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Hetrosis of Early Growth Performance in Three Breeds of Rabbits (*Oryctolagus cuniculus*)

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Abstract – **The study investigated heterosis effects for early growth performance using three popular breeds of rabbits in Nigeria (Chinchilla, New Zealand White and Dutchbreeds). Thirty six (36) sexually mature rabbits belonging to three genetic groups (Twelve per breed at the mating ratio of three males to nine females) were employed for the study. Matings within each breed were carried out to generate purebred progenies. These were reared and monitored for growth performance from birth to 32 weeks of age (age of sexual maturity). At 32 weeks of age, 3 males and 9 females each of the three breeds were randomly selected from their respective groups and used in cross breeding in a ratio of one Buck to two does. F_1 crossbred progenies were reared according to crossbred groups to weaning (8 weeks of age). The bioeconomic traits considered in this investigation for the purebreds and F_1 crossbred groups were; individual kitten weight at birth and at bi-weekly intervals up to 8 weeks of age; individual kitten weight at weaning; litter size at birth and at weaning sex-ratio, pre-weaning mortality and estimates of heteroses. Data collected were subjected to Analysis of Variance to test for the effect of breeding groups on parameters measured. Comparison between crossbred and purebred groups was done using independent samples (T-Test), while significance of heterosis was performed using one-sample T-Test. All analyses was performed using the Statistical Package for Social Sciences (SPSS) Version 17.0 (2007). Significant means were separated using the Duncans New Multiple Range Test in SPSS. Results showed that the crossbred kits were heavier in weight (g) than the purebred kits from birth to weaning (45.39g from Nzw x Nzw to 48.35g from CH x CH among the purebreds and 38.25g from Nzw x CH to 55.50g from D x CH) for the crossbreds at birth; and rose to 420.14g from D x D and 569.38g from CH x CH) among the purebreds to 670.63g from Nzw x CH and 704.41g from Nzw x D) for the crossbreds. The result of the reproductive performance of the breeds indicated lack of significant (P>0.05) differences except in the preweaning mortality of the purebreds and the litter size at weaning (LSW) among the crossbreds. Litter size at birth (LSB) were (on average) lower for the purebreds than the crossbreds. Estimates of direct heterosis for body weight were all positive and favorable for the crossbred kits except (Nzw x CH) crosbred kits. Positive heterosis for litter size at birth ranged from 14% to 26% and 14% to 50% for litter size at weaning among the crossbred kits. Within litter mortality in Nzw x D and Nzw x CH crosses were negative but increased and were positive among the D x CH crossbred kits. The potential of crossbreeding to tap the non-additive genes for reproductive performance was confirmed in the present study. Crossing (Nzw x CH) and (Nzw x D) resulted in positive heterosis for body weight, while (D x CH) helped to improve preweaning mortality and litter size.**

Keywords – **Growth Performance, Breeds of Rabbits, Heterosis, Genetic Groups, T-Test.**

I. Introduction

Growth traits in growing rabbits are important because heavier marketable body weight promotes the economics of rabbit production (1). Cross breeding is one of the fast tools offered to breeders to improve many traits in farm animals (2). One major basis for crossbreeding lies in the fact that the crossbred animals often manifest heterosis due to good interbreeding or nicking ability.

Heterosis usually occurs where the populations crossed differ genetically. Positive heterosis is the superiority of the heterozygous above the average value of the two parents. The percent superiority depends on the magnitude of non-additive genetic variation in the trait under consideration (3). Breed complementation for growth and carcass traits by crossing animals of different genotypes has generated a lot of interest among rabbit breeders (4), (5), (6), (7), (8), (9). For instance, breed complementary was achieved by crossing the fast growing indigenous Sinar Gabali breed with the imported V-rabbit line (9). Also similar result by (10) was observed in a study to investigate the heterosis effects for preweaning litter characteristics using three Nigerian local rabbits (local white, local brown tail and local black). The needed information on breed complementarity which should precede commercial trend is much less documented in developing countries like Nigeria.

