World Rabbit Science Association
Proceedings 10 th World Rabbit Congress – September 3 - 6, 2012– Sharm El- Sheikh –Egypt, 69- 74

LITTER TRAITS IN A DIALLEL CROSSING OF THREE RABBIT BREEDS IN NORTHERN GUINEA SAVANNAH ZONE OF NIGERIA

Kabir M[1]., Akpa G.N[1], Nwagu B.I[2]. and Adeyinka I.A[2]

[1]Genetics and Animal Breeding Unit, Department of Animal Science, Ahmadu Bello University, Zaria.
[2]National Animal Production Research Institute (NAPRI) Shika–Nigeria
Corresponding Author: Mohamed Kabir, E-mail: mkabir@abu.edu.ng; kabirkbs@gmail.com

ABSTRACT

This Study was conducted at the rabbitry unit of Ahmadu Bello University Zaria, with a view to utilize California White (CAW), Chinchilla (CHC) and New Zealand White (NZW) rabbits in a diallel cross to evaluate general and specific combining abilities, as well as maternal and reciprocal effects on litter performance. Data collected from 202 purebred kits born in 34 litters and 528 crossbred kits from 74 litters were used. The crossbred group comprised of 272 'main cross' kits and 256 'reciprocal cross' kits. Results of the study revealed that breed differences in general combining ability (GCA) for litter size indicated that CHC rabbits had better performance in terms of litter weight, individual kit weight and neonatal/preweaning mortality at birth and weaning than NZW and CAW. Analysis for specific combining ability (SCA) showed that the best combinations for litter size was NZW x CAW (8.5) at birth and (7.0) at weaning. Results of maternal heterotic effects for litter size and weight at birth and weaning showed that higher percentages were obtained from NZW x CAW cross than those from CHC x NZW and CAW x CHC crosses. Similarly, litters from CHC x NZW cross showed better size at birth and at weaning than those from CAW x CHC. Reciprocal effects showed a highly significant effect on litter weight at birth (31.39%) for NZW x CHC cross while a significant effect was observed for gestation length and litter size at birth in NZW x CHC and CHC x CAW. Neonatal and preweaning mortality showed no significant reciprocal effect in NZW x CHC and CHC x CAW crosses. Similarly, reciprocal effect was not important in CAW x NZW cross for all litter traits studied.

Key words: Diallel cross, combining ability, Litter traits.

INTRODUCTION

A diallel cross is a very important tool used to evaluate the performance of breeds in their various combinations, especially for those already indigenous to a region or area (Dickerson, 1993). The performance of all crosses that derive from one breed is designated the general combining ability (GCA) of this breed, while the specific combining ability (SCA) is a joint attribute of two breeds and signifies the deviation of a cross from the sum of the GCA's of its parent breed (Pirchner, 1983). In Nigeria, particularly the Northern Guinea Savannah zone, there are several breeds of rabbits available to the producers; however, diallel crosses with rabbit breeds to evaluate their performance in various combinations have not been carried out so far. The objective of this study is to estimate the general and specific combining abilities for litter size and weight at birth and weaning in a diallel crossing of Chinchilla, New Zealand White and Californian White breeds of rabbits in Nigeria.

MATERIALS AND METHODS

Experimental site, animals and management

The study was conducted at the rabbitry unit of the research and experimental farm, Department of Animal Science, Ahmadu Bello University Zaria. A 3 x 3 diallel cross involving three rabbit breeds; New Zealand White (NZW), Chinchilla (CHC) and the California White (CAW) was conducted. They were housed in well ventilated pens according to group and small metallic ear-tags were used for their identification and proper record keeping. Feed and clean drinking water were provided *ad libitum*.

