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Heterotic Effect on Body Weight, Reproductive, Morphometric and Carcass Traits of Crossbred Kits of New Zealand White and Chinchilla Rabbits

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Abstract

There is need for breeders and farmers to know the best mating method to employ and the breeding goals to expect in rabbit breeding programmes. However, information on which breed should be used as male or female in crossbreeding rabbit for commercial purpose is limited. This study was conducted to evaluate the effect of reciprocal crossing on body weight (BW), reproductive, morphometric and carcass characteristics of two breeds of rabbits, New Zealand White (NZW) and chinchilla (CHA) raised in tropics. Offspring from the crossing of NZW x CHA and CHA x NZW were studied for body weight (BW) and reproductive traits for twelve weeks. Reproductive traits studied were litter size at birth (LSB), litter size at weaning (LSW), Average birth weight (ABWT), Average weaning weight (AWWT), Gestation length(GSTL) and percent mortality. Morphometric traits studied were body width (BWD), body length (BL), heart girth (HG) and tail length (TL). While carcass characteristics were dressed weight, foreleg, thoracic, loin, hind and skin. The heterotic values and their percentages were calculated in the two genetic groups using the linear contrast procedure. The direct and percent heterosis for reproductive traits were all positive for the two genetic groups except in gestation length and percent mortality which showed negative heterosis (-1 and -3.2%; 3.19;10.12% for gestation length and -7.19 and -19.07; -9.36 and -24.83% for percent mortality in CHA X NZW and NZW X CHA respectively). Body weight at different ages studied, morphometric and carcass traits were also positive for NZW x CHA off springs while CHA x NZW off springs had negative values for all these parameters measured indicating that CHA sired off springs had no improvement for BW at various ages, reproductive, morphometric and carcass traits studied. It could therefore be concluded that rapid improvement in Body weight, Reproductive, morphometric and carcass could be achieved by crossbreeding involving mating of New Zealand White male and Chinchilla does.

Keywords: Rabbit, crossbreeding, heterosis, reproductive traits, body weight

Effet hétérotique sur le poids corporel, les caractéristiques reproductrices, morphométriques et de carcasse des kits croisés de lapins blancs et chinchilla de Nouvelle-Zélande

Résumé

Il est nécessaire que les éleveurs et les agriculteurs connaissent la meilleure méthode d'accouplement à utiliser et les objectifs d'élevage à attendre dans les programmes d'élevage

de lapins. Cependant, les informations sur la race qui doit être utilisée comme mâle ou femelle dans les croisements de lapins à des fins commerciales sont limitées. Cette étude a été menée pour évaluer l'effet du croisement réciproque sur le poids corporel (PC), les caractéristiques reproductives, morphométriques et de carcasse de deux races de lapins, le New Zealand White (NZW) et le chinchilla (CHA), élevés sous les tropiques. La progéniture issue du croisement NZW x CHA et CHA x NZW a été étudiée pour son poids corporel (PC) et ses caractéristiques de reproduction pendant douze semaines. Les caractères reproductifs étudiés étaient la taille de la portée à la naissance (TPN), la taille de la portée au sevrage (TPS), le poids moyen à la naissance (PMN), le poids moyen au sevrage (PMS), la durée de la gestation (DGST) et le pourcentage de mortalité. Les traits morphométriques étudiés étaient la largeur du corps (LRC), la longueur du corps (LC), la circonférence du cœur (CC) et la longueur de la queue (LQ). Les caractéristiques des carcasses étaient le poids paré, la patte antérieure, la poitrine, la longe, l'arrière et la peau. Les valeurs hétérotiques et leurs pourcentages ont été calculés dans les deux groupes génétiques en utilisant la procédure de contraste linéaire. L'hétérosis direct et le pourcentage pour les caractères reproductifs étaient tous positifs pour les deux groupes génétiques, sauf pour la durée de gestation et le pourcentage de mortalité qui présentaient une hétérosis négative (-1 et -3,2% ; 3,19 ; 10,12 % pour la durée de gestation et -7,19 et -19,07 ; - 9,36 et -24,83 % pour le pourcentage de mortalité dans CHA X NZW et NZW X CHA respectivement). Le poids corporel à différents âges étudiés, les caractéristiques morphométriques et de carcasse étaient également positifs pour NZW x CHA hors printemps, tandis que CHA x NZW hors printemps avaient des valeurs négatives pour tous ces paramètres mesurés, indiquant que CHA engendré hors printemps n'avait aucune amélioration du poids corporel à différents âges, de la reproduction. , caractères morphométriques et carcasses étudiés. On pourrait donc conclure qu'une amélioration rapide du poids corporel, reproducteur, morphométrique et carcasse pourrait être obtenue par un croisement impliquant un accouplement de mâles blancs de Nouvelle-Zélande et de chèvres Chinchilla.