Commercial rabbit production in Nigeria has been maintained mainly through the use of imported exotic breeds and their crosses. Consequently, the availability of breeds differing in their growth characteristics is an important source of flexibility that can allow more rapid adjustments to changing economic conditions in the country. However, a sound knowledge of this important aspect of animal production and its interaction with the environment is essential for a maximum and rational utilization of the breeding stock.

Reference (11) had observed that, when crosses are made between two parental lines which differ genetically, such as different inbred lines or different breeds or strains within a particular specie, heterozygosity is presumably generated in the resulting F_1 progeny. The mean performance of the F1 progeny may exceed the mean of both parents (mid-parents heterosis) or the performance of the poorer parents (Poor parent heterosis). In the same vein, (12) also stated that the genetic explanation for the hybrid extra vigor is basically the same, whether it be animal or crop. Heterosis is produced by the fact that, the dominant gene of a parent is usually more favorable than the recessive partner. When the genetic group differ in frequency of gene they have and dominance exist, then heterosis will be produced.

In animal breeding, crossbreeding allows the exploitation of breed qualities from genetic and biological point of view (13). It also enables breed discrimination and the analysis of genetic variability. To effectively utilize genetic resources, the genetic and environmental causes of phenotypic variation in economic attributes need to be differentiated (14). Furthermore, the genetic components have to be decomposed into direct and maternal effects (15). Characterization of genetic and maternal effects attributable to each breed or breed combinations enable producers to choose amongst breeds and to assign appropriate role(s) to selected breeds in breeding schemes.

Crossing different breeds may lead to improved performance over the pure/inbred parents. This improved performance is recognized as heterosis. In secondary generations such as backcrosses, epistatic effects may also be important. Although considerable research has evaluated cross breeding in farm animals in Nigeria, the analysis and reporting of the results have often been inadequate. Most reports presented only the breed group means and mid-parent heterosis values paying little or no attention to the evaluation of the genetic components: direct additive and maternal effects, direct heterosis, maternal heterosis, recombination loss, over dominance, relative heterosis, heterobeltiosis etc, or to the development of parameters that allow prediction of the performance of crosses that have not actually been tested (16).

Accordingly, this study is designed to estimate the crossbreeding parameters of the main economically important traits in cross involving three breeds commonly reared in Nigeria. This work shall investigate the breed additive effects (direct and maternal) and heterosis effects on growth, litter size traits, and preweaning mortality rate of the breeds.

1.1 Objectives of the Study

The main objective of this investigation is to determine the heteroses of early growth performance and other reproductive traits of economic importance in three popular breeds of rabbits. Other objectives include;

a) To determine the heteroses involved in traits like litter size at weaning (LSW), litter size at birth (LSB), and preweaning mortalities among the three popular breeds of rabbits in Nigeria.

b) This study shall also ascertain heteroses for litter weight at birth and weaning in order to establish the impact of crossbreeding on these traits.

1.2 Justification of the Study

One major advantage of cross breeding is breed complementarily. This exercise will help to expose the potential of crossbreeding in helping to tap the non-additive genes for possible improvement in the reproductive performance. For instance, (17) observed a positive heterosis of 28% for litter weight in a synthetic breed (APRI) when they crossed highly adaptable Egyptial Baladi Red with the Spanish V-line noted for prolificacy and mothering ability.

A study by (18) showed a less successful result 92.5% to 5.0% for total gain and 0.7% to 9.5% for daily gain) in the local Baladi Red x New Zealand white crossed kits.

The variations in the manifestations of heterosis indicate that in some cases, heterosis is apparent at birth, while in others, it does not appear until a considerable period following birth. Among rabbit crosses made by previous workers, only one cross, polish and Himalayan (19) produced F_1 rabbits which were heavier than both parental races. The body weight of the F_1 rabbits in castle's experiment was 45% heavier than the polish and 9% heavier than the Himalayan. However, (17) crossed Flemish and Ermine, and White Giant and Ermine rabbits without heterosis in the F_1 generation, but observed heterosis in haemoglobin value, erythrocyte number and viability. It was probable that the extremely heavy rabbits e.g. Flemish, had a larger number of effective quantitative growth genes than the extremely small rabbits e.g. Polish and that F_1 from extremely heavy and extremely small rabbits received half the effective growth genes from each parent, and became intermediate in size. Nevertheless, the size of the F_1 rabbits was closer to that of the heavy parent. This probably was due to the influence of heterosis derived from certain pairs of effective allelic growth genes. Most of these genes were probably paired in the cross and produced heterosis which made the F_1 animals heavier than both parental strains.