Data collection and statistical analysis

The data generated for this study comprised of 202 purebred kits born in 34 litters and 528 crossbred kits from 74 litters. The crossbred group was made up of 272 kits from 'maincross' and 256 kits from 'reciprocal cross', hence a total of 730 offspring bred from June 2007 to May 2009 were evaluated. There were three parities. The statistical analysis for this study was performed using the IML procedure of SAS (Martinez-Garza, 1983, 1991). The dependent variables were litter size at birth and at weaning and litter weight at birth and at weaning whereas the independent variables were the progenitor breeds of rabbits used. The statistical model used for the investigation was as follows: $Y_{ijk} = \mu + g_i + g_j + s_{ij} + m_i + m_j + r_{ij} + \ell_{ijk}$

Where; Y_{ijk} = variable analysed; μ = overall mean; g_i = effect of the general combining ability of the $_i^{th}$ breed of rabbit; g_j = effect of the general combining ability of the $_j^{th}$ breed of rabbit; s_{ij} = interaction or effect of the specific combining ability of the cross $(_{i\,x\,j})$; r_{ij} = reciprocal (sex-linked) effect of the cross $(_{i\,x\,j})$; m_i and m_j are maternal effects for $_i^{th}$ and $_j^{th}$ breed; ℓ_{ijk} = random error; assumed to be independently randomly distributed (0, σ^2). Statistically all effects were considered as fixed effects. General Combining Ability (GCA) and Specific Combining Ability (SCA) were estimated using the following formulae: $GCA_i = ½\, n\, (Y_i + Y_{.i}) – 1/n^2\, Y_{..}$ and $SCA_{ij} = ½\,(Y_{ij} + Y_{ji}) – ¼\, n\,(Y_{i.} + Y_{.i} + Y_{j.} + Y_{.j}) + 1/n^2\, Y_{..}$ Where **n** is the number of records considered; Y. is the sum of the observations $Y_1+Y_2+Y_3+\ldots+Y_n$ for respective breeds (i or j) of rabbit.

RESULTS AND DISCUSSION

Litter performance

The California White (CAW) does had significantly (P<0.05) higher litter size (LS) at birth than the Chinchilla (CHC) and New Zealand White (NZW) does. This result agreed with the reports of Irekhore (2007) who stated that California breed produced higher litter size at birth than New Zealand White, New Zealand Black and Flemish Giant breeds. The result observed in this study was at variance with the results of Yahaya (1993) who reported higher litter size at birth for Chinchilla does than for New Zealand White and California White does. Though the mean LS at birth obtained in this study compares with that reported by Patial *et al.* (1991), it was higher than that (5.6) reported by Odubote and Akinokun (1991). The range of 6.05–7.33 for LS at birth obtained herein (Table 1) was higher than the litter size of 4.4 (Iyeghe *et al.*, 1996), 4.77 (Fayeye and Ayorinde 2003), 5.8–6.61 (Irekhore, 2007) and 5.69 (Akpa and Alphonsus 2008). California White (CAW) does produced heavier litters at birth compared to NZW and CHC does. This could be explained by the findings of Rao *et al.* (1977) who stated that the total weight of rabbits in a given litter increased with increased litter size. It also corroborated the earlier submissions of Ozimba and Lukefahr (1991).

General combining ability (GCA)

The significant effect (P<0.05) of GCA observed for litter size (LS) and litter weight (LW) at birth and weaning (Table 1) indicated that additive gene action is important in the expression of these traits. This suggests that traits with additive gene effects are expected to respond to selection for their genetic improvement. This is because their heritability values are also expected to be moderate to high. For other traits that showed positive but insignificant (P>0.05) effect of GCA, the implication is that additive gene action operates in their respective mode of expression but to a lesser extent. The results observed in this study was in contrast with the reports of Afifi and Emara (1990), who worked in Egypt and indicated that breed differences in GCA for litter size at birth and weaning were non-significant. For litter weight at weaning however, Afifi and Khalil (1992), reported highly significant differences (P<0.01) among the breeds studied, where the Californian kits had the highest litter weight, followed by the Bouscat and Giza White kits.

