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Evaluation of Rabbit Breeds and Crosses for Pre-Weaning Reproductive Performance In Humid Tropics

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Abstract: Pre-weaning data on 466 kits from 109 litters, 280 kits from 78 litters and 261kits from 74 litters at birth, 21 and 28 days of age respectively were collected over 3years (1998- 2001). The litters representing 8 genotypes namely New Zealand white x New Zealand white (NZW x NZW) and Chinchilla x Chinchilla (CHA x CHA) purebreds; and New Zealand white x Chinchilla (NZW x CHA), New Zealand white Dutch belted x New Zealand white Dutch belted (NZWDBD x NZWDBD), New Zealand white x New Zealand white Dutch belted (NZW x NZWDBD), New Zealand white Croel x New Zealand white Croel (NZW CRL x NZW CRL), Chinchilla x New Zealand white Dutch Belted (CHA x NZWDBD) and Chinchilla x New Zealand white Croel (CHA x NZW CRL) crossbreds were assessed for effect of genotype, parity of dam, litter size, sex and season of birth on Individual Kit weight (IKT), Litter Weight (LWT) average Litter Weight (LWT) and Litter Size (LTZ) at birth, 21 and 28 days. The analytical results showed that genotype, litter size, parity, sex and season were important sources of variation for performance characteristics studied. Crossbred NZW x CHA and NZWDBD x NZWDBD individual kit weights at birth and 28 day were comparable ($p>0.05$). NZW- CHA kits were significantly heavier in ALT at birth and 21 days ($p<0.05$). NZWDBD x NZWDBD kit weighed more in LWT ($P<0.05$) and recorded larger litter size ($p<0.05$) at all ages than other genotypes IKT and ALT consistently in creased with litter size at all ages. All traits considered in this study at various ages were inconsistent with parity. The litters born in wet season maintained superior body weights over dry season litters. The sex mean for IKT at 21 day was significantly different ($p<0.05$) with females weighing more than males. The results of this study indicate that choice of breeds for commercial production should be based on pre-weaning performance. In addition genotype, litter size, parity, sex and season as important sources of variation should be considered in improvement programme to increase meat yield from rabbit breeds and crosses. Furthermore, this study provides corroborative evidence in support of the adoption of cross breeding in the commercial rabbit industry in the humid tropics.

Key words: Rabbits, breeds, crosses, pre-weaning, performance

INTRODUCTION

Few studies on pre-weaning litter performance of purebred and cross bred rabbits in the humid tropics have been conducted. In Europe and North America, cross breeding and selection among available breeds have been used extensively to improve rabbit productivity[1]. In a study conducted to compare purebred rabbits and the terminal crosses involving these breeds, observed a heterotic effect on litter growth rate. In a similar experiment[2] reported that cross bred rabbits showed superior performance over the purebreds in all pre-weaning litter traits studies. These findings suggest that cross breeding under tropical conditions hold some promise in improving performance traits in rabbits.

Doe productivity is a major factor that affects the efficiency and economy of rabbits enterprise[3]. Owen[4] had earlier ascertained that rabbit kept under tropical conditions raised less number of offspring to weaning. The author attributed such poor performance of rabbits in the tropics compared to the temperate regions to depressed reproduction and growth. There exist breed variations in the performance of rabbits in temperate and tropic regions[5-8] Breed influences have been observed on litter size at birth, litter size alive at birth and litter birth weight (Iyeghe-Erakpotobor *et al.*,[9]. Breed, strain and breeding technique influence litter size at birth and number born alive[10]. The environmental effect such as nutrition on doe mothering ability may have contributed to pre-weaning mortality of kids thus reducing litter size at weaning. With the present status of production, it is thus more justifiable to use breeds which are capable of maintaining their litter size to weaning with litte mortality. Ozimba and Lukefahr[11] reported that breed type means did not differ for litter weaning weight and then suggested that strong maternal effects of litter size and milk production more than genetic effects may influence kid weights at 28 days.

The differences in productivity attributable to breed and non-genetic factors indicate that a breeding programme for selection and improvement is imperative for the establishment of breeds suitable for intensive commercial rabbit's production in the tropics.

This study therefore was designed to investigate the influence of genotype and factor such as sex, parity, litter size and season on the pre-weaning performance of breeds of rabbit and their crosses raised in a humid environment.

MATERIALS AND METHODS

Location of study: The study was conducted in the rabbit unit of the Teaching and Research Farms, Federal University of Technology, Akure Nigeria. Akure is situated on 350.52 m above sea level at latitude 7°14^{1}N and at longitude 5^{0}14$_{1}$E. The city falls within the rainforest zone of the humid tropics which is characterized by hot and humid climate. The mean annual rainfall is 1500 mm and the rain period is bimodal with a short break in August. The mean annual relative humidity is 75% and that of temperature 15 20°C.

Experimental animals and their management: 466 kits from 109 litters at birth obtained from breeding programme involving New Zealand white and chinchilla purebreds and crossbreds were used in the study. The mortality recorded decreased these numbers to 280 kits from 78 litters and 261 kits from 74 litters at pre-weaning ages of 21 and 28 days. These litters representing 8 genotype groups namely New Zealand white x New Zealand white (NZW x NZW) and Chinchilla x Chinchilla (CHA x CHA) purebreds; and New Zealand white x Chinchilla (NZW x CHA) New Zealand white Dutch belted x New Zealand white Dutch belted (NZWDBD x NZWDBD), New Zealand white x New Zealand white Dutch belted (NZW x NZWDBD) New Zealand white Croel x New Zealand white Croel (NZW CRL x NZW CRL), Chinchilla x New Zealand white Dutch belted (CHA x NZWDBD) and Chinchilla x New Zealand white Croel (CHA x NZW CRL) Crossbreds were assessed for the effects of genotype and non genetic factors on litter parameters at birth, 21 and 28 pre-wearing ages. The breeding season covered 3years of data collection starting in the raining period (June) of 1998.