In meat rabbit industry, there is need to develop sire breeds and (or) lines to cross to available dam breeds to potentially enhance breed complementarity and heterosis benefits on post weaning fryer performance. Commercial rabbit meat is usually produced by a three-way cross involving crossbred females mated to males from a sire line. The crossbred females are obtained by mating males and females from two female lines selected for litter size, while the sire lines are generally selected for growth rate, carcass yield and meat quality (20), (21). When designing a genetic selection programme, two aspects must be considered; the choice of partner lines and their crossbreeding scheme and the within-line selection. Concerning the choice of partner lines and their optimal utilization, different crossbreeding schemes have to be tested in order to identify or to predict the best combination of line. (22) has theorized the choice of breeds and breed combinations and proposed a set of parameters allowing the prediction of performance from a potential breed combination.

This study shall aim at comparing different crosses of three rabbit breeds (New Zealand White, Dutch and Chinchilla) and estimate heterosis and direct and maternal additive effects, as well as some non-genetic effects (litter size, mortality) on rabbit growth, so as to identify the best crossbreeding plan to use for rabbit meat production in the south eastern derived savanna zone of Nigeria.

II. MATERIALS AND METHODS

2.1 Experimental Site

The breeding bucks and does used for this experiment were raised at the Teaching and Research Unit of the

Department of Animal Science, Ebonyi State University, Abakaliki.

2.2 Experimental Animals

Thirty six (36) sexually mature rabbits belonging to three genetic groups (twelve per breed at the mating ratio of three males to nine females) were employed for the study. Mating within each breed was carried out to generate purebred progenies. These were reared and monitored for growth performance from birth to 32 weeks of age (age at sexual maturity). At 32 weeks of age, three males and nine females each of New Zealand white, Dutch, and Chinchilla were randomly selected from their respective groups and used in crossbreeding according to the following scheme: New Zealand white (NZW) female with Dutch (D) male (NZW x D); New Zealand white female with Chinchilla (CH) male (NZW x CH); and Dutch female with Chinchilla male (D x CH) in a ratio of one buck: two does. F_1 crossbred progenies were reared according to crossbred groups to weaning at 8 weeks of age.

2.3 Management of the Animals

The three breeds of rabbits used were sourced from a reputable farm (Emmpina Farms, Akwa Ibom State). They were housed in hutches measuring about 75cm x 63m x 54cm. Kits and Does were fed mash diet containing 46.59% rice bran, 25.00% palm kernel cake, 15.50% wheat offal, 1.50% Oyster shell, 0.55% bone meal and 0.5% salt. The mash diet was supplemented with available local forages (Banana leaves, Centrosema Pubescence). The experiment was carried out under a hygienic environment by sweeping the rabbitry unit and cages thoroughly every day and disinfected weekly using concentrated isol solution. The animals were injected with ivermectin for the treatment of both ecto and endo-parasites at bi-monthly intervals.

2.4 Data Collection

The bio-economic traits considered in this investigation for the purebreds and F_1 crossbred groups are:

a) Individual kitten weight at birth and at bi-weekly intervals up to 8 weeks of age.
b) Individual kitten weight at weaning (8 weeks of age)
c) Litter size at birth
d) Litter size at weaning
e) Number of males and females at birth and at weaning.
f) Pre-weaning mortality (%)
g) Sex-ratio at birth and at weaning
h) Estimates of direct heteroses were obtained following (Dickerson, 1992)

