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RESEARCH

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Effects of genotype, gestation length and litter size on the birth weight, litter weight, pre- and post-weaning weight of crossbred kits

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Abstract

Background: Performance of rabbit is hinged on many factors of which the birth weights, gestation length and the litter size are most important. Linear body traits provide vital information on the performance, productivity and carcass characteristics which could be useful tool for the improvement in genetic potentials of rabbits. Therefore, this study investigated the effects of genotype, gestation length and litter size on the birth weight, pre- and post-weaning weight of crossbred kits.

Results: Five breeds: Rex (RX), Dutch-belted (DBT), New Zealand white (NZW), Californian white (CFW) and local breed (LAB) of rabbit were used for the study. A foundation stock of 40 growing rabbits consisting of six does and two bucks were used for the crossing experiment. Genotype exerted significant influence ($P<0.01$) on the litter weight at birth as well as on the body weight of the kits at 21st and 35th days. The kit kindled from mating CFWxDBT breeds had the highest mean body weight from birth (91.90 ± 9.84 g) to 35th days (368.25 ± 17.36 g), while the crosses of DBTxCFW recorded the least mean body weight from birth (74.25 ± 1.78 g) to 35th days (332.60 ± 12.54 g). Gestation length significantly ($P<0.05$) influenced individual and litter birth weights, pre- and post-weaning weights of kits. Does with short gestation length (29 days) had kits with light body weight compared to those with longer period of gestation (34 days). More so, kits belonging to large litter size (7) had the lowest body weight at birth as well as 21st and 35th day (69.93 ± 1.63 g, 209.57 ± 3.70 g, 319.11 ± 9.22 g) compared to kits that belonged to small litter group size. Highly significant ($P<0.01$) and the strongest phenotypic relationships were recorded between body weight at day 21 and day 35 for all crosses, while weak and negative genetic correlation ($r=-0.19$) was observed between litter birth weight and individual birth weight of crossbred kits.

Conclusion: Crossbreeding produces offspring with better performances. Birth weight of kits is a prediction tool for the overall performance of rabbits provided the environment is uninterrupted.

Keywords: Genotype, Gestation length, Litter size, Body weight, Phenotypic and genetic correlation

Background

The FAO prediction (FAO 2012) concerning the increase demand for animal protein throughout the globe has been attributed to the rising population size which has necessitated delving into massive meat production. In recent years, rabbit production has gained more attention in developing countries such as Nigeria as a sustainable and inexpensive means of providing high-quality animal protein to supplement the deficiency arising from the dependency on plant protein for Nigerians (Onifade et al. 1999). Although most meat types are rich in saturated fat and cholesterol and had been found to be responsible for the development of cardiovascular diseases (CVD) (Briggs et al. 2017), rabbit meat is low in

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calorie and cholesterol and its consumption is being encouraged among the old-age group. Nutritionally, rabbit meat is rich in proteins of high biological value, low in cholesterol content and high in linolenic acid when compared to other types of meat (Samkol and Lukefahr 2008; Nistor et al. 2013). There is no taboo or beliefs against the consumption of rabbit meat. The litter size (Nofal et al. 2005) and pre-weaning survival percentage of kit rabbits (Fadare and Fatoba 2018) are major determinants that enhance successful rabbit production, as it is crucial in evaluating the net financial income of the farms (Rashwan and Marai 2000). Likewise, the overall performance and sustainability of the animal are greatly influenced by its live body weight (Chineke 2005) as well as the selection of the best choice of genotypes in breeding (Oyegunle et al. 2015). Hence, the choice of genotype, numbers of kits per litter and the duration of pregnancy (gestation length) could be contributing factors to the overall rabbit's weight in SouthWest, Nigeria. Therefore, it is imperative to know the relationship between individual birth weight, litter birth weight and pre-weaning weights of the different crosses of rabbit breeding. Thus, the aim of this study was to find out the effects of genotype, gestation length and litter size on the individual kit birth weight, litter birth weight and the weight gained at the 3rd and 5th week post-parturition as well as to estimate the phenotypic and genetic correlation of body weights of crossbred kits.

Methods

Experimental site

The experiment was carried out at Livestock section (Rabbit experimental unit) of the Teaching and Research Farm, Akure, Nigeria, between May and October, 2014. The study location lies between latitude 7° 15′ North of the equator and 5° 12′ East of the Greenwich Meridian in the humid tropical rain forest region. The climatic condition of Akure follows the pattern of southwest Nigeria, and it has an average annual rainfall of about 1524 mm and the rainy season lasts for about 9 months (March to November).