The rabbits were housed in hutches. Each hutch has the following dimensions: length 105 cm, width 85 cm and height 60 cm. The hutches placed inside a low walled house built with concrete block and corrugated iron sheets as roofing material were raised on wooden or metallic legs about 60 cm above the ground. The wooden and metallic hutches were covered to some extent with mesh that could permit inspection, ventilation and dropping of waste on the cemented floor. Kindling boxes, (each having the following dimensions: length 40cm, width 30 cm and height 25 cm) were provided inside does hutches. Also supplied in each hutch were feeding and watering troughs, which were made from tins.

The rabbit were given *ad libitum* access to commercial diets in the morning, supplemented with sweet potato leaves and *Aspillia africana* in the evening over the course of the experiment. The chemical composition of the commercial diet consisted of 2300 k cal/kg metabolisable energy, 15% crude protein, 8% ash, 7.2% fibre, 0.67% ether extract, 8.24% moisture content and 91.76% dry matter. The chemical composition of the sweet potato leaf was 11.68% crude protein 7.68% ash, 3.22% fibre, 0.72% ether extract, 93.12% moisture content and 6.88% dry matter while that of *Aspillia africana* was 17.41% crude protein, 12.98% ah, 6.65% fibre, 0.77% ether extract, 93.33% moisture content and 6.67% dry matter.

Clean water was supplied regularly. The incidence of diarrhoea was combated with antibiotics such as embassin forte^{R}. To ensure absence of haemoparasites, internal and external parasites the animals were treated with Ivomec injection. The kits were maintained on doe's milk from birth till weaning at 35 days. At pre-weaning age of 21 days when the kits sex was determined, they were taking little concentrates and leafy supplements provided in the doe's cages.

Data collection and traits studied: Basic information of genotype, parity, sex, litter size gestation length, birth season, sire and dam were kept on each litter in addition to body weight records at birth, 21 and 28 days pre-weaning. Evaluation criteria on which genotype, parity, sex, litter size, gestation and birth season comparisons were based included Individual Kit weight (IKT), Litter Weight (LWT), Average weight (ALT) and Litter size (LTZ) at birth, 21 and 28 days. All weights were determined using electronic weighing scale.

Analytical procedures: The effects of genotype, parity, litter size, gestation and season on body weights at birth and the effects of genotype, sex, parity, litter size and season on body weight at 21 and 28 were estimated from least square procedures of unequal sub-class number[12].

Where significant differences were observed, differences between means were tested using Duncan's multiple range test outlined in the Harvey statistical package. The models used were

For birth weight:

$$Y_{ijklnm} = U + B_i + G_j + P_k + S_l + R_n + (BP)_{ik} + (BS)_{il} + (PS)_{kl} + (BPS)_{ikl} + E_{ijklmn}$$

Where Y_{ijklmn} = the observation of the dependent variable on the ${}_m^{th}$ kit of the i^{th} genotype of the ${}_j^{th}$ gestation length of ${}_k^{th}$ parity of ${}_{lt}^{h}$ season of birth of ${}_n^{th}$ litter size.

U = overall mean of all observations

Bi = effect of the i^{th} genotype of kit, *i* = 1, 2, 3, 4, 5, 6, 7, 8 (NWZ x NWZ, CHA x CHA, NWZ x CHA, NZWDBD x NZWDBD, NZW x NWZDBD, NZWCRL x NZWCRL, CHA x NZWDBD and CHA x NZW CRL).

G_j = effect of the ${}_j^{th}$ gestation length, $_j$ = (29, 30, 31, 32, 33 days)

P_k = effect of the ${}_k^{th}$ parity, $_k$ = (1, 2, 3, 4, 5, 6)

S_l = effect of the ${}_l^{th}$ season of birth, $_l$ = 1, 2, (dry: March to October, wet: April to September)

R_n = effect of the ${}_n^{th}$ litter size, $_n$ = (2, 3, 4, 5, 6, 7)

$BP)_{ik}$ = effect of interaction between ${}_i^{th}$ genotype and ${}_k^{th}$ parity.

$BS)_{il}$ = effect of interaction between i^{th} genotype and ${}_l^{th}$ season.

$(PS)_{kl}$ = effect of interaction between ${}^{th}{}_k$parity and l^{th} season.

$(BPS)_{ikl}$ = effect of interaction between i^{th} genotype, ${}_k^{th}$ parity and l^{th} season

E_{ijklmn} = random error normally, identically and independently distributed with zero mean and variance σ^2 e.

For individual kit weight at 21 and 28 days of age:

$$Y_{ijklmn} = U + B_i + C_j + P_k + S_l + R_n + (BC)_{ij} + (BP)_{ik} + (BS)_{il} + (CP)_{jk} + (PS)_{kl} + (CS)_{jl} + (BCP)_{ijk} + (BCS)_{ijl} + (CPS)_{jkl} + (BCPS)_{ijkl} + E_{ijklmn}$$

Where Y_{ijklmn} = the observation of the dependent variable on the ${}_m^{th}$ kit of the ${}_i^{th}$ genotype of the ${}_j^{th}$sex of kth parity of l^{th} season of birth of ${}_n^{th}$ litter size.

U = overall mean of all observations

B_i = effect of the genotype of kit, i = 1, 2, 3, 4, 5, 6, 7, 8 (NZW x NZW, CHA x CHA, NZW x CHA, NZWDBD x NZWDBD, NZW x NZWDBD, NZWCRL x NZWCRL, CHA x NZWDBD and CHA x NZWCRL)

C_j = effect of the ${}_j^{th}$ sex of kit; $_j$ = 1, 2 (male, female)

P_k = effect of the ${}_k^{th}$ parity, $_k$ = (1, 2, 3, 4, 5, 6)

Sl = effect of the ${}_l^{th}$ season, 1., 2 (dry, wet)

R_n = effect of the ${}_n$th litter size, $_n$ = (2, 3, 4, 5, 6)

$(BC)_{ij}$ = effect of interaction between i^{th} genotype of kit and ${}_j^{th}$ sex of kit.