H^1 (NZW X D) = {NZW X D} – {NZW X NZW} {D X D}

H^1 (NZW X CH) = {NZW X CH} – {NZW X CH} {NZW X NZW} {CH X CH}

H^1 (D X CH) = {D X CH} – {D X D} {CH X CH}

NZW, D and CH represent the New Zealand white, Dutch and Chinchilla breeds respectively. The percent heterosis shall be collected as follows:

$$\frac{H^1\ (\text{Units})}{\text{Means of purebreds}} \times \frac{100}{1}$$

H^1 = Estimate of heterosis in units

2.5 Data Analysis

Data collected were subjected to analysis of variance to test for effect of breeding groups on parameters measured. Comparison between crossbred and purebred groups was done using independent samples T-Test, while significance of heterosis was performed using one-sample T-Test. All analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 17.0 (2007). Significant means were separated using the Duncan New Multiple Range Test in SPSS.

The statistical model used in this study is as follows:-

$Y_{ij} = \mu + B_i + e_{ij}$, where

Y_{ij} = Record of the jth individual or litter belonging to the ith breed of the rabbit,

μ = Random mean,

B_i = Effect of the ith breed

E_{ij} = Residual error

III. Results

Table 1: Mean ($\pm$ S.E) of the body weight (g) performance of the three breeds of rabbits and their F_1 crosses.

Age (Wks)	Purebred			F_1 Crossbred		
	CH x CH	NZW x NZW	D x D	D x CH	NZW x CH	NZW x D
0	48.35$\pm$1.05	45.39$\pm$1.06	45.40$\pm$1.12	55.5$\pm$0.73^a	38.25$\pm$0.71^b	53.84$\pm$0.66^b
2	156.00$\pm$3.19^a	155.39$\pm$3.23^a	137.14$\pm$3.41^b	156.43$\pm$1.31	159.59$\pm$1.27	160.05$\pm$1.18
4	287.13$\pm$5.89^a	241.03$\pm$5.96^b	212.43$\pm$6.30^c	374.47$\pm$3.31^b	342.41$\pm$3.21^c	408.92$\pm$2.98^a
6	398.75$\pm$10.23^a	281.15$\pm$10.36^b	278.29$\pm$10.94^b	551.07$\pm$6.54^a	501.81$\pm$6.33^b	506.84$\pm$5.89^b
8	569.38$\pm$10.90^a	435.13$\pm$11.04^b	420.14$\pm$11.65^b	696.10$\pm$6.42^a	670.63$\pm$6.21^b	704.41$\pm$5.78^a

a, b, c: Means not followed by the same superscripts are significantly (P>0.05) different for the purebred and crossbreds.

Data on the body weight (g) performance of the three breeds of purebred and their F_1 crosses of rabbits were presented in Table 1. Result indicated lack of significant (P>0.05) differences in the body weight of the purebreds at birth but varied significantly (P<0.05) as from 2^{nd} week of birth up to their 8^{th} week.

However, their F_1 crossbreds differed significantly (P<0.05) as from birth but did not vary at their 2^{nd} week of age. Significant variation (P<0.05) in body weight was recorded as from the 4th week of age continuously up to their point of weaning at 8th week of age.

The Chinchilla breed were the heaviest in body weight among the purebreds, followed by the New Zealand white and the least in weights were the Dutch breed. In the F_1 crossbreds, the cross between the male Dutch and Female Chinchilla were the heaviest in weight followed by the crossbreds from male New Zealand and female Dutch although not statistically (P>0.05) different from the cross between New Zealand male and female Chinchilla at birth. This trend however dropped in week 2, 4 and 8 in favour of the cross between the male New Zealand white and Dutch female as the animals approached their weaning period at 8 in favour of the cross between the male New Zealand white and Dutch female as the animals approached their weaning period at 8 week of age.