Table 1. General Combining Ability (GCA) for litter traits from birth to weaning.

Age (days)	Traits	CHC x CHC	NZW x NZW	CAW x CAW
(Birth)	N	54	66	82
	LS*	6.05±0.29[c]	6.89±0.25[b]	7.33±0.19[a]
	LW* (g)	163.68±5.76[a]	149.25±3.92[b]	155.94±4.34[b]
	IKW* (g)	27.05±2.14[a]	21.66±1.61[b]	21.27±1.39[b]
	NM (%)	3.7[a]	7.5[c]	6.1[b]
7	LS*	5.25±0.28[c]	5.97±0.49[b]	6.78±0.27[a]
	LW* (g)	344.49±14.63[b]	324.29±13.68[b]	512.77±128.77[a]
	IKW* (g)	65.62±2.25[b]	54.32±2.44[c]	75.63±2.21[a]
14	LS*	4.91±0.28[c]	5.63±0.48[b]	6.13±0.28[a]
	LW* (g)	678.02±30.29[b]	673.96±26.63[b]	742.69±22.47[a]
	IKW* (g)	138.09±2.7[a]	119.71±1.86[b]	121.15±1.41[b]
28	LS*	4.58±0.29[c]	5.39±0.23[b]	5.91±0.22[a]
	LW* (g)	1264.15±51.85[c]	1391.5±50.56[b]	1469.35±54.11[a]
	IKW* (g)	276.67±2.16[a]	239.65±2.32[d]	263.9±2.99[b]
35 (Weaning)	N	38	54	70
	LS*	4.58±0.29[c]	5.39±0.23[b]	5.86±0.22[a]
	LW* (g)	1596.93±66.31[C]	1764.05±64.36[b]	1838.40±66.22[a]
	IKW* (g)	348.67±2.77[a]	327.28±2.14[b]	313.72±2.55[c]
	PWM (%)	14.6[a]	29.6[c]	18.2[b]

[abc] =Means within the same row having the same letter are not significantly (P>0.05) different.
N= Sample size; LS= litter size; LW=litter weight; IKW=Individual Kit weight; NM=Neonatal mortality; CHC=Chinchilla; NZW=New Zealand White; CAW=California White.

Specific combining ability (SCA)

The results of SCA (Table 4) indicated that the CHC x NZW cross was the best combination regarding the use of sire and dam breed to exploit non-additive genetic variance. It was also observed that the CHC breed performed generally well in crosses with either NZW or CAW. Cross performance was however low or almost poor for NZW x CAW cross, implying poor manifestation of non-additive gene action (Obasi and Ibe, 2008). The negatively non-significant SCA is an indication that crossing to utilize non-additive gene effects will result in depression of such traits (Nagpure *et al.,* 1991). The findings of this study were in conformity with the reports of other workers (Brun *et al.,* 1992; Krogmeier *et al.,* 1994; Obasi and Ibe, 2008). According to Obasi and Ibe (2008), significant SCA is an indication of non-additive gene action for the traits concerned and can be improved genetically through appropriate crossing, utilizing non-additive gene effects such as dominance and epistasis. Improving the environment may also bring about improvement in the character (Obasi and Ibe, 2008). Carregal (1980) and Afifi and Emara (1990) reported non-significant differences due to SCA for kit body weight at several ages and litter size at birth or weaning, respectively. However, Afifi and Khalil (1992), found a significant effect for litter weight at birth attributable to SCA, when utilizing Bouscat, Giza White, White Flander and Baladi Red rabbits.