$(BP)_{ik}$ = effect of interaction between i^{th} genotype and ${}_k^{th}$ parity.

$(BS)_{il}$ = effect of interaction between i^{th} genotype and ${}_l^{th}$ season.

$(CP)_{ji}$ = effect of interaction between i^{th} sex and ${}_k^{th}$ parity

$(CS)_{jl}$ = effect of interaction between ${}_j^{th}$ sex and ${}_l^{th}$ season

$(PS)_{kl}$ = effect of interaction between ${}_k^{th}$ parity and l^{th} season.

$(BCP)_{ijk}$ = effect of interaction between ${}_i^{th}$ genotype, ${}_j^{th}$ sex and ${}_k^{th}$ parity.

$(BCS)_{ijl}$ = effect of interaction between ${}_i^{th}$ genotype, ${}_j^{th}$ sex and ${}_l^{th}$ season.

$(CPS)_{jkl}$ = effect of interaction between ${}_j^{th}$ sex, ${}_k^{th}$ parity ${}_l^{th}$ season.

$(BCPS)_{ijkl}$ = effect of interaction between ${}_i^{th}$ genotype, ${}_j^{th}$ = sex, ${}_k^{th}$ parity and ${}_l^{th}$ season.

E_{ijklmn} = random error normally, identically and dependently distributed with zero mean and variance σ^2 e.

For litter weight, average litter weight and litter size at 21 and 28 days:

$$Y_{ijklmn} = U + B_i + C_j + P_k + S_l + R_n + (BC)_{ij} + (BP)_{ik} + (BS)_{il} + (CP)_{jk} + (CS)_{jl} + (PS)_{kl} + (BCP)_{ijk} + (BPS)_{ikl} + (BCS)_{ijl} + (CPS)_{jkl} + E_{ijklmn}$$

Where Y_{ijklmn} = the observation of the dependent variable on the ${}_m^{th}$ kit of the ${}_i$th genotype of the ${}_j$th sex of the ${}_k$th parity of ${}_l$th of season of birth of the ${}_n$th litter size.

U= overall mean of all observations

B_i = effect of the ${}_i^{th}$ genotype of kit ($_i$= NZW x NZW, CHA x CHA, NZW x CHA, NZWDBD x NZWDBD, NZW x NZWDBD, NZWCRL x NZWCRL, CHA x NZWDBD and CHA x NZWCRL.

C_j = effect of ${}_j^{th}$ sex of kit ($_j$ = male, female)

P_k = effect of ${}_k^{th}$ parity ($_k$ = 1,2,3,4,5,6)

S_i = effect of ${}_l^{th}$ season ($_l$ = dry, wet)

Rn = effect of nth litter size $_n$ = (2,3,4,5,6)

$(BC)_{ij}$ = effect of interaction between ${}_i^{th}$ genotype and ${}_j^{th}$ sex.

$(BP)_{ik}$ = effect of interaction between ${}_i^{th}$ genotype and ${}_k^{th}$ parity.

$(BS)il$ = effect of interaction between ${}_i^{th}$ genotype and ${}_l^{th}$ season.

$(CP)_{jk}$ = effect of interaction between ${}_j^{th}$ sex and ${}_k^{th}$ parity.

$(PS)_{kl}$ = effect of interaction between ${}_k^{th}$ parity and ${}_l^{th}$ season.

$(BCP)_{ijk}$ = effect of interaction between ${}_i^{th}$ genotype, ${}_j^{th}$ sex and ${}_k^{th}$ parity.

$(BPS)_{ikl}$ = effect of interaction between $_i^{th}$ genotype, $_k^{th}$ parity and $_l^{th}$ season.

$(CPS)_{jkl}$ = effect of interaction between $_j^{th}$ sex, $_k^{th}$ parity and $_l^{th}$ season.

E_{ijklmn} = random error normally, identically and independently distributed with zero mean and variance σ^2e.

RESULTS

Reproductive traits at birth: Genotype was an important source of variation for Individual Kit weight (Ikt) ($p<0.001$) and for Litter Weight (Lwt), Average litter weight (Alt), Litter size (Ltz) and Gestation Length (Glt) at birth ($p<0.05$). Parity effects were significant for Ikt ($p<0.001$) and for Alt and Glt ($p<0.05$) and not significant ($p>0.05$) for Lwt and Ltz. Season effect was not significant for all litter birth traits except for gestation length ($p<0.05$). Examination of interactions involving genotypes, parity and season showed that genotype x parity ($p<0.001$), genotype x season ($p<0.01$), parity x season ($p<0.05$), genotype x parity x season ($p<0.01$) significantly affected Ikt and also genotype x parity and genotype x season significantly ($p<0.01$) affected Glt at birth. (Appendix 1). These interactions were assumed to be important sources of variation.

The least square means with their corresponding standard error for Individual Kit weight (Ikt), Litter Weight (Lwt), Average Litter weight (Alt), Litter size (Ltz) and Gestation Lengths (Glt) at birth are presented in Table 1. The overall means were 48.870.46 g, 49.48±0.86 g, 219.09±11.92 g, 4.42±0.26 and 30.54 ±0.19 days for Ikt, Alt, Lwt, Ltz and Glt, respectively.