Mots-clés: Lapin, croisement, hétérosis, caractères reproductifs, poids corporel

Introduction

Production of rabbit has become very lucrative in recent times due to its numerous attributes. Some of which include high reproductive performance (Kabir *et al*., 2016), excellent mothering ability (Lukefahr and Cheeke 1990), ability to adapt in different environmental conditions (Sam *et al*., 2020a), high genetic variability (Sam *et al.,* 2020b), low capital investment (Aduku and Olukosi 1990). Rabbit meat contains very high protein 21-22% (Dale, 2002) and low fat and cholesterol levels (Ekpo *et al.,* 2016). In addition, rabbit has no religious taboo linked to its consumption. Body weight, Reproductive, morphometric and carcass traits are very important in rabbit production. Reproductive performance of rabbits determines the profitability and economic success of commercial rabbit breeding (Ekpo *et al*., 2018; Sam *et al.,* 2020a). Body weight and morphometric traits on the other hand are crucial because heavier body weights lead to greater economic of production in rabbit production (Fayeye, 2013). Estimation of morphometric traits in animals are very vital in estimating genetic parameters in animal breeding programmes (Chineke, 2000; Sam *et al.,* 2020a). Body weight is an economic important trait in the commercial rabbit production and was found to be improved by

crossing of local breeds with exotic standard breeds (Afifi *et al*., 2000; Piles *et al*., 2004). Similarly, crossbreeding is a major tool used by animal breeders to improve many traits in farm animals (Medellin and Lukefahr, 2001). Several research have been conducted on breed complementation for reproductive and growth traits by crossing animals of different genotypes (Rashau and Marai 2000, Iraqi *et al.,* 2008, Fayeye 2013, Sam *et al.,* 2020a). Breed complementarity was achieved by crossing local White and local black rabbits to tap the non-additive genes for improving reproductive traits (Fayeye, 2013). Studies have shown that under field and experimental breeding situations, not every crossbreeding strategy produces desirable results (Nwachuckwu and Okoji. 2012). It is pertinent that breeders know what mating methods to employ and what breeding goals to expect (Dickerson, 1992). The needed information on which breed should be used as male or female in crossbreeding rabbit for commercial purpose is limited. Therefore, this study was undertaken to evaluate the level of heterosis for body weight, reproductive, morphometric and carcass traits in main and reciprocal crossbreed of New Zealand White and Chinchilla breeds of rabbit.

Materials and Methods

Experimental site

This experiment was carried out at the Rabbitary Unit, Teaching and Research Farm, Akwa Ibom State University, Obio Akpa Campus, Obio Akpa is located between latitudes $5^{0}17^{1}$N and $5^{0}27^{1}$N and between longitudes $7^{0}27^{1}$E and $7^{0}58^{1}$E. Obio Akpa falls within rainforest zone of South South Nigeria, with an average annual rainfall which range from 3500 to 5000 mm distributed over eight months (March to October) with its peak in June and July and dry season between November and February. It has a hot-humid climate with temperature ranges of 21-26^{0} C in wet season and 30-33^{0}C in the dry season and relative humidity between 60 to 90% (AKSG, 2022).