Table 2: Mean (±S.E) of the reproductive traits of the purebred and their F_1 crosses

	Purebred			F_1 Crossbred		
Traits	CH x CH	NZW x NZW	D x D	D x CH	NZW x CH	NZW x D
LSB	5.33±0.44	5.78±0.40	5.38±0.38	6.17±0.40	6.50±0.34	7.17±0.31
LSW	4.44±0.24	4.33±0.24	4.25±0.37	4.83±0.40^{b}	5.33±0.21^{ab}	6.17±0.48^{a}
PWM	14.68±3.10^{b}	20.56±4.55^{a}	19.17±6.63^{a}	20.95±5.84	16.97±4.89	13.69±6.4
MAB	2.13±0.10	2.51±0.14	2.85±0.14	3.50±0.49	3.17±0.49	4.33±0.49
FAB	2.05±0.11	2.62±0.12	2.10±0.08	2.67±0.44	3.33±0.44	2.83±0.44
MAW	1.80±0.13	2.0±0.20	2.3±0.13	2.50±0.40	2.67±0.40	3.33±0.40
FAW	1.90±0.17	2.10±0.18	2.30±0.05	2.33±0.36	2.67±0.36	2.83±0.36
SRB	0.43±0.03	0.33±0.01	0.42±0.05	0.56±0.06	0.49±0.06	0.60±0.06
SRW	0.31±0.07	0.41±0.07	0.45±0.05	0.52±0.06	0.51±0.06	0.53±0.06

a, b: Means not followed by same superscript on the same row are statistically (P<0.05) different.

LSB: Litter size at birth, LSW: Litter size at weaning, PWM: Pre-weaning mortality, MAB: Males at birth, FAB: Females at birth, MAW: Males at weaning, FAW: Females at weaning, SRB: Sex-ratio at birth SRW: Sex-ratio at weaning

Table 2 presents the results of data on litter size at birth, litter size at weaning, post weaning mortality rate, males and females at birth and at weaning as well as the sex ratio at birth and at weaning. The pre-weaning mortality (PWM) varied from 14.68% (CH x CH) to 20.56% (NZW x NZW) which also did not differ from 19.17% (D x D) purebreds. There was lack of significant (P>0.05) differences in the reproductive traits measured among the three popular breeds of rabbits used in the experiment. Similar trend as in the purebreds was observed among the crossbreds except in the litter size at weaning (LSW) that showed significant (P<0.05) differences and ranged from 4.83 (D x CH) to 6.17 (NZW x D) per litter. Litter sizes at birth and at weaning were higher numerically among the crossbreds than the purebreds. Pre-weaning survivability in the crossbreds was highest in the New Zealand white males crossbred with Dutch female crossbreds.

Table 3: Estimates of direct heterosis (%) for body weight (g) performance of three breeds of rabbits

CROSSBREDS			
Age (weeks)	**NZW x D**	**NZW x CH**	**D x CH**
0	25.06±2.59 **	-14.09±2.55 **	22.46±3.57 **
2	10.81±3.44 **	05.09±3.39 **	10.30±4.73 **
4	79.19±4.07 **	25.65±4.01 **	49.14±5.60 **
6	75.81±4.37 **	44.36±4.31 **	56.73±6.02 **
8	61.38±4.55 **	33.16±4.48 **	41.89±6.26 **

**Heteroses were highly significant (P<0.01) among the crossbreds.

The percent heterosis effects for body weight were positive in NZW x D and D x CH crossbred kits and negative for NZW x CH crossbred kits ranging from (+25.06%, +22.46% and -14.09%) respectively at birth. Percent heteroses were however positive for body weight (g) from birth to 8th week (point of weaning) for all the crossbred kits. The highest positive heterosis of 79.19% was recorded from the NZW x D crossbred kits at 4th week and decreased gradually from the 6th and 8th week of age respectively. Percent heterosis effects were highly significantly (P<0.01) different among the crossbreds from birth to weaning (Table 3).

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Table 4: Heterosis (%) of litter traits for various breeding groups

Groups	LITTER TRAITS		
Breeding groups	LSB	LSW	PW
NZW x D	0.26 ± 0.17^{NS}	0.50 ± 0.17^{NS}	-0.25 ± 0.18^{NS}
NZW x CH	0.17 ± 0.14^{NS}	0.26 ± 0.14^{NS}	-0.18 ± 0.15^{NS}
D x CH	0.14 ± 0.30^{NS}	0.14 ± 0.30^{NS}	0.17 ± 0.33^{NS}

NS: Non-significant differences (P>0.05) in the litter trait heteroses.