Genotype means differed significantly for all reproductive traits at birth (Table 1). The New Zealand White x Chinchilla (NZW x CHA) kits had the highest Ikt (54.46±1.42 g) which was not significantly ($p>0.05$) different from Ikt for New Zealand White-Dutch belted x New Zealand White-Dutch belted (NZWDBDxNZWDBD), New Zealand White x New Zealand White-Dutch belted (NZW x NZWDBD), Chinchilla x New Zealand White-Dutch belted (CHA x NZW.DBD) and Chinchilla x New Zealand White-Croel (CHA x NZWCRL). The lowest Ikt mean (45.04±0.61) was observed for New Zealand White-Croel x New Zealand White-Croel (NZWCRL x NZWCRL), followed by New Zealand White x New Zealand White (NZW x NZW) and Chinchilla x Chinchilla (CHA x CHA). The NZW.DBD x NZWDBD kits had a superior edge over other genotypes in Lwt (257.75±24.96 g) and Ltz (5.25±0.54) at birth, whereas the lowest Lwt (173.17±26.08) and Ltz (3.60±0.53) were obtained in NZWCRL x NZWCRL and NZW x CHA respectively. The gestation length ranged from 30.10±0.36 to 31.19±0.09days), with NZW x NZW recording the longest and CHA x NZW.DBD the shortest.

Parity differences ($p<0.05$) were observed for Individual Kit Weight (Ikt), Average Litter Weight (Alt) and Gestation Length (Glt) but not for litter weight (Lwt) and litter size (Ltz) (Table 1). All traits consistently increased with parity up till parity 3 except Glt. The highest mean values for Ikt (50.87±1.16 g) and Alt (52.37±2.05 g) were observed at parity 4 that dropped in parities 5 and 6. The longest Glt was observed at parity 2 and from there dropped consistently in parities 3, 4 and 5 and picked up in parity 6.

Litter size was not only considered as a variable but as a factor in this study. As a factor, it was an important source of variation ($p<0.01$) in Individual Kit weight (Ikt), Average Litter weight (Alt) and Litter Weight (Lwt). The Ikt and Alt decreased consistently with litter size from 2 to 7. The rabbits born twins were significantly ($p<0.05$) heavier in Ikt (54.67±4.67 g) and Alt (56.08±3.7 g) than others. Litter size of 7 kits was the heaviest in Lwt. (Table 1)

Gestation length was also considered as a variable and as a factor in the study. As a factor, its effect on Individual Kit Weight (Ikt), Average Litter weight (Alt) and Litter Weight (Lwt) was similar. Majority of the does kindled at 30 days when highest Ikt (49.91±0.65 g) and Alt (51.01±1.18 g) were recorded. Those that kindled at 29 days had the heaviest Lwt (23.83±14.87 g). But differences were not statistically significant ($p>0.05$).

All the traits studied were not affected by seasonal influence except gestation length ($p<0.05$). Dry season recorded longer gestation (Glt) than wet season (30.17±0.22 versus 30.36±0.20 days). The kits born in the wet season (April-September) had superior Ikt (49.13±0.60 versus 48.50±0.71 days), Lwt (225.26±13.02 versus 212.92±14.45) and Alt (49.89±1.17 versus 49.00±1.27) as compared to kits born in the dry period (October-March). However, larger Ltz was recorded in the dry season than in the wet season (4.44±0.32 versus 4.39±0.29).

Reproductive traits at 21 days of age: Table 2 shows the least square means and standard error for reproductive traits at 21 days of age. The overall means for Individual Kit weight (Ikt), Average Litter weight (Alt), Litter Weight (Lwt) and Litter size (Ltz) were 194.35±2.87, 204.90±5.13, 675.83±28.72 and 3.47±0.16g, respectively. Analyses of variance showed that genotype and season strongly influenced ($p<0.001$) Ikt but had no significant ($p>0.05$) effect on Lwt and Ltz. There were also significant ($p<0.05$, $p<0.01$) effects of genotype, parity, sex and litter size on Ikt. Sex as well had significant ($p<0.05$) influence on Ltz.

Table 1: Least square means for reproductive traits at birth

Variables	No	Individual kit wt (g)	No	Litter wt (g)	Average litter wt (g)	Litter size (no.)	Gestation length (days)
Genetic Group							
NZW x NZW	101	46.02±0.91^{b}	21	221.38±17.11^{ab}	46.27±2.13^{b}	4.81 ±37^{ab}	31.19±0.29^{a}
CHA x CHA	138	46.28±0.89^{b}	32	199.34±14.01^{ab}	47.19 ±1.74^{b}	4.31±0.30^{ab}	30.52±0.21^{ab}
NZW x CHA	39	54.46 ±1.42^{a}	10	194.40±24.44^{ab}	54.83±3.04^{a}	3.60±0.53^{b}	30.18±0.36^{bc}
NZW.DBD x NZW.DBD	42	50.26 ±0.95^{a}	8	257.75±24.96^{a}	50.32±3.10^{ab}	5.25±0.54^{a}	30.75±0.40^{ab}
NZW x NZW.DBD	44	51.36±1.55^{a}	11	205.36±22.44^{ab}	52.13±2.80^{ab}	4.00±0.49^{ab}	30.18±0.37^{bc}
NZWCRL x NZWCRL	27	45.04±0.61^{b}	7	173.71±26.08^{ab}	46.88±3.24^{b}	3.86±0.56^{b}	30.29±0.41^{bc}
CHA x NZW.DBD	41	52.46±1.56^{a}	11	217.81±23.33^{ab}	53.43±2.90^{ab}	4.09 ±0.50^{ab}	30.10±0.41^{bc}
CHA x NZWCRL	34	52.46 ±1.63^{a}	9	199.11±25.19^{ab}	52.40±3.13^{ab}	3.78±0.54^{b}	30.22±0.38^{ab}
Parity							
1	60	44.95±1.48^{b}	15	179.73±20.25	45.09±2.52^{b}	4.00±0.44	30.27±0.29^{a}
2	94	47.74±1.21^{ab}	21	216.76±17.77	48.80±2.21^{ab}	4.52±0.38	31.14±0.24^{bc}
3	105	49.18±1.09^{a}	23	226.87±16.31	49.80±2.03^{ab}	4.70±0.35	30.48±0.22^{ab}
4	98	50.87±1.16^{a}	25	197.76±16.48	52.37±2.05^{a}	3.92±0.36	30.40±0.21^{ab}
5	81	49.43±1.31^{a}	18	216.67±18.84	50.60±2.34^{ab}	4.33±0.41	30.22±0.27^{ab}
6	28	49.39±2.03^{a}	7	197.14±28.56	51.46±3.55^{ab}	4.00±0.62	30.57 ±0.41^{bc}
Litter size							
2	12	54.67±4.67^{a}	12	108.08±7.49^{f}	56.08±3.75^{a}	-	-
3	21	48.67±1.63^{b}	17	154.14±4.84^{e}	51.38±1.61^{ab}	-	-
4	30	49.30±1.43^{ab}	30	202.33±5.31^{d}	50.59±1.33^{ab}	-	-
5	21	45.29±1.70^{bc}	21	236.62±6.81^{c}	47.92±1.48^{ab}	-	-
6	19	41.21±2.00^{c}	19	279.47±10.18^{b}	46.91±1.65^{bc}	-	-
7	6	39.50±4.61^{c}	6	301.13±24.33^{a}	42.24±3.69^{b}	-	-
Gestation Length							
29	29	46.34±1.94	6	223.83±14.87	46.79±3.04	-	-
30	245	49.91±0.65	59	208.24±8.64	51.01±1.18	-	-
31	130	47.67±0.79	31	200.81±12.94	48.52±1.46	-	-
32	28	48.11±1.67	6	216.33±23.49	48.42±2.49	-	-
33	34	46.38±9.14	7	219.71±25.14	47.97±1.81	-	-
Season							
Dry	205	48.50±0.71	49	212.92±14.45	49.00 ±1.27	4.44±0.32	30.71±0.22^{a}
Wet	261	49.13±0.61	60	225.26±13.02	49.89 ±1.17	4.39±0.29	30.36 ±0.20^{b}
Overall Mean	466	48.87±0.46	109	219.09±11.92	49.48±0.86	4.42±0.26	30.54±0.19