Maternal heterotic effects

For litter size and weight at birth and at weaning (Tables 2 and 3), higher percentages for heterotic effect were obtained from NZW x CAW cross than those from CHC x NZW and CAW x CHC crosses. Similarly, for litter size at birth and at weaning, litters from CHC x NZW cross showed better performance than those from CAW x CHC. Henry (2007) reported that crossbreeding has helped to improve litter size at birth, litter weight at birth and gestation gain substantially in all the matings in their study. The positive and high heterotic effects obtained in this study agreed with the reports of other workers (Sheridan, 1986; Brun *et al.,* 1992; Afifi and Khalil, 1992). Carregal (1980) found significant differences for body weight of kits at 28 and 70 days of age attributable to maternal heterosis in favour of New Zealand and Californian does, when compared to Dutch and Blanc du Bouscat does. Afifi and Emara (1990) reported that the best maternal heterosis was exhibited by white Flander and Baladi Red does at birth and at weaning respectively. Afifi and Khalil (1992) reported significant differences for litter weight at weaning due to breed of doe. Brun *et al.* (1992) found differences for litter size between breed of rabbits attributable to maternal heterosis. The superiority which some breeds of doe exhibit for maternal ability can be attributed to increased milk production, maternal behaviour and care of the litter. Results for %H' for all weaning traits were positive and substantial for all mating groups except for weaning mortality, which showed lower estimate (Table 2). Higher estimates of %H' for a given trait indicated that crossbreeding has improved the performance of that trait in the mating concerned. Fayeye and Ayorinde, (2000) reported that the most promising crossbred for the exploitation of heterotic effect was the NZW x CHC.

Reciprocal effects

The high reciprocal effects observed (Tables 2 and 3) for LSB, LWB, LSW and LWW in the CHC x NZW cross agreed with the earlier reports of Fayeye and Ayorinde (2000). The authors reported that reciprocal effect was higher in the NZW x CHC crossbreds than in NZW x CAL and CAL x CHC crossbred for litter size at birth. Ponce de Leon and Menchaca (1974) found significant effect for litter size at birth which is attributable to reciprocal effects.

Table 2. Estimates of maternal heterosis (%H') and percent reciprocal (%R') effects for birth traits

Mating group	Traits		
	LSB	LWB	NM
CHC x NZW (%H')	41.85	38.74	-21.17
NZW x CAW (%H')	63.24	52.18	-26.03
CAW x CHC (%H')	36.19	46.25	-28.75
Overall (%H')	**54.28±15.72**	**49.22±8.41**	**-33.26±17.74**
NZW x CHC (%R')	16.27*	31.39*	0.62 NS
CAW x NZW (%R')	07.36 NS	24.07 NS	3.52 NS
CHC x CAW (%R')	25.13*	39.30 NS	12.07 NS
Overall (%R')	**19.17±10.14**	**30.99±9.24**	**10.18±44.13**

CHC=Chinchilla; NZW=New Zealand white; CAW=California White; LSB=Litter size at birth; LWB=Litter weight at birth; NM=Neonatal Mortality; * (P<0.05); NS = Not significant.

Table 3. Estimate of maternal heterosis (%H') and percent reciprocal (%R') effects for weaning traits

Mating group	Traits		
	LSW	LWW	PWM
CHC x NZW (%H')	37.11	29.27	2.43
NZW x CAW (%H')	38.48	29.49	4.51
CAW x CHC (%H')	33.23	25.66	4.32
Overall (%H')	31.27±9.44	20.18±6.66	6.55±1.08
NZW x CHC (%R')	10.6	12.12	3.1
CAW x NZW (%R')	5.55	13.73	1.87
CHC x CAW (%R')	16.37*	19.19	2.29
Overall (%R')	10.10±4.4	17.91±11.4	4.07±1.36

CHC=Chinchilla; NZW=New Zealand White; CAW=California White; LSW=Litter size at weaning; LWW=Litter weight at weaning; PWM=Pre-Weaning Mortality; * (P<0.05)

The highest averages in their study were found where the Semi-giant breed was included as the sire in the mating. Nagpure *et al.* (1991) observed from their study that the use of New Zealand White males on White Giant females can be made to exploit reciprocal effects (maternal and sex-linked) in obtaining higher body weights from birth to 6 months of age. Carregal (1980) found that the use of Dutch males on New Zealand, Californian and Bouscat does produced the highest individual kit body weight at 28 days of age. Afifi and Khalil (1992) reported a highly significant effect (P<0.01) on litter weight at birth attributed to reciprocal effects.

