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Direct and Maternal Additive Effects on Rabbit Growth and Linear Body Measurements

Egena, S. S. A. [1*], Akpa, G. N. [2], Alemede, I. C[1]. and Aremu, A[1].

[1]Department of Animal Production, Federal University of Technology, P.M.B 65, Minna, Niger State, Nigeria. [2]Department of Animal Science, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

*corresponding author: achenejesirisky@gmail.com

Target audience: Geneticists and breeders, Rabbit farmers

Abstract

Growth and linear body measurements of rabbits which consisted of 17 New Zealand White (NZW), 19 Chinchilla (CH), 29 NZW x CH and 33 CH x NZW kittens were compared. The aim of the experiment was to evaluate the crossbreeding effects (i.e direct and maternal additive effect) for growth (individual body weight, IBW) and linear body traits (nose to shoulder, NTS; shoulder to tail length, STL; heart girth, HG; trunk length, TL; length of ear, LE). Results revealed that significant (P<0.05) general combining ability (GCA) was observed for IBW and NTS with NZW rabbits having greater body weight (408.59) and the CH rabbits having better value for NTS (11.36). Significant (p<0.05) specific combining ability (SCA) was observed for all the traits evaluated. NZW x CH progenies had better NTS (12.05), STL (22.79), HG (16.04), TL (18.59) and LE of ear (8.03) while CH x NZW progenies had better IBW (422.50). Direct additive effect was significant (P<0.01) but negative for all the traits; an indication of minimal contribution of the sires to the inheritance of the traits. Maternal additive effect was observed to be non-significant (P>0.01) for all the traits except IBW. It could be recommended that CH sires be used to mate NZW dams to improve body weight and linear body traits. NZW does could be favoured to give the best IBW based on their superior maternal ability. Crossing between NZW and CH could be advantageous in increasing IBW and linear body measurements.

Keywords: Growth, linear body measurements, heterosis, maternal, additive effect

Description of Problem

Crossbreeding is a breeding method used to take advantage of heterosis arising from the crossing or mating of purebred lines which have characteristics pleasing to a breeder and beneficial in the progeny. Positive effects of crossbreeding on growth traits in rabbits have been observed and studied by several investigators (1, 2, 3, 4). Results from most crossbreeding experiments carried out in Egypt reported that crossing does of New Zealand White breed with bucks of local breeds was generally associated with heterotic effects on growth traits (5, 6). Afifi *et al*. (7) reported significant direct and maternal additive effects as well as direct heterosis on post-weaning

body weight traits favouring V-line rabbits compared to Baladi Black ones.
Khalil *et al.* (8) reported higher direct and maternal genetic effects of V-line rabbits than Saudi Gabali rabbits for most weaning growth traits. (9) in their study of additive and heterotic components for post-weaning growth traits in a crossing project of V-line with Gabali rabbits in Egypt, observed that means of body weights for Gabali and V-lines rabbits obtained fell within the range earlier reported by some authors (6, 10, 11, 7)
Until recently, it is difficult to find purebreds of rabbits in Nigeria. What are obtainable are strains of the common breeds such as the NZW, CH, Dutch belt etc and crossbreds of the various strains. These strains have genetic potentials and should be further improved. There is the need to carry out studies to ascertain the best combination of rabbit strains in the various agro-ecological zones of the country so that heterosis could be imparted in the progenies arising from these crosses. This is what informed this study. The objective of the study was to evaluate the general and specific combining abilities, as well as maternal, heterotic and direct additive effects for growth and linear body measurements traits in rabbits.

Materials and Methods

The experiment was conducted at the Rabbit 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 above sea level. Annual precipitation averages 1312 mm with a mean temperature of between 19^0C and 37^0C. The mean relative humidity is between 21 – 73 % (12).

Animals used for this study were NZW and CH strains obtained from the National Veterinary Research Institute Vom, Plateau state, Nigeria. The foundation animals consisted of 6 bucks (3/strain) and 18 does (9/strain). The rabbits were 11 weeks old. The animals were housed in groups (i.e according to strain) in well ventilated and shaded hutches. Each cage or hutch had the following dimensions: length 75 cm, width 75 cm and height 50 cm. The hutches were raised on wooden legs about 60 cm above the ground. A 16 % CP diet with energy level of 2776 Kcal/Kg was fed to the rabbits. The diet consisted of 38.13 % maize, 17.22 % GNC, 40.50 % maize bran, 3.00 % bone meal, 0.20 % methionine, 0.20 % lysine, 0.50 % salt and 0.25 % premix. Mango leaves, *Tridax procumbens* 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 as well as prophylactic treatment of coccidiosis. All healthy does without noticeable defects were retained for breeding. 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 to take place. They were allowed to remain with the bucks until mating was assured. The does were monitored for pregnancy through palpation of the abdominal region between the thigh and also through observation of the abdomen which got enlarged due to the growth of the foetuses. Ten days to kindling, nesting boxes were placed in the doe's hutch in preparation for kindling.