Mean with different superscripts in the same column are significantly different ($p<0.05$, $p<0.01$, $p<0.001$)

Table 2: Least square means for reproductive traits at 21 days of age

Variables	No	Individual kit wt (g)	No	Litter wt (g)	Average litter wt (g)	Litter size
Genetic Groups						
NZW x NZW	50	156.20 " 6.71^{d}	14	564.60±51.87	176.18±14.99^{b}	3.67±0.39
CHA x CHA	68	201.76±5.65^{b}	21	657.60±64.53	211.19±8.88^{ab}	3.41±0.34
NZW x CHA	32	226.69±7.12^{a}	10	725.40±85.14	243.02±15.44^{a}	3.07±0.49
NZW.DBD x NZW.DBD	25	196.24±6.56^{bc}	6	817.34±144.37	195.18±9.14^{b}	4.85±0.54
NZW x NZW.DBD	23	205.65±11.59^{ab}	7	558.10±41.51	212.67±16.70^{ab}	2.71±0.52
NZWCRL x NZWCRL	20	177.50±11.59^{cd}	5	567.60± 41.51	193.02±22.41^{b}	3.24±0.58
CHA x NZW.DBD	41	197.93±5.21^{bc}	10	811.60±68.34	198.28±8.07	4.43±0.36
CHA x NZWCRL	21	206.47±7.12^{ab}	5	784.80±32.39	208.62±12.57^{ab}	3.27±0.20
Parity 1	42	181.40±7.63^{b}	12	634.9±66.50	187.35±12.63	3.50±0.36
2	50	187.04±5.71^{b}	14	623.50±65.72	194.97±10.91	3.33±0.36
3	53	188.32±8.07^{b}	16	595.90±57.73	211.38±14.96	3.12±0.35
4	67	197.84±5.53^{ab}	17	736.30±61.29	206.35±9.00	3.77±0.34
5	48	213.90±5.39^{a}	13	796.80±75.73	222.60±10.03	3.77±0.44
6	20	200.10±7.51^{ab}	6	595.90±120.15	202.75±9.13	3.33±0.67
Litter size 2	25	241.63±15.06^{a}	25	431.43±12.48^{a}	251.53±9.63	-
3	20	230.07±12.05^{ab}	20	472.79±14.00^{b}	236.46±7.00^{bc}	-
4	12	190.15±7.03^{bc}	12	615.38±19.86^{c}	205.13±6.62^{ab}	-
5	8	187.65±8.35^{bc}	8	786.13±31.52^{d}	195.55±7.82^{a}	-
6	9	175.00±14.68^{c}	9	875.31±60.63^{d}	175.06±12.13^{a}	-
7	4	170.50±33.73^{c}	4	999.25±63.59^{e}	173.40±5.01^{a}	-
Sex Male	128	186.20±4.18^{b}	37	705.70±40.07	189.50±7.32	3.10±0.22^{a}
Female	152	200.68±3.86^{a}	41	648.88±40.96	218.80±6.52	3.89±0.21^{b}
Season Dry	131	180.19±4.54^{b}	33	660.76±40.33	191.17±9.39^{b}	3.70±0.24
Wet	149	205.85±3.38^{a}	45	686.89±40.35	214.57±5.27^{a}	3.31±0.21
Overall mean	280	194.35±2.87	78	675.83±28.72	204.90±5.13	3.47±0.16

Mean with different superscripts in the same column are significantly different ($p<0.05$, $p<0.01$, $p<0.001$)