Experimental animals and management

A total of 40 matured breeding rabbit stock (10 months of age) with average weight of 3.5 - 4.00kg was used in this experiment. It consisted of twenty New Zealand White (2 bucks and 18 does) and twenty Chinchilla breeds of rabbit (2 bucks and 18 does).The rabbits were purchased from reputable rabbit farms in Uyo metropolis, Akwa Ibom state, Nigeria. On arrival, the rabbits were allowed to acclimatize for two weeks to the environment before commencing the study. The rabbits were housed in hutches measuring 60 x 60 x 44cm for the length, width and height respectively. The animals were given ivomectin injection subcutaneously to treat both external and internal parasites that may affect their growth and reproductive performance. They were also treated prophylactically with Amprolium 200 for one week against coccidiosis given via drinking water. Multivitamins were also given to the rabbits to boost them up for the study. Every other care as applicable according to international, national and University guidelines for the care and use of animals were followed (SAMRC, 2004).

During breeding one New Zealand White buck was used to mate with nine New Zealand White does and the second New Zealand buck was used to mate with nine Chinchilla does. While one Chinchilla buck was used to mate with nine Chinchilla does and the second Chinchilla buck was used to mate with nine New Zealand White does as shown in Table 1.

Table 1: Mating Scheme and no of Progenies Produced

Genotype	No of Sire	No of Dam	No of Progenies
NZW X NZW	1	9	27
CH X CH	1	9	35
NZW X CH	1	9	33
CH X NZW	1	9	31

At the end of the breeding period 126 kits produced from crosses comprising of NZW x NZW, CHA x CHA, NZW x CHA and CHA x NZW as presented in Table 1 were produced. The rabbits were kept in 4 hutches each measuring 170 cm by 32 cm and consisting of 10 cells, each of which measured 60 cm x 60 cm x 50 cm for the length, width and height respectively, such that one rabbit was accommodated in one cell. Identification marks were placed on the cells in which each rabbit was accommodated.

All the rabbits in their respective cells were fed with forages, *Ipomoea batatas, Centrosema spp, Peuraria phaseoloides* and commercial concentrates feed was also given with drinking water *ad-libitum*. The commercial concentrate fed to the animals consisted of 18% CP, 2600 Kcal/kgME, and 8% CF as analyzed. Routine management operations were carried out on a daily basis. Pregnancy was detected by careful abdominal palpation on 14th and 21st days after mating, if confirmed pregnant, nest boxes were provided on 28th day of pregnancy.

Data collection

Measurement of Body weight and Reproductive Traits

Gestation length: This was measured by finding the interval between the date of last mating and date of kindling.

Litter size at birth: This was measured by direct counting of the kits immediately after kindling with still births inclusive.

Litter size at weaning: This was the number of kits in each litter at weaning time (6 weeks).

Birth weight: This was measured by transferring all the kits in a litter with gloved hands well rubbed on the body of the doe in question to the weighing scale. And the weight of the litter read off and divided by the total number of kits in the litter.

Body weight at weaning: This was measured by taking the weight of each kit in a litter at weaning time (6 weeks).

Weekly body weight: This was measured by weighing each kit in a litter on weekly basis for a period of twelve weeks. Sensitive weighing balance (S. Miller Digital Scientific Scale) was used in weighing the animals.

Measurement of Morphometric Traits*:*

Measurement of morphometric traits was done biweekly using tailors tape. These measurements were recorded early in the morning before feeding. The morphometric traits measured were; body width (BWD), Body length (BL), heart girth (HG) and tail length (TL). The measurements were taken according to methods describe by Obasi *et al.* (2019).

Body width: measurement was when rabbit is held in a resting position from the front leg to the hind leg.

Body length: measurement was taken from the base of the shoulder to the base of the tail.

Hearth girth: a circumferential measure was taken round the chest region behind the front legs.