Table 4 presents the percent heterosis effects for liter traits among the crossbred kits. Result showed non-significant (P>0.05) differences in the heteroses of litter traits of the crossbred kits. Percent heterosis were negative for the pre-weaning morality in NZW x D and NZW x CH crossbreds and positive for D x CH crossbreds. Highest percent heterosis of litter size at weaning was recorded in the NZW x D crossbred kits and lowest for the D x CH crossbred kits.

IV. Discussion

4.1 Growth Performance of the Breeds

Data on the body weight (g) of the three breeds of the rabbits (purebreds and their F_1 crosses) are presented in Table 1. Mean body weight (g) varied from 45.39 (NZW x NZW) to 48.35 (CH x CH) among the purebreds and 38.25 (NZW x CH) to 55.5 (D x D) for the crossbreds at birth and rose to 420.14 (D x D) and 569.38 (CH x CH) among the purebreds to 670.63 (NZW x CH) and 704.41 (NZW x D) for the crossbreds. Crossbred kits in this study were heavier than the purebreds kits from birth to weaning at 8 week of age due to the smaller litters in which they were raised. Previous studies by (10), (23) and (1) showed that kit weight at birth and weaning body weight as well as post weaning body weight and market age were significantly higher for crossbred breeds or strains of rabbits. The present study disagrees with the report of (24) who observed a decline in growth rate with advancing kits age in their work on New Zealand white, Californian and Gray Giant Flander breeds. Other rabbit crosses made by previous workers showed that only one cross, polish and Himalayan (19) produced F_1 rabbits which were heavier than both parental races. The body weight of the F_1 rabbits in castle's experiment was 45% heavier than the polish and 9% heavier than the Himalayan. The differences in body weight of the crossbreds over the purebreds in this work did not reach the levels recorded in castle's work.

4.2 Reproductive Performance

The results of the reproductive performance of the purebreds and their F_1 crossbreds are presented in table 2. Results indicated lack of significant (P>0.05) differences in the reproductive traits measured except that the preweaning mortality in the present study was higher compared with 5-7% of still born reported for highly prolific does in modern French Rabbitries (10) and (6). The present study also agrees with the submission of (8) who observed that about 94% of preweaning losses occurred within the first two weeks of life.

Litter size at birth were (on average) lower for the purebreds than the crossbreds. Generally, all the reproductive traits measured except the preweaning mortality were numerically (on the average) higher among the crossbreds than the purebreds. The pre weaning survivability of the rabbits was also higher among the crossbreds than the purebred.

Litter size at birth and at weaning as well as the sex ratio at birth and at weaning recorded in this study was similar to that reported by (25), for Sudanese local rabbit but lower compared with litter size at birth in Egyptian and Exotic rabbits (26, 1).

First parity litter size at birth (total number born or total number born alive has been the selection criterion most frequently adopted to modify liter size genetically with no attention given to litter size at subsequent parities which has a major environment component influencing the litter size (8).

The differences in litter traits at birth due to parity effect may be attributed to changes in the physiological efficiency such as those associated with ovulation rate, ova wastage, implantation, embryo survival rate, embryonic mortality, uterine capacity, efficiency of providing the young with nourishment and intra uterine environment during the pre-natal development and also may be due to difference on the age of doe within parity (18).

However, the basis of the production is the genotype but the manifestation of genetic depends on numerous elements from the moment of fertilization; the surrounding in the uterus (space and blood supply of fetuses), the milk supply of kits, the nutritional and environmental condition during rearing, age at first mating, the physiological status at mating etc; can modify the performance of does; this implies that the reproductive performance of rabbit does is influenced by several genetic; physiological and environmental factors (27).