Table 3: Least square means for reproductive traits at 28 days of age

Variables	No	Individual kit wt (g)	No	Litter wt (g)	Average litter wt (g)	Litter size
Genetic Groups						
NZW x NZW	50	237.32 " 7.17^{c}	14	798.88±64.22^{ab}	242.23±21.50	3.46±0.38
CHA x CHA	61	265.83± 8.72^{ab}	18	767.24± 112.38^{ab}	268.96±32.31	2.97 ±0.48
NZW x CHA	30	268.01 ±11.15^{abc}	10	612.67±90.12^{ab}	279.77±21.60	2.50±0.52
NZW.DBD x NZW.DBD	24	277.91±9.54^{abc}	6	1099.52±143.79^{a}	286.75±19.33	4.27 ±0.62
NZW x NZW.DBD	21	252.05±9.53^{ab}	7	737.12±116.45^{b}	270.63±11.34	3.05± 0.52
NZWCRL x NZWCRL	18	240.88±15.11^{bc}	5	796.46±75.07^{ab}	266.10±27.72	3.32±0.58
CHA x NZW.DBD	38	242.39±7.80^{bc}	9	831.86±70.33^{ab}	244.80±14.83	3.80±0.31
CHA x NZWCRL	19	269.05±10.40^{abc}	5	914.54±109.92^{ab}	270.56±17.12	3.16±0.40
Parity 1	38	251.50±8.95^{b}	11	741.59±82.13^{ab}	280.72±14.15	3.06±0.41
2	50	250.40±8.54^{b}	14	800.88±73.25^{ab}	266.25±22.58	3.22±0.42
3	50	271.20±9.69^{a}	15	799.10±76.22^{ab}	290.08±22.82	2.91±0.40
4	67	248.13±6.66^{b}	17	990.98±75.89^{ab}	253.95±16.85	3.74±0.34
5	43	244.47±8.34^{b}	12	1099.28±76.02^{a}	245.18±17.04	4.59±0.37
6	13	251.37±8.45^{b}	5	486.90±140.71^{b}	225.82±13.60	2.37±0.67
Litter size 2	25	362.07±12.17^{a}	25	493.14±18.42^{e}	342.32±27.67^{a}	-
3	20	318.92±11.96^{b}	20	649.17±23.90^{d}	295.25±24.77^{ab}	-
4	10	253.31±14.31^{c}	10	782.54±33.06^{cd}	260.85±11.02^{b}	-
5	7	241.45±11.76^{c}	7	962.70± 42.87^{bc}	245.13±9.60^{c}	-
6	8	215.36±10.93^{c}	8	1108.64±46.75^{ab}	221.73±9.35^{c}	-
7	4	194.50±22.52^{d}	4	1270.75±117.20^{a}	211.79±19.53^{c}	-
Sex Male	119	258.50±5.86	35	859.84±45.25	245.31±13.13	3.03±0.25
Female	142	255.78±4.61	39	779.73±51.74	275.36±10.51	3.60±0.23
Season Dry	116	270.02±5.77^{a}	32	814.64±50.1	264.29±13.87	3.07±0.23
Wet	145	244.26±4.38^{b}	42	824.93±47.9	256.38±10.13	3.56±0.24
Overall mean	261	253.02±3.66	74	815.19±34.62	263.55±8.38	3.42±0.17

Mean with different superscripts in the same column are significantly different ($p<0.05$, $p<0.01$, $p<0.001$)

The significant ($p<0.001$, $p<0.05$) litter size effect on Lwt and Alt was observed. The interactions between genotype x parity, genotype x season and parity x season significantly ($p<0.001$, $p<0.01$) influenced Ikt. Other interactions were assumed not to be important.

At 21 days of age, genotype means differed for Individual Kit Weight (Ikt) and Average Litter weight (Alt) but were similar for Litter Weight (Lwt) and Litter size (Ltz). The New Zealand White x Chinchilla (NZWxCHA) kits were superior in Ikt and Alt (226.67±7.12 and 243.02±15.44 g) when compared with other genotypes. While New Zealand White-Dutch belted x New Zealand White-Dutch belted (NZWDBDxNZWDBD) had the highest Lwt (817.34±114. 37 g) and Ltz (4.85±0.54). The lowest mean values for Ikt and Alt (156.20±6.71g and 176.18±14.99 g) were obtained in New Zealand WhitexNew Zealand White (NZW x NZW). All genotype were similar in Lwt and Ltz.

There was sex difference in Ikt, Alt and Ltz at 21 days of age. Females weighed more than males in Ikt (200.68±3.86 g versus 186.20±4.18 g) and in Alt (218.80±6.52 g versus 189.50±7.32 g). Males among the litters were heavier in Lwt (705.70±40.07 g) and smaller in Ltz (3.10 to 0.22 versus 3.89±0.21) than the females.

Differences in parity means showed that individual kit weight (Ikt) of parity 5 (213.90±5.39 g) was heavier than those of other parities. The kits of first parity dams were least in Ikt (181.40±7.63 g), which did not differ significantly ($p>0.05$) from kits of second parity dams (187.40±7.63 g) and third parity dams (188.32±8.07 g). Parity influence on Average Litter weight (Alt), Litter Weight (Lwt) and Litter size (Ltz) was not significant ($p>0.05$). However, parity means for Ikt and Alt increased from parity 1 to 5 and then dropped in parity 6. The parity means for Lwt and Ltz dropped consistently from, parity 1 to 3 and then picked in parities 4 and 5 and finally declined in parity 6 (Table 2).

The Individual Kit weight (Ikt), Average Litter weight (Alt) and Litter Weight (Lwt) mean values by litter size were significantly ($p<0.05$) different. The mean values for Ikt and Alt consistently decreased as the litter size increased. On the other hand Lwt mean increased with litter size. The litter size of 2 kits was superior in Ikt (241.63±15.06) and in Alt (251.53±9.63), while litter size of 7 kits recorded the highest Lwt (999.25±63.59 g).

The Ikt and Alt means by season were different ($p<0.01$). The kits born in the wet season weighed more than those born in the dry season with respect to Ikt (205.85±40.35 versus 180.19±4.54 g), Alt (214.90±5.13 g) and Lwt (686.89±40.35 versus 660.76±40.33 g). The dry season recorded larger Ltz than the wet season.

Reproductive traits at 28 days of age: Table 3 presents the least square means and standard error for reproductive traits at 28 days of age. The overall means recorded for Individual Kit weight (Ikt), Average Litter weight (Alt), Litter Weight (Lwt) and Litter size (Ltz) were 253.02±3.66 g, 263.55±8.38 g, 851.19±34.62 g and 3.42±0.17, respectively.

