36.40
		(0.50)	(0.47)	(18.23)	(2.84)
July	15	5.00	5.00	233.33	47.22
		(0.91)	(0.85)	(33.28)	(5.28)
August	21	5.25	5.25	198.67	42.77
		(0.79)	(0.74)	(23.53)	(3.74)
September	23	5.75	5.00	185.00	38.33
		(0.79)	(0.74)	(28.82)	(4.58)
October	37	5.29	5.14	248.57	44.95
		(0.60)	(0.56)	(21.78)	(3.45)
November	10	5.00	4.00	200.00	42.19
		(1.12)	(1.04)	(40.75)	(6.47)
Overall mean		7.69	7.21	288.30	42.19
		(1.16)	(1.11)	(43.66)	(1.12)

[ab]:Means within the same column with different superscripts differ significantly ($p<0.05$)

Table 2. Heritability estimates for litter size and birth weight traits of rabbit

Parameter	Heritability±SE
TNB	0.44±0.92
NLBA	0.32±0.94
LLBWT	0.27±3.04
ABWT	NA

NA= Not estimated due to negative genetic variance component

on their superiority to their progenies. Higher heritability values are reported for production traits in the tropics than is generally reported from temperate environments (Lukefahr et al.,1992; Odubote and Somade, 1992; Ferraz and Eler, 1994; Moura et al., 1997). Rastogi et al. (2000) posited that such moderate to high estimates were associated with rather high standard of error. The differences observed in the heritability estimates might be due to differences in the method of estimation and the role played by various environmental factors. No estimate of heritability was obtained for ABWT. This was due to negative genetic variance component. Negative genetic variance as observed in this study, is commonly associated with the analysis of variance method of estimation (Akanno and Ibe, 2005). According to them, negative variance components are regarded as an indication of negligible contribution of additive genes to variation of the trait concerned. Low to medium heritability estimates as observed in this study is a cluethat variability due to additive gene effect is probably lower than non-additive components.

Repeatability estimates were observed to be low for all the traits ranging from 0.17 to 0.26 (Table 3). No repeatability estimate was obtained for ABWT due to negative genetic variance. Although repeatability estimates were observed to be low, they were higher than values earlier reported by Ferraz et al. (1991), and Prayaga and Eady (2001). According to Prayaga and Eady (2001), repeatability sets the higher limits of heritability meaning that the traits are lowly heritable in the rabbit breeds considered. They further stated that traits with low repeatability values show less correlation between the repeated measures of the same individuals and hence, selection decisions on such traits should be based on multiple litter measurements. The low repeatability estimates may be due to high environmental variance acting on the rabbits.

The result of correlation between the traits studied is presented in Table 4. Correlation between the traits was observed to be positive, and significant (P<0.01) except for correlations between litter size traits and ABWT, and between LLBWT and ABWT respectively which although positive, were observed to be non-significant. Although the correlation between litter size traits and ABWT was not negative and hence contradicts earlier reports (Vincente et al., 1995; Argente et al., 1999; Poigner et al., 2000; Adeyinka et al., 2007), it is a hintthat birth weight traits should be selected with caution as there is no assurance that improving litter size traits will result in a correspondingly positive improvement in ABWT of rabbits.

Conclusions

From the results of the study, the following deductions could be made (1) dam and sire breed had no significant effect on total number of kittens born per litter, number of litter born alive and average litter birth weight while dam breed significantly affected live litter birth weight, (2) month of birth did not significantly influence all the parameters measured, (3) heritability estimates were low to moderate for all the traits while repeatability estimates were observed to be low, and (4) significant correlations were observed between litter size traits and birth weight. Correlation between litter size traits and average litter birth weight, live litter birth weight and average litter birth weight were observed to be non-significant.

Table 3. Phenotypic variance and repeatability (standard error) estimates for litter size and birth weight traits of rabbit

Parameter	σ^2_e	σ^2_g	σ^2_p	R
TNB	15.3	5.23	20.53	0.26
NLBA	14.7	2.97	17.67	0.17
LLBWT	33063	10766.33	43829.33	0.25
ABWT	25.4	-0.87	24.53	NA

TNB = total number of kittens born per litter; NLBA = number of litter born alive;
LLBWT = live litter birth weight; ABWT = average litter birth weight; NA =not estimated due to negative genetic variance component

Table 4. Phenotypic correlation between litter size and birth weight traits of rabbit

	TNB	NLBA	LLBWT
NLBA	0.98*		
LLBWT	0.91*	0.92*	
ABWT	0.14	0.15	0.15

TNB = total number of kittens born per litter; NLBA = number of litter born alive;
LLBWT = live litter birth weight; ABWT = average litter birth weight.

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