Statistical analysis was performed by means of the PROC GLM procedure of SAS (13). Variables measured were individual body weight (IBW), nose to shoulder length (NTS), shoulder to tail length (STL), heart girth (HG), trunk length (TL) and length of ear (LE) at 49 days post-partum. The parameters were measured as given below:

a. Individual body weight: This was obtained using a weighing scale and expressed in grams.

b. Nose to shoulder length: This was the distance from the nose to the point of the shoulder.

c. Shoulder to tail length: This was the distance from the point of the shoulder to the pin bone or the end of coccygeal vertebrate.

d. Heart girth: This was taken as the body circumference just behind the fore limbs.

e. Trunk length: This was measured as the longitudinal distance from the point of the shoulder to the tuberosity of the ischium.

f. Length of ear: This was the distance from the point of attachment of the ear to the tip of the ear. Measurement was taken on the left ear only.

All linear measurements in cm were carried out using a flexible tape rule. Measurements was done by two people; one taking the measurements and the other holding the rabbits.

Estimates of crossbreeding effects (direct additive and maternal additive) for all the traits studied were estimated using CBE package (14). Estimates of each component were calculated according to (15). The following symbols were described in Table 1.

Table 1: Number of rabbits used in the experimental work and description of genetic group of sires and dams produced from them

Genetic group of rabbit*	N	Genetic group of sire	Genetic group of dam
NZW x NZW	17	NZW	NZW
CH x CH	19	CH	CH
NZW x CH	29	NZW	CH
CH x NZW	33	CH	NZW
Total	98		

*NZW= New Zealand White; CH= Chinchilla strains; N= number of individuals.

Direct additive effect (G^I): ½ ((NZW x NZW – CH x CH) – (NZW x CH – CH x NZW))
Maternal effect (G^M): ½ ((NZW x CH) – (CH x NZW))

Results and Discussion

Table 2 shows the least square means (mean ± SEM) of growth and linear body measurements traits taken at 49-days post-partum according to general combining ability (GCA) and specific combining ability (SCA) effects. NZW strain had the best averages (p<0.05) for individual body weight, shoulder to tail length and trunk length while CH strain showed better averages for nose to shoulder length, heart girth and length of ear, respectively in terms of GCA. Results for SCA indicated that the combination CH x NZW was superior to NZW x CH for individual body weight only while the combination NZW x CH was superior to CH x NZW for nose to shoulder length, shoulder to tail length, heart girth, trunk length and length of ear, respectively. CH kittens were significantly (p<0.05) heavier and had longer NTS. This is a clear pointer to the fact that additive gene effects are important for the expression of these traits. The superior performance of the CH strain suggests that it has the uppermost predominance genes which impart additive effect on individual body weight and NTS. This is a clue that CH rabbits could possibly increase in growth performance because of their higher GCA values (16). This applies also to NTS. Maximum use of additive genetic variance could be made therefore by using CH rabbits for improved individual body weight and NTS.

Table 2: Least square means (mean ± SEM) of growth and linear body measurement traits according to general (GCA) and specific combining ability (SCA) effects

	IBW	NTS	STL	HG	TL	LE
GCA						
NZW	408.59±48.40[a]	10.69±0.99[b]	22.32±2.15	14.91±1.39	18.03±1.68	7.86±0.74
CH	427.47±15.36[b]	11.38±0.99[a]	21.95±0.39	15.39±0.28	17.62±0.51	8.13±0.12
SCA						
NZW X CH	390.26±20.48[b]	12.05±0.46[a]	22.79±0.90[a]	16.04±0.62[a]	18.59±0.73[a]	8.03±0.31[a]
CH X NZW	422.50±49.89[a]	10.80±0.87[b]	21.11±1.76[b]	14.70±1.23[b]	17.29±1.44[b]	7.08±0.57[b]

NZW= New Zealand White; CH= Chinchilla strains (in each combination, the breed of the sire is listed first); IBW = Individual body weight; NTS = Nose to shoulder; STL = Shoulder to tail; HG = Heart girth; TL = Trunk length; LE = Length of ear.