There were significant influences of genotype ($p<0.001$) on individual kit weight (Ikt) and ($p<0.05$, $p<0.01$) on Litter Weight (Lwt) at 28 days. Parity had significant ($p<0.05$) effect on Ikt and Average Litter weight (Alt). Seasonal and litter size effects were also important sources of variation ($p<0.01$) for Ikt. The interactions between genotype x parity ($p<0.01$) and genotype x parity x season ($p<0.001$) significantly influenced Ikt at 28 days. Also affected significantly by genotype x parity ($p<0.05$) was Lwt.

Table 3 indicates the statistical significance among the mean values for Individual Kit weight (Ikt) and Litter Weight (Lwt) ($p<0.001$, $p<0.05$) by genotype; for Ikt and Lwt ($p<0.05$) by parity of dam and for Ikt ($p<0.01$) by season. The kits of New Zealand White-Dutch belted x New Zealand White-Dutch belted (NZW.DBD x NZWDBD) had the highest mean values for Ikt (277.96±9.54 g), Lwt (1099.52±143.79 g) and litter size (Ltz: 4.27±0.65). The lowest means for Ikt (237.32±7.17 g) in NZW x NZW, Lwt (612.67±90.12 g) in New Zealand White x Chinchilla (NZW x CHA), Average Litter weight (Alt) (242.23±21.50 g) in New Zealand White x New Zealand White (NZW x NZW) and smallest Ltz (2.97±0.48) in CHA x CHA were observed. The Alt and Ltz by genotype were not statistically different.

The Individual Kit weight (Ikt), Litter Weight (Lwt), Average Litter weight (Alt) and Litter size (Ltz) mean values by sex were not statistically different ($P>0.05$). Males were heavier than females in Ikt (258.50±5.86 g versus 255.78±4.61 g) and in Lwt (859.84±45.25 g versus 779.73±51.74 g). Females were heavier in Alt (275.36±10.51 g versus 245.31±13.13 g) and more in number among litters Ltz (3.60±0.023 versus 3.03±0.25) than males (Table 3).

The mean values for individual kit weight (Ikt) and litter weight (Lwt) by parity of dam were significantly different ($p<0.05$) with kits of third parity recording the heaviest Ikt mean of 271.20±9.69 g. Whereas the highest Lwt mean of 1099.28±76.02 g was observed for kits of fift parity dam. The parity means for Average Litter weight (Alt) and Litter size (Ltz) were similar. But the kits of third parity recorded the highest Alt (290.08±22.82 g) while the sixth parity had least Alt (225.82±13.60 g) and smallest Ltz (2.37±0.67).

Seasonal effect was not different in all the traits except ($p<0.01$) for Individual Kit weight (Ikt) where dry season recorded higher Ikt mean of 270.02±5.77 g than wet season (244.26±4.38 g). The wet season recorded higher litter weight (Lwt: 824.93±49.9g versus 814.64±50.1 g) and larger litter size (Ltz: 3.56±0.4 versus 3.07±0.23) than the dry season.

There was strong significant ($p<0.01$) influence of litter size on Individual Kit weight (Ikt), Average Litter weight (Alt) and Litter Weight (Lwt). While Ikt and Alt decreased with litter size, Lwt increased with the litter size. Litters having 2 kits were bigger in Ikt (362.07±12.17 g), Alt (342.32±27.67 g) and least in Lwt (493.14±18. 42 g). The litter size of 7 kits had the best performance in Lwt (1270.75±117.20 g) but least in Ikt and Alt.

DISCUSSION

In this study, observations from the analytical results showed differences in Individual Kit weight (Ikt), Average Litter weight (Alt), Litter Weight (Lwt) and Litter size (Ltz) of genotypes among the litters at various ages. The differences in genotype performance was due to set of genes received from parents and environment provided for gene expression. Differences in individual performance among animals inhabiting the same environment had been envisaged[13]. The reasons had been attributed to strong maternal effects of litter size and milk production more than genetic effects[11]. Crossbred does had been reported to produce more milk to cater for their kits than the purebred does[9,14].

In rabbit breeding research, emphasis had been on Litter Weight (Lwt) rather than Individual Kit weight (Ikt) as a trait of economic importance. However, the present study has proved that Ikt is an important trait in rabbit breeding. Since Ikt at birth, 21 and 28 days were significantly influenced by genotype ($p<0.01$) as shown in Tables 1-3. This finding corroborated Hamond and Marshall[15] who reported significant breed ($p<0.05$) influence on Ikt at birth. Among the genotypes in the study Chinchilla x New Zealand White (NZW x CHA) and New Zealand White-Dutch belted x New Zealand White-Dutch belted (NZW.DBD x NZW.DBD) were generally superior in Ikt over other genotypes at various ages. NZW x CHA was highest in Ikt at birth and 21-day, next to NZW.DBD x NZWDBD in Ikt at 28 day. It has been shown early that crossbreeding improved litter traits at pre-weaning growth rates of rabbits[1]. The New Zealand White x New Zealand White (NZW x NZW) had the least performance for Ikt at different ages except at birth. The genotype was from pure New Zealand White parents. It would not be surprising that it performed less than its crossbred counterparts.

Genotype effect ($p<0.05$) on Litter Weight (Lwt) at birth was obvious but not at day 21. Similarly, breed differences for Lwt at birth[9,16], at 28 days (Ozimba and Lukefahr[11] had been reported. The range and mean values for Lwt in this study were in line with the Figures reported in the tropics[9,17-20], though typically lower than reports in the temperate regions[11,21]. The NZW.DBD x NZWDBD was consistently superior over other genotypes in Lwt at all ages considered in the study.