Tail length: measurement was taken from the base of the tail to the end of the tail

Measurement of carcass traits

At the age of 12 weeks, five rabbits from each genetic group were randomly selected after starving them overnight. The rabbits were weighed individually to obtain live body weight and thereafter slaughter and dissected according to methods recommended by Larzul and Rochambeau (2004). Slaughtered rabbits were bled, skinned and emptied of the digestive tract & urogenital organs before being weighted (Dress weight). The carcass cut (Thoracic cage, loin, forelegs, hind legs and skin) were weighed immediately using sensitive weighing balance (S. Miller Digital Scientific Scale) and were expressed in grammes. All body weight, reproductive, morphometric and carcass traits measurements were carried out early in the morning (6.00 am) before feeding.

Statistical Analysis

The design for this study was a completely randomised design with genetic group as major factor of interest. Direct and percentage heterosis were estimated using the linear contrast procedure as described by Dickerson (1992). The procedure is as follows:

- Direct heterosis= Mean of crossbred – Mean of purebreds
- Percentage heterosis = $\frac{\text{Direct heterosis}}{\text{Pure line}} \times 100$

Results and Discussion

Heterosis for body weight

The estimate of direct and percent heterosis of main and reciprocal crossing of Body weights of New Zealand White and Chinchilla breeds of rabbit according to age is shown in Table 2. The results indicates that percent heterosis for body weight were positive in NZW X CHA crossbreed kits at all the ages studied, (29.54,29.28,30.43,26.46,33.14, and 40.63 for 2,4,6,7,8,10 and 12 weeks, respectively). Direct heterosis and percent heterosis were however negative for body weight in CHA X NZW crossbred in all the ages studied, direct heterosis were -9.06, -95.46, -61.79, -96.33, -145.19 and -245.20 for weeks 2, 4, 6, 8, 10 and 12, respectively. The highest positive heterosis of 40.63% was recorded at week 12 followed by week 10 (33.14), exception of week 8 which recorded 26.46%, heterosis increased gradually as the age of the rabbit increased. The observed differences in heterotic effect for body weight among breed crossed in this work is in consonance with earlier studies on New Zealand White local Egyptians rabbits and Nigerian local rabbits (Tag-El-Din *et al*., 1992; Rashwan *et al*., 1997 and Fayeye 2013).

The negative direct heterosis and percent heterosis observed in the cross between CHA X NZW indicated that means of this crosses were lower than that of pure breeds. Therefore, crossing CHA X NZW did not improve body weight of these rabbits at different ages studied. However, the cross between NZW X CHA resulted in positive direct and percentage heterosis at all ages, this method of mating could be used for commercial production of rabbits. These results agreed with previous work by Ouyed and Bran (2008). Heterosis is the relationship between the performance of the crossbred offspring and their parents. Positive and higher values of heterosis for a given trait shows that improvement has been made in the said trait through crossbreeding. The magnitude of heterosis depends on genetic diversity of the breeds that are crossed (Abo Khadiga *et al*., 2008; Ragab *et al.,* 2016; **Hagan and Opoku-Mensah, 2019**).

Table 2: Estimate of direct and percentage heterosis of main and reciprocal crossing of Body weights of New Zealand White and Chinchilla breeds of rabbit according to age

Age	CHA X NZW		NZW X CHA	
(weeks)	Direct Het	% Heterosis	Direct Heterosis	% Heterosis
0	0.03	0.045	0.98	1.48
2	-9.06	-5.83	45	29.54
4	-95.46	-26.36	106.03	29.28
6	-61.79	-13.55	138.03	30.43
8	-96.33	-16.75	152.21	26.46
10	-145.19	-20.57	233.9	33.14
12	-245.20	-28.49	349.6	40.63