SCA estimates show that all the traits were significantly (P<0.05) affected by the mating combinations. The combination CH x NZW produced kittens with better body weight only, while the combination NZW x CH produced kittens with better NTS, STL, HG, TL and LE. This is indicative of non-additive gene action. An advantage could be derived therefore by mating NZW dams to CH sires for better body weight. This could be due to their better milking and mothering ability (17). Mating CH dams to NZW sires will however lead to better performance in the other traits. Crossing to utilize non-additive gene effects will therefore lead to improvement in the traits evaluated.

Estimates of G^I and their percentages for the traits studied are given in Table 3. The estimates were all negative for individual body weight and for linear body measurement traits and showed highly significant (P<0.01) effects for all the traits. Percentages of these estimates to the means of the two foundation parents were generally low and negative. LE had the lowest percentage (-90.99 %) while IBW had better percentage (-38.97 %). Direct additive effect estimates were all negative for individual body weight and linear body measurement traits and showed high significant (p<0.05) effect. The results indicate that CH strain was superior to NZW strain in direct additive gene action for growth traits; this difference in direct genetic effect for growth traits should encourage the use of CH strain in crossbreeding programmes. Direct genetic effects from crossing NZW with Baladi Red (BR) and Baladi Black (BB) rabbits in Egypt were consistently in favour of BR and BB rabbits for post-weaning body weights (2, 18). Minitt *et al.* (19) reported that loci responsible for a given trait play a key role in complementarity between additive effects of genes leading to the expression of direct additive effects. The result obtained indicates however that crossing of NZW with CH is associated with decrease in individual body weight and the associated traits. There is no available local information for direct additive effects on linear body measurements to compare the result of this study with.

Table 3: Estimates of direct additive effects (G^I) for body weight and linear body measurement traits in crossing of NZW and CH strains of rabbits

Trait	G^I±SEM NZW vs CH	G^I %$^+$	Significance
IBW	-178.48±5.29	-38.97	**
NTS	-9.33±0.55	-84.55	**
STL	-19.70±1.06	-88.99	**
HG	-13.54±0.74	-89.37	**
TL	-13.96±0.94	-78.32	**
LE	-7.25±0.35	-90.66	**

*Significant (p<0.01); $^+$ = (Estimated value/(NZW + CH)/2) x 100; IBW = Individual body weight; NTS = Nose to shoulder; STL = Shoulder to tail; HG = Heart girth; TL = Trunk length; LE = Length of ear.

Estimate of G^M and its percentages for the traits studied are given in Table 4. Most of these estimates were negative for individual body weight and for linear body measurement traits. Only G^M estimate for IBW showed any significant positive (P<0.05) effect while NTS, STL, HG, TL and LE all showed no significant (p>0.05) effect. Percentages of these estimate ranged from -6.00 % (LE) to 3.51 % (IBW). Estimate of maternal additive effect was positive and significant (P<0.05) only for IBW while the linear body traits all returned negative and non-significant (P>0.05) effects. Negative maternal effect (as observed for the linear traits) means that kittens mothered by CH strain are favoured to those mothered by NZW strain. CH dams should therefore be considered in crossbreeding programmes for maximum utilization of maternal ability as far as these traits are concerned. With regard to individual body weight however, NZW kittens are preferred and NZW dams should be used in crossbreeding programme for maximum utilization of maternal additive effect. Abdul-Ghany *et al.* (20) reported negative but significant maternal additive effects for live weight at weaning influenced by Californian dams. Minitt *et al.* (19) reported that maternal effect consist mainly from additive maternal and cytoplasmic inheritance, and that in terms of complementarity effect, certain crosses may show much maternal effect than others depending on the extent to which the crossed populations differ in reproductive performance and in production characters. This type of effect therefore relies on the direction of the crossing (21).

Table 4: Estimates of maternal additive effects (M^I) for body weight and linear body Measurement traits in crossing of NZW and CH strains of rabbits

Trait	M^I±SEM NZW vs CH	M^I %$^+$	Significance
IBW	16.07±2.24	3.51	**
NTS	-0.63±0.49	-5.71	ns
STL	-0.84±0.99	-3.80	ns
HG	-0.67±0.68	-4.16	ns
TL	-0.65±0.81	-3.65	ns
LE	-0.48±0.32	-6.00	ns

*Significant (p<0.01), ns = not significant (p>0.05); $^+$ = (Estimated value/(NZW + CH)/2) x 100; IBW = Individual body weight; NTS = Nose to shoulder; STL = Shoulder to tail; HG = Heart girth; TL = Trunk length; LE = Length of ear.

Conclusion and Application

Based on the results of this study, the following deductions could be made:

1 CH sires could be used to mate NZW dams to improve body weight and linear body traits.

2 NZW does could be favoured to give the best individual body weight based on their superior maternal ability.

3 A cross between NZW and CH could be advantageous in increasing IBW and linear body measurements.

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