Table 4. Specific combining ability (SCA) for litter traits from birth to weaning.

Age (days)	Traits	Specific Combining Ability					
		Main cross			Reciprocal Cross		
		CHC x NZW	NZW x CAW	CAW x CHC	NZW x CHC	CAW x NZW	CHC x CAW
(Birth)	N	83	102	87	77	99	80
	LS*	6.41 ± 0.43^{c}	8.50 ± 0.28^{a}	7.25 ± 0.52^{b}	6.91 ± 0.28^{b}	8.25 ± 0.21^{a}	6.66 ± 0.28^{c}
	LW* (g)	170.08 ± 11.36^{b}	169.17 ± 8.06^{b}	184.96 ± 7.69^{a}	149.17 ± 4.29^{b}	170.12 ± 4.66^{a}	149.98 ± 9.05^{b}
	IKW* (g)	26.53 ± 2.22^{a}	19.9 ± 1.31^{c}	25.51 ± 2.77^{b}	21.58 ± 2.38^{b}	20.62 ± 2.17^{c}	22.52 ± 2.19^{a}
	NM (%)	3.6^{a}	6.8^{c}	4.6^{b}	5.2^{b}	5.0^{a}	6.25^{c}
7	LS*	6.0 ± 0.53^{b}	8.08 ± 0.22^{a}	5.91 ± 0.49^{b}	6.25 ± 0.39^{a}	6.25 ± 0.35^{a}	6.0 ± 0.30^{b}
	LW* (g)	394.91 ± 26.18^{b}	796.7 ± 382.89^{a}	361.37 ± 20.11^{c}	352.18 ± 22.85^{b}	305.57 ± 24.31^{c}	382.44 ± 22.09^{a}
	IKW* (g)	65.82 ± 2.74^{b}	98.6 ± 2.04^{a}	61.14 ± 2.36^{c}	56.35 ± 2.17^{b}	48.89 ± 2.29^{c}	63.74 ± 2.22^{a}
14	LS*	5.67 ± 0.47^{b}	7.33 ± 0.25^{a}	5.67 ± 0.54^{b}	5.91 ± 0.33^{b}	6.17 ± 0.35^{a}	5.16 ± 0.17^{c}
	LW* (g)	756.65 ± 64.31^{b}	833.11 ± 34.57^{a}	717.31 ± 31.07^{c}	720.77 ± 39.62^{a}	643.6 ± 49.98^{c}	701.25 ± 38.13^{b}
	IKW* (g)	133.45 ± 3.42^{a}	113.66 ± 3.76^{c}	126.51 ± 3.13^{b}	121.96 ± 3.33^{b}	104.31 ± 3.71^{c}	135.9 ± 3.3^{a}
21	LS*	5.16 ± 0.47^{c}	7.17 ± 0.23^{a}	5.41 ± 0.54^{b}	5.67 ± 0.21^{b}	6.08 ± 0.35^{a}	4.75 ± 0.17^{c}
	LW* (g)	1031.4 ± 67.80^{b}	1248.90 ± 62.16^{a}	1022.59 ± 60.42^{c}	1098.55 ± 58.59^{a}	1052.77 ± 62.57^{b}	957.35 ± 48.12^{c}
	IKW* (g)	199.88 ± 2.91^{a}	174.18 ± 2.24^{c}	189.02 ± 1.96^{b}	193.75 ± 2.53^{b}	173.15 ± 1.88^{c}	201.55 ± 2.43^{a}
28	LS*	5.16 ± 0.47^{c}	7.17 ± 0.29^{a}	5.41 ± 0.54^{b}	5.58 ± 0.31^{b}	6.08 ± 0.35^{a}	4.75 ± 0.17^{c}
	LW* (g)	1374.37 ± 82.04^{c}	1696.5 ± 110.73^{a}	1380.99 ± 86.26^{b}	1472.58 ± 55.37^{a}	1457.08 ± 85.98^{b}	1314.18 ± 59.82^{c}
	IKW* (g)	255.26 ± 2.93^{b}	236.61 ± 2.74^{c}	266.35 ± 2.26^{a}	248.62 ± 2.27^{c}	258.16 ± 2.46^{b}	276.01 ± 2.59^{a}
35 (Weaning)	N	67	85	65	62	73	56
	LS*	5.16 ± 0.47^{c}	7.08 ± 0.31^{a}	5.41 ± 0.54^{b}	5.58 ± 0.31^{b}	6.08 ± 0.35^{a}	4.67 ± 0.18^{c}
	LW* (g)	1748.48 ± 96.71^{c}	2089.5 ± 141.56^{a}	1754.15 ± 114.66^{b}	1870.3 ± 65.49^{b}	1890.6 ± 115.04^{a}	1622.0 ± 71.46^{c}
	IKW* (g)	338.85 ± 2.13^{a}	295.12 ± 2.46^{c}	324.24 ± 2.39^{b}	335.18 ± 2.14^{b}	310.95 ± 2.36^{c}	347.32 ± 2.59^{a}
	PWM (%)	19.3^{b}	25.3^{c}	16.6^{a}	19.5^{a}	30^{c}	21^{b}