Reproductive Traits

Estimate for direct and percent heterosis for reproductive traits are shown in Table 2. The estimate for direct and percent heterotic effect for litter size at birth, litter size at weaning and average birthweight were positive in the two crossbred groups. CHA and NZW recorded 1.16, 0.52 and 0.03 direct heterosis for LSB, LSW and ABWT respectively, whereas the group percent heterosis were 25.77%, 14.77% and 0.045 for LSB, LSW and ABWT respectively. However, NZW and CHA crosses recorded higher direct and percent heterosis than CHA X NZW. The results showed that direct heterosis were 0.67, 1.46 and 0.98, while percent heterosis were 14.88%, 42.03% and 1.48% for LSB, LSW and ABWT respectively. The direct and percent heterosis for AWWT was negative for CHAXNZW progenies (-87.79 and -17.18%respectively), but positive for NZWXCHA progenies (118.72 and 24% respectively). A positive heterosis shows the progress made as a result of the crossbreeding exercise while a negative heterosis mean otherwise. It was observed that NZWX CHA genetic group recorded higher positive heterosis for LSB, LSW, ABWT and AWWT which shows that the progenies from this cross was better than their purebred parents. Abdel-Azeem *et al*. (2007) and Nwakpu *et al*. (2015) also recorded positive heterosis for LSB and LSW for New Zealand crosses with California or Flemish giant breeds raised under tropical conditions. Kabir *et al*. (2012) also reported of a positive heterotic effect for LSB between the New Zealand and California White cross. The difference in heterotic effect for weaning weight between the two crossbred groups is in line with previous studies on new Zealand White, local Egyptian rabbits and Nigerian local rabbits (Tag-el din *et al.1992*; Rashwan *et al.,* 1997; Fayeye. 2013). According to Brun *et al*. (1992) differences in LSB among breeds of rabbits are 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 (**Hagan and Opoku-Mensah, 2019)**. It was also observed that NZW and CHA crosses had negative direct and percent heterosis for gestation length, which still indicates its superiority over the other genetic group. Results for heterosis for mortality were negative for the two crossbred genetic groups (NZW X CHA and CHA X NZW). The improvement in survivability of the crossbreds could be attributable to better mothering ability or maternal effects expressed by the two breeds. It may be desirable to experience negative heterosis for some traits such as mortality and gestation length which is an implication of higher parental or purebred performance as against crossbred performance.

Table 3: Estimate of direct and percentage heterosis of main and reciprocal crossing of reproduction traits of New Zealand White and Chinchilla breeds of rabbit

Parameter	CHA X NZW		NZW x CHA	
	Direct Heterosis	% heterosis	Direct heterosis	% heterosis
LSB	1.16	25.77	0.67	14.88
LSW	0.52	14.77	1.46	42.03
ABWT(g)	0.03	0.045	0.98	1.48
AWWT(g)	-87.79	-17.18	118.72	24.95
GSTL(day)	1.00	3.2	- 3.19	10.25
Mortality %	-7.19	-19.07	-9.36	-24.83

LSB -Litter size at birth, LSW-Litter size at weaning, ABWT-Average birth weight, AWWT-Average weaning weight, GSTL -Gestation length

Morphometric traits

The result of direct and percentage heterosis of morphometric traits of two genetic groups of rabbits at weeks 2,4,6,8,10 and 12 are presented in table 4. The results showed that NZW X CHA kits had positive estimates of direct and percent heterosis for morphometric traits measured at all ages studied. Positive heterosis for body weight and morphometric traits in crossbred rabbits had earlier been reported by Ghosh *et al.,* 2004; Abdel Azeem *et al.,* 2007; Kabir *et al*., 2012. . The CHA X NZW kits had negative estimate for direct and percent heterosis for morphometric traits measured at all ages. This indicates that these animals were not good compared to the mid-parent value of the traits studied. The implication of this in practical rabbit breeding in the study area is that CHA X NZW females would not produce vigorous of spring in breeding programs carried out to improve the rabbits for commercial production.

