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General combining ability (GCA), specific combining ability (SCA) and reciprocal effects on average daily gain in body weights at various ages of rabbit in northern guinea savannah zone of Nigeria

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Abstract: *Complete diallel experiment was carried out involving three rabbit breeds (Chinchilla {CHC}, New Zealand White {NZW} and Californian White {CAW}). Data on post weaning average body weight gain were analysed by complete diallel analysis after first been corrected for significant effects of season of birth and sex of animal using the least squares constants. The variations due to general combining ability (GCA) as well as specific combining ability (SCA) were highly significant (P<0.01) for all the post weaning growth periods. However, reciprocal effect was not significant (P>0.01) indicating absence of maternal effect. The GCA effect was positive and considerably high for CHC and NZW but negative for CAW. The crosses of NZW and CHC with CAW rabbit had positive and high SCA effect. The findings from this study further revealed positive GCA effect in the two breeds (NZW and CHC) in respect of post weaning growth performance up to 90, 120 and 150 days of age. This was contrary to the negative GCA effect in CAW breed. The results suggested that the growth performance of NZW and CHC breeds far exceeded that of CAW breed of rabbit. When crossed with CAW breed, NZW and CHC showed positive SCA effects for the tested trait. On the basis of these findings, crossbreeding of CAW with NZW as well as with CHC was advocated.*

Keywords: *Average daily gain, Body weight, Combining Abilities, Rabbit, Reciprocal effect.*

I. Introduction

Combining ability in crosses is defined as the ability of parents to combine amongst each other during the process of fertilization so that favourable genes or characters are transmitted to their progenies [1]. Two types of combining ability, general (GCA) and specific (SCA), have been recognized in quantitative genetics. The concepts of general combining ability (GCA) and specific combining ability (SCA) were first introduced by [2] in relation to corn breeding and have been expanded into animal breeding by [3] and others. The term GCA is used to designate the average performance of an inbred line in hybrid combinations while SCA is used to designate those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the lines involved [1]. According to [2] GCA is due to genes which are largely additive in their effects and SCA is due to genes with dominance or epistatic effect [4].

Rabbit possesses a number of characteristics that makes it a suitable meat producer. Rabbit needs less space and feed due to small body size. Besides, shorter generation interval, high prolificacy, faster growth and high feed conversion efficiency are the qualities that have made rabbit an ideal species for meat production [5]. There is paucity of documented information regarding combining abilities and reciprocal effects on growth performance of rabbits in Nigeria, particularly the Northern Guinea savannah zone. The objective of this study therefore, is to investigate GCA, SCA and reciprocal effects on average daily gain in body weights of three rabbit breeds under a diallel crossing experiment.

II. Materials And Methods

1.1 Experimental Site

This study was carried out at the rabbitry unit of the Animal Science Departmental Farm, Ahmadu Bello University, Zaria. Zaria is located between latitude 11^0 and 12^0N and on altitude of 640m above sea level [4]. The area falls within the Northern-Guinea Savannah zone having an average annual rainfall of 1100mm which starts from late April and early May to mid October. Detailed description of Zaria was given elsewhere by [5].

1.2 Housing and Management

The animals were kept in cages under uniform conditions of management. Weaning was done at 35 days of age. Feed and clean drinking water were provided *ad libitum* throughout the experimental period. The rabbits were raised on a mixed feeding regime and fed twice daily at 8:00am and 4:00pm. Concentrates was first given in the morning and forage (*Panicum maximum* grass and/or *Centrosema pubescence* legume) in the evening to enhance intake [6].

1.3 Data Collection and Analysis

Records of average post weaning daily body weight gain up to 90 days, 120 days and 150 days of age generated from a complete diallel experiment involving CHC, NZW and CAW breeds of rabbit, constituted the materials used for the study. In order to study the GCA, SCA and reciprocal effects (RE), data were analysed by complete diallel analysis as per [7] as detailed by [8]. Prior to diallel analysis, individual records were corrected for significant effects of season of birth and sex of animal using the least squares constants [9].

III. Results And Discussion

The average post weaning daily body weight gain was studied separately up to 90 days, 120 days and 150 days of age. It was observed that the variation amongst the 9 genetic groups including pure lines, direct and reciprocal crosses were highly significant for all the above mentioned periods of growth which justified diallel analysis study. The average daily post weaning body weight gain up to the age of 90, 120 and 150 days were respectively 17.93, 20.11 and 19.43 g in CHC; 16.84, 19.08, 18.57 g in NZW and 15.02, 15.59 and 16.08 g in CAW (Table 1). [6] reported average daily gain of 15–20g as the common range in the tropics, which agreed with the result obtained in this study. The variations in average daily gain due to GCA were highly significant, which suggested that growth performance of NZW and CHC far exceeded that of CAW breed. The results obtained shows positive GCA effect in the two breeds NZW and CHC, in respect of post weaning growth performance up to 90, 120 and 150 days of age. This was contrary to the negative GCA effect observed in CAW breed. Reports by [10] in Nigeria and [11] in Egypt indicated that breed differences in GCA for litter size at birth and weaning were non-significant. For litter weight at weaning however, [12] 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. [13] and [11] reported non-significant differences due to SCA for kit body weight at several ages and litter size at birth or weaning, respectively.