4.3 Heterosis for Preweaning Body Weight

Estimates of direct heterosis for body weights were all positive and favorable for the crossbred kits in this study (Table 3) except (NZW x CH) crossbred kits at birth which was negative (-14.09%). Heterosis effect for body weight at birth was highest (25.06%) for (NZW x D) crossbreds and (22.46%) for (D x CH) crossbreds respectively at birth, dropped by more than fifty percent at the second week of birth and attained the highest value at week four (79.19%) before dropping gradually as they animals approached their weaning age of 8 week.

There were fluctuations in the bi-weekly heterosis effect for body weight among the rabbit crosses. Crossbreeding was unfavourable for growth rate in NZW x CH crossbred kits at birth and the 2^{nd} week postpartum. Generally, crossbreeding assisted tremendously in improving the growth rate of crossbred rabbits up to weaning and even beyond.

Previous works by (10), (28), (29), (30) revealed significant heterosis for growth rate and bodyweight, though at variable values of the parental means. Reference (31) observed that estimates of direct heterosis were and ranged from 4.9 to 16.7% for body weight; but the estimates for maternal heterosis were in most cases significantly negative (-4.5 to -15.2%) for body weight. Estimates of heterosis effect obtained by (24) for body weight and relative growth rate in post weaned New Zealand white, California and Flander crossbred rabbits were generally negative. On the other hand, a high positive heterosis effect (42.27%) for rate of growth at 10-12 weeks of age was observed in California x Flander rabbits.

In animal breeding, crossbreeding allows the exploitation of breed qualities from genetic and biological point of view (13). And one major advantage of crossbreeding is breed complementarily. This was demonstrated in a synthetic breed which combined the adaptability of Egyptian Baladi Red with prolificacy and mothering ability of the Spanish V-line. The synthetic breed showed a direct heterosis of 28% for litter weight (17). The results of this work have shown far higher heterosis in the bodyweight of the crossbred kits than the synthetic breed. A study by (18) showed a less successful result in the Local Baladi Red and New Zealand white crossbred kits.

4.4 Heterosis for Preweaning Litter Size

There was a non-significant (P<0.05) differences in the heterosis for the preweaning litter size traits. The percent heterosis effects were positive among the crossbred kits from birth to weaning age. A positive direct heterosis for litter size at birth ranged from 14% to 26% and 14% to 50% for litter size at weaning among the crossbred kits.

The differences in heterosis effect for litter size among breed crosses in this study is in line with previous studies on New Zealand white and local Egyptian rabbits (1). Breed combination to improve litter size has generated a lot of interest among rabbit breeders (8), (9), (10). For instance, a new line named APRI, Produced by (17) showed a direct heterosis of 24 and 28 percent for litter size at birth and at weaning.

In a contemporary study, (28) observed a positive heterosis for litter size at birth and at weaning in their four-breed crosses under Egyptian rearing conditions. Reference (32) evaluated traits such as litter size at birth and at weaning in Spanish V-line x Saudi Gabali rabbits and reported that direct heterosis varied from 5.3% to 27.5% among the investigated production traits. However, the crossing of Sinai Gabali breed with the Spanish V-line did not give a significant individual heterosis for litter size at birth and at weaning (9).

4.5 Heterosis for Preweaning Mortality

Result of this experiment demonstrate strongly that crossbreeding can help to reduce pre-weaning mortality among crossbred kits. Within litter mortality in NZW x D and NZW x CH crosses were negative but increased and were positive in D x CH crossbred kits (Table 4). The present work agrees with the earlier findings of (1), (32)Both workers reported that preweaning mortality (PWM) was reduced when New Zealand rabbit was crossed with local Egyptian rabbit in a crossbreeding programme.

The superiority of the crossbred over the purebred in this work suggests that there exist a quantum of non-additive genetic effects to improve kits liveability especially in NZW x D and NZW x CH crossbred rabbits (3).

V. Conclusion

The potential of crossbreeding to tap the non-additive genes for improving the reproductive performance are confirmed in the present study. (Nzw x CH) and (Nzw x D) crossbred kits had a positive heterosis for body weight, while (D x CH) was superior in pre-weaning mortality and litter size.

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