Table 4: Estimate of direct and percentage heterosis of main and reciprocal crossing of Morphometric Traits traits of New Zealand White and Chinchilla breeds of rabbit

Age (weeks)	Parameter (cm)	CH X NZW Direct Heterosis	CH X NZW % heterosis	NZW X CH Direct heterosis	NZW X CH % heterosis
2	BWD	0.825	5.35	0.805	5.22
4		-0.575	-2.59	-0.575	2.59
6		-0.22	-0.88	2.18	8.73
8		1.31	5.13	2.17	8.49
10		-0.74	-2.53	0.42	1,43
12		-0.65	-3.10	1.30	2.80
2	BL	0.87	7.92	0.89	8.10
4		-2.77	-15.96	-0.39	2.24
6		0.34	-2.09	1.6	9.84
8		-1.43	-7.70	0.31	1.67
10		4.92	27.18	2.16	11.93
12		3.24	16.29	4.18	18.24
2	HC	0.14	1.04	0.90	6.68
4		0.15	0.94	3.31	20.80
6		-0.3	-1.58	1.23	6.48
8		0.02	0.10	1.37	7.06
10		1.09	5.34	2.85	13.98
12		1.50	6.50	4.95	20.10
2	TL	0.52	10.56	0.96	19.51
4		0.91	12.33	1.30	17.61
6		-0.34	-3.97	0.84	9.82
8		-0.09	-0.97	0.29	3.14
10		0.05	0.50	0.73	7.41
12		0.71	0.81	0.83	9.02

BWD-Body width, BL- Body length,HC-Heart girth, TL-Tail length

Carcass Traits

Estimate for direct and percent heterosis for carcass traits are presented in table 5. The results indicate negative direct and percent heterosis for CHA X NZW genetic group (-119.9/-27.08%,-5.10/-17.05, -10.2/-17%, -31/-33%, -15.9/-22.39% and -8.4/-11.08% for dressed weight, foreleg, thoracic, loin, hind leg and skin respectively. However, the direct and percent heterosis for carcass traits of NZW X CHA were all positive. The results indicated that direct heterosis were 223.3, 9.50, 55, 16.80, 5.9 and 21.8 for dressed weight, foreleg, thoracic, loin, hind, and skin. While percent heterosis was 54.05%, 31.77%, 91.6%, 18.02%, 8.29% and 28.75% respectively. The result obtained in this study for heterotic influence on carcass traits agrees with those of Oke *et al*., 2010 and Kabir *et al*., 2016 who both observed that the proportions of carcass traits differed between the cross breeds and pure breeds. Crossing take advantage of traits with considerable non-additive effect between populations (Ahmed, 2003; Kabir *et al*., 2016). The positive heterosis

observed for all the carcass traits measured in NZW X CHA genetic group indicated that cross between these two breeds with CHA acting as the dam could improve carcass traits in rabbits, the positive heterosis and higher percentages of carcass traits in this group also showed that this mating method is associated with carcass enhancement performance of growing rabbits. All carcass parameters measured were negative in the CHA X NZW genetic group indicating that this mating method is not ideal in the study area.

Table 5: Estimate of direct and percentage heterosis of main and reciprocal crossing of Carcass traits of New Zealand White and Chinchilla breeds of rabbit

Parameter(g)	CHA X NZW	CHA X NZW	NZW X CHA	NZW X CHA
	Direct Heterosis	% Heterosis	Direct Heterosis	% Heterosis
Dressed weight	-119.9	-27.08	223.3	54.05
Foreleg	-5.10	-17.05	9.50	31.77
Thoracic	-10.2	-17	55	91.6
Loin	-31	-33	16.8	18.02
Hindlegs	-15.9	-22.39	5.9	8.29
Skin	-8.4	-11.08	21.8	28.75

Conclusion

The study revealed strong crossbreeding effect on the NZW x CHA offspring as indicated by positive estimate of direct and percentage heterosis for body weight at different ages studied, reproductive traits (LSW, ABWT, AWWT, GSTL), morphometric and carcass traits. The study also showed negative direct and percent heterosis for CHA x NZW off springs in AWWT and body weight at all ages reflecting that there was no improvement for these traits following crossbreeding in the animals.

It could therefore be recommended that in breeding programme involving New Zealand White and Chinchilla breeds of rabbits, the New Zealand White should be used as the sire while the chinchilla be use as dam, especially in the study area.

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