^{abc} =Means within the same row for a particular cross having the same letter are not significantly (P>0.05) different; N=Sample size; LS=litter size; LW=litter weight; IKW=Individual Kit weight; NM=Neonatal mortality; CHC=Chinchilla; NZW=New Zealand White; CAW=California White.

CONCLUSIONS

New Zealand White proved superior litter size at birth and at weaning, but Chinchilla breed is the best for individual weight at birth and at weaning as well as milk yield and mothering ability. The results of SCA indicated that the CHC x NZW cross was the best combination regarding the use of sire and dam breed to exploit non-additive genetic variance. CHC breed performed generally well in crosses with either NZW or CAW. Cross performance was however low or almost poor for NZW x CAW cross, implying poor manifestation of non-additive gene action.

REFERENCES

Afifi, E.A. and Emara, M.E. 1990. Analysis of litter size in rabbits in a diallel crossing scheme involving four local Egyptian and exotic breeds. *Journal of Applied Rabbit Research,* 12:256-258.

Afifi, E.A. and Khalil, M.H. 1992. Crossbreeding experiments of rabbits in Egypt: Synthesis of results and overview. In: Rabbit production and genetics in the Mediterranean Area. Serie A: *Seminaires.* Options Mediterraneennes. 17:35-52.

Akpa, G.N. and Alphonsus, C. 2008. Relationship of parity with litter size and gestation length and their repeatabilities in rabbits. Proceedings of the 13th Annual Conference of the Animal Science Association of Nigeria (ASAN), September 15-19, Ahmadu Bello University, Zaria. Pp 76-77.

Brun, J.M., Bolet, G. and Ouhayoun, J. 1992. The Effects of Crossbreeding and Selection on Productive and Reproductive Traits in a Triallel Experiment between Three Strains of Rabbits. *Journal of Applied Rabbit Research.* 15:181-189.

Carregal, R.D. 1980. Evaluation of heterosis, combining ability and the maternal and reciprocal effects in rabbits (in Spanish). Proceedings of the 2nd World Rabbit Congress, Barcelona, Spain. Pp.213-222.

Dickerson, G.E. 1993. Evaluation of breeds and crosses of domestic animals. Animal Production and Health Paper 108. FAO, Rome. Italy. 47p.

Fayeye, T.R. and Ayorinde, K.L. 2000. Heterosis and reciprocal effect for litter characteristics in rabbit crosses. Proceedings of the 25th Annual Conference of the Nigerian Society for Animal Production, (NSAP), Michael Okpara University of Agriculture, Umudike, Abia State, March 19-23, 25:248-251.