Considering the fact that variances due to SCA were significant in respect of the post weaning average daily weight gain at different growth periods, it may be opined that crossing of these two breeds cannot be advocated due to negative hybrid vigor (heterosis). On the other hand, NZW and CHC when crossed with CAW breed show positive SCA effects for the tested traits indicating notable presence of positive heterosis for growth. The different cross combinations also showed some degree of variation in mean average daily gain. The results of analysis of variance for combining abilities showed that, the variations due to GCA as well as SCA were highly significant for all the post weaning growth periods (Table 2). However, reciprocal effect was significant. The results conclusively demonstrated presence of significant additive and non-additive genetic variance in regards to gain in weight per unit time. Also, the findings indicated absence of maternal effect on post weaning growth performance of the rabbits.

The GCA effect was positive and considerably high for CHC and NZW (Table 3), ranging from 0.44 to 0.70 and negative for CAW, ranging from –1.65 to –0.93 for all the post weaning growth periods. The SCA effect in the crosses of NZW and CHC were found to be negative (–0.74, –0.63 and –0.81) at 90, 120 and 150 days, respectively. Whereas the crosses of these two breeds with CAW had positive and high SCA effect (Table 3). Thus, in respect of post weaning growth performance up to 90, 120 and 150 days of age the cross of CHC x NZW, exhibited negative hybrid vigor (heterosis) and the crosses of these two breeds with CAW exhibited positive heterosis. In their study involving NZW, Grey Giant, Soviet Chinchilla, Flemish Giant and six two breed crosses, [14] observed SCA for birth weight and average daily gain to be low while that for weaning weight to be moderate. On the other hand, on the basis of the results of a 4 x 4 diallel crossing experiment [15] observed significant role of GCA and SCA in growth parameters. Crossbreds of different breeds with differential direct effect on body weight of rabbit was also reported [15]. In a four-year crossing scheme involving Spanish V line (V) and Egyptian Baladi Red (B) rabbits producing five genetic groups: V, B, ½B½V(F), (½B½V)1(F2), and (½B½V)2 22, [16] evaluated the body weights (BW) and daily gains in weight (DG) from four to twelve weeks under Egyptian condition. The authors found that crossbreds were intermediate and the direct effect of V line was found higher. The crosses were found superior to indigenous Egyptian breed (B) and inferior to V line.

Table 1. Means of crosses for post weaning gain in 3 x 3 diallel rabbit experiment

Breed of		Average Daily Gain (g)		
Sire	Dam	90 days	120 days	150 days
CHC	CHC	17.93	20.11	19.43
NZW	NZW	16.84	19.08	18.57
CAW	CAW	15.02	15.59	16.08
CHC	NZW	18.69	19.83	18.86
CHC	CAW	17.12	19.10	19.65
NZW	CAW	18.19	17.07	18.41
NZW	CHC	20.22	19.49	18.08
CAW	CHC	18.99	18.62	19.08
CAW	NZW	17.47	18.65	18.94

CHC=Chinchilla, NZW=New Zealand White, CAW=Californian White

Table 2. Analysis of Variance for combining abilities for post weaning gain at various ages

	Body weight at 90 days		Body weight at 120 days		Body weight at 150 days	
Sources of variation	df	MSS	Df	MSS	Df	MSS
GCA	2	7.82^{**}	2	9.64^{**}	2	6.49^{**}
SCA	3	5.36^{**}	3	6.19^{**}	3	4.37^{**}
RE	3	0.25	3	0.22	3	0.32
Error	462	0.569	444	0.11	378	0.133

GCA=general combining ability, SCA=specific combining ability, RE=reciprocal effect, df=degree of freedom, MSS=mean sum of squares, **=highly significant ($P<0.01$)

Table 3. GCA (for lines), SCA (for crosses) and RE for post weaning gain at various ages

Effects	Body weight at 90 days	Body weight at 120 days	Body weight at 150 days
General Combining Ability (GCA)			
g_1 (CHC)	0.53	0.70	0.64
g_2 (NZW)	0.59	0.61	0.44
g_3 (CAW)	-1.65	-1.38	-0.93
Specific Combining Ability (SCA)			
S_{12} (CHC x NZW)	-0.74	-0.63	-0.81
S_{13} (CHC x CAW)	1.62	1.58	1.43
S_{23} (NZW x CAW)	1.28	1.35	0.98
Reciprocal Effects (RE)			
r_{21}	0.32	0.26	0.29
r_{31}	0.46	0.23	0.25
r_{32}	0.27	0.29	-0.20

IV. Conclusion

On the basis of these findings, crossbreeding of CAW with NZW as well as with CHC can be advocated for better growth performance. The reciprocal effect was not found to be significant for growth performance. The findings therefore revealed that use of separate male and female lines in any crossbreeding programme using the three breeds will not accrue additional advantage.

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