The significant ($p<0.05$) genotype influence on Average Litter weight (Alt) at birth and 21 days was observed in the study. This agreed with the reports of Lukefahr *et al.*[22]. These authors reported significant ($p<0.05$) breed-type effect on average kit weight at birth in purebred progeny comparisons of NZW and large breeds like Gigante de Bouscat and Flemish Giant. The Alt reported by Iyeghe-Erakpotobor;*et al.*[9] compared favorably with Alt mean and range values obtained in the present study. The similarities in Alt values by genotype at 28 had been observed elsewhere[23]. At birth and 21 days, Chinchilla x New Zealand White (NZW x CHA) had significant ($p<0.05$) higher Alt than other genotypes while the superiority of New Zealand White-Dutch belted x New Zealand White-Dutch belted (NZW.DBD x NZWDBD) over others in Alt was obvious at 28 day.

The Litter size (Ltz) differed at birth among the genotypes but was similar at other ages. Breed differences in litter size at birth had been reported by other workers[9,16]. The similarity in Ltz at 28 days among rabbit breed-types had been confirmed in reports by different workers[4,24,25]. The Ltz obtained in the study was within the range values for the tropics[33]. New Zealand White-Dutch belted x New Zealand White-Dutch belted (NZWDBD x NZWDBD) had larger Ltz than other genotypes at various ages. Breed, strain and breeding techniques influence Ltz as well as environmental effect such as nutrition of the doe[10]. Generally, litter size in rabbit varied between breeds and strain and within breeds[26]. Also differences in litter size due to doe effect were attributed to differences in number of viable eggs and pre-implantation viability[3] .

Besides, Litter size (Ltz) as a source of variation was significantly ($p<0.01$) important for Individual Kit weight (Ikt), Litter Weight (Lwt) and Average Litter weight (Alt) at all ages. There was a consistent increase in Ikt and Alt with litter size at all ages. And at all ages, litter size of two rabbits were superior in Ikt and Alt, corroborating observation made in goat by Akpan[27] that kids born twins were heavier than triplets but their growth rate was slower. The Ltz of 7 rabbits maintained a consistent significant ($p<0.05$) heavier Lwt than other Ltz at all ages. The result of this study compared favourably with reports in available literature[14,18]. The litter size depends on the number of egg produced after mating and this number depends on the body size of the breed[14]. The significant influence by litter size in the present study would suggest that the maternal environment exerted significant influence on the traits studied. It might be further ascribed to the doe's mothering ability and available food for litter size.

The Gestation Length (GLT) considered only at birth showed breed differences with range and overall mean values of 30.10±0.36-31.19±0.29 and 30.54±0.19, respectively. While Khalil *et al.*[3] reported gestation length differences due to breed, Adesina[25,28] and Ohiosimuan *et al.*[16] did not obtain significance in GLT by breed. New Zealand White (NZW) does had the longest GLT of 31.19±0.29 and Chinchilla x New Zealand White-Dutch belted (CHA x NZWDBD) the shortest GLT of 30.10±0.36. The GLT obtained in this study compared closely to range values reported by other workers[18,29]. The inconsistency of production traits with GLT was not uncommon since GLT was highly influenced by day length fluctuations, which are common in the tropics.

Generally the reproductive traits at the various ages assumed undulating trend with parity. The Individual Kit weight (Ikt) and Average Litter weight (Alt) at birth increased from parity 1 to 4 and finally dropped in parities 5 and 6. The Litter Weight (Lwt) and Litter size (Ltz) at birth increased with parity from 1 up to parity 3, declined in parity 4, picked up in parity 5 and eventually dropped in parity 6. A similar trend was obtained for the traits with parity at ages of 21 and 28 days. In constrast to these findings, Ozimba and Lukefahr[11] reported that parity effect was never a significant source of variation.

The effect of season on Litter size (Ltz) at 28 days had been reported[9,11]. Yahaya[28,30] reported no significant influence of season on litter size. The non-significant effect of season on litter size at birth was in agreement with Abdul-malik *et al.*[9,28]. These authors also reported significant influence of season on Average Litter weight (Alt) and Litter Weight (Lwt) at birth. The wet season mean values for all the traits at birth and 21 day were higher than mean values for dry season except for Ltz at 21 days. Similar higher mean values for wet periods had been reported elsewhere[9,11]. This could be due to high feed intake as a result of the low daily temperature, which was converted into tissue in the growing rabbits. But the dry periods had higher mean values for Ikt and Alt at 28 and days. This was contrary to reports by Casady *et al.*[23,31,32]. However, kits in the dry periods survived and performed better than those of wet seasons.

For Individual Kit weight (Ikt), Average Litter weight (Alt) and Litter size (Ltz) at 21day, sex exerted significant effect with females among the litters performing better than males. The report of Ozimba and Lukefahr[11] disagreed with this observation. The effect of sex for other traits at various ages was similar. The females having heavier body weights than males agreed with the findings of Lebas *et al.*[14].

CONCLUSION

This study considered NZW x NZW, CHA x CHA, NZW x CHA, NZWDBD x NZWDBD, NZW x NZWDBD, NZWCRL x NZWCRL, CHA x NZWDBD and CHA x NZWCRL kits for pre-weaning performance characteristics namely Individual Kit weight (Ikt), Litter Weight (Lwt), Average Litter weight (Alt) and Litter size (Ltz). Overall, NZWDBD x NZWDB was superior, particularly for birth Lwt & Ltz; 21-day Lwt and Ltz; 28-day Ikt, Alt, Lwt and Ltz. Such superioty is likely to enhance faster genetic gain enabling faster rate of improvement in total herd productivity. The NZW, well recognized as a suitable breed for meat production, occupied last position in some of the traits considered in the study. The genotype differences in performance observed indicate that a breeding programme for selection and improvement is imperative for the establishment of breeds suitable for intensive commercial rabbit production in the tropics. The choice of breeds for commercial production should however be based on per-weaning and kit performance. In addition, the genotype, sex, litter size, parity and season as important sources of variation should be considered in improvement programme to increase meat yield from these rabbit breeds and crosses. Results of this study provide corroborative evidence in support of the adoption of crossbreeding in the commercial rabbit industry in Nigeria.

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