Fayeye, T.R. and Ayorinde, K.L. 2003. Correlations between some weaning traits in domestic rabbits in Nigeria. *Nigerian Journal of Genetics*. 18:63-67.

Henry, A.J. 2007. Effect of parity on litter traits of breeding rabbits in a humid tropical environment. Proceedings of the 32nd Annual Conference of the Nigerian Society for Animal Production (NSAP), March 18-22, Calabar, 35:165-168.

Irekhore, O.T. 2007. Reproductive performance of four breeds of rabbit in the tropics. Proceedings of the 32nd Annual Conference of the Nigerian Society for Animal Production (NSAP), March 18-22, Calabar. 32:120-122.

Iyeghe, G.T., Abdulmalik, M.E., Osinowo, O.A., Adeyinka I.A. and Nwagu, B.I. 1996. Genetic and environmental factors affecting litter size, gestation length and weaning weight in rabbits. *Journal of Animal Production Research.* 15 & 16:81-89.

Krogmeier, D., Dzapo, V. and Mao, I.L. 1994. Additive genetics and maternal effects on Postweaning growth and carcass traits in rabbits. *Journal of Animal Breeding and Genetics*, 111:420-437.

Martinez-Garza, A. 1983. *Statistical designs and analysis of experiments of Diallel crosses* (In Spanish). Colegio de Postgraduados. Montecillo, Edo. Mexico. Pp 252.

Martinez-Garza, A. 1991. Analysis of Diallel experiments by means of the IML procedure of SAS. (In Spanish). Comunicaciones en Estadistica y Computo Centro de Estadistica y Calculo. Colegio de Postgraduados. Montecillo, Edo. Mexico. Pp 36.

Nagpure, N.S., Kothekar, M.D., Gore, A.K. and Deshmukh, S.N. 1991. Estimation of general and specific combining ability variances from a 4 x 4 diallel cross in rabbits. *Journal of Applied Rabbit. Research,* 14:38-43.

Obasi, V.N. and Ibe, S.N. 2008. Influence of additive and non-additive gene effects on body measurements in domestic rabbit. *Nigerian Journal for Animal Production,* 35(1):1-8

Odubote, I.K. and Akinokun, J.O. 1991. Reproductive and body weight performance of the New Zealand White rabbits in the Humid tropics of Nigeria. *Nigerian Journal for Animal Production* 18:61-65.

Ozimba, C.E. and Lukefahr, S.D. 1991. Comparison of rabbit types for Postweaning litter growth, feed efficiency and survival performance traits. *Journal of Animal Science,* 69:3494-3500.

Patial, K.K., Manuja, N.K., Gupta, K. and Sanjeet, K. 1991. The effect of season on litter size of broiler rabbits in Himachal Pradesh, India. *Indian Journal of Animal Science,* 51-55p

Pirchner, F. 1983. Population Genetics in Animal Breeding. 2nd Ed. Plenum Press, New York NY. 414p.

Ponce de Leon, R. and Menchaca, D. 1974. Study of genetic factors of variation in a triple crossbreeding (in Spanish). 1st World Congress on Genetics Applied to Livestock Production. Madrid, Spain. 3:455-463.

Rao, D.R., Sunki, G.E., Johnson, W.M. and Chen, C.P. 1977. Postnatal growth of New Zealand White rabbit. *Journal of Animal Science* 44:1021-1025.

Sheridan, A.K. 1986. Selection for heterosis from crossbred populations: Estimation of the F1 heterosis and its mode of inheritance. *British Poultry Science,* 27:541-550.

Yahaya, H.K. 1993. Performance of New Zealand White, California and Chinchilla rabbits and their crosses in a warm tropical environment. M. Sc. Thesis submitted to the Department of Animal Science, Ahmadu Bello University, Zaria.