Animal breeding and management

The experiment was approved by the Animal Welfare Committee of Federal University of Technology, Akure, after due proposal has been presented and approved. The experimental animals used for this study were litters from crosses of New Zealand white, Rex, Dutch, California white and local breeds of rabbits which belong to the Department of Animal Production and Health, Federal University of Technology, Akure. A population of 40 growing rabbits comprising of six does and two bucks each of New Zealand white (NZW), Dutch-belted (DBT), Californian white (CFW), Rex (RX) and locally adapted breeds (LAB) were procured from reputable source for the study. The breeding stock (bucks and does) were kept in individual hutches and provided with stainless steel feeders for serving of feeds and stainless steel bowls for the serving of fresh clean water regularly. Each doe was moved to the buck's cage for mating purpose, and after successful copulation, the does were palpated 10 days after for pregnancy detection. Does that failed to conceive were returned to the same mating buck for re-breeding. Nest boxes were placed in the does cages on the 25th day after conception prior to kindling, and the litters were weaned at 28 days post-kindling. Commercial pelleted ration containing 16.23% crude protein, 10.27% crude fiber and 2280 Kcal/kg energy was fed to the rabbits in the morning, and fresh forages (*Tridax procumbens* and *Talinum triangulare*) were served in the evening. All genetic groups of rabbits were subjected to the similar environmental, medication and managerial conditions. At the end of the experiment, the rabbits were left on the farm for further research studies. The mating procedure is shown in Table 1.

Data collection

Ninety-eight crossbred kits comprising 18 NZWxREX, 23 DBTxCFW, 18 LABxNZW, 20 REXxLAB and 19 CFWxDBT were weighed in the study. The kits were weighed immediately after birth singly and in group as litters. The doe is moved to another cage before the weighing exercise done in the early hours of the morning is being carried out. The kits were weighed up to the 5th week which is the post-weaning phase as the kits were weighed at 4 weeks old. Weighing of kits from birth to the 5th week was carried out using a sensitive scale of 10 kg capacity with 0.01 kg accuracy. Body weights at day 21 and 35 were recorded as the pre- and-post-weaning weights of kits, respectively.

The data collected from the study were analyzed using the mixed model least-squares Procedure of the Statistical Analysis Systems Institute (SAS 2008) and maximum

Table 1 Mating procedure

Sire genotype	Dam genotype	Kit genotype	Number of kits
NZW	REX	NZW x REX	18
DBT	CFW	DBT x CFW	23
LAB	NZW	LB x NZW	18
REX	LAB	REX x LAB	20
CFW	DBT	CF x DBT	19

N.B: NZW New Zealand white, *RX* Rex, *DBT* Dutch-belted, *CFW* California white, *LAB* local breed likelihood computer program (SAS 2008) which uses Henderson's Method 3 to estimate the observable variance components due to genotype (σ_g^2), gestation length (σ^2), litter size (σ_l^2) and error (σ_e^2) by equating computed mean squares to their expectations and solving for the components. The model used was:

$$Yijk = \mu + Bi + Cj + Dk + eijk$$

where *Yijk* = observation on the *i*th rabbit of the *i*th genotype of the *j*th gestation length of *k*th litter size. μ = overall mean of all observations; *Bi* = effect of the genotype of rabbit, $i = 1, 2, 3, 4, 5$ (NWZ x RX, DBT x CFW, RX x LAB, CFW x DBT and LAB x NZW). *eijk* = random error.

The estimate of correlation for genotypic and phenotypic components was obtained using correlation coefficient formula, written as follows:

$$\text{Genetic correlation from sire component } rG = \delta_{Sxy} / \sqrt{(\delta^2_{Sxx}.\delta^2_{Syy})}$$

$$\text{Genetic correlation from dam component } rG = \delta_{Dxy} / \sqrt{(\delta^2_{Dxx}.\delta^2_{Syy})}$$

$$\text{Genetic correlation from sire and dam component } rG = \delta_{Sxy} + \delta_{Dxy} / \sqrt{(\delta^2_{Sxx}.\delta^2_{Syy}).(\delta^2_{Dxx}.\delta^2_{Syy})}$$

where *rG* is the genetic correlation; δ_{xy} is the variance due to traits *x* and *y*; δ_{xx} is the variance due to *xx* traits; δ_{Dxx} is the variance due to doe for *xx* traits; δ_{Dyy} is the variance due to doe for *yy* traits; δ_{sxy} is the variance due to buck for *x* and *y* traits; δ_{sxx} is the variance due to buck for *xx* traits; and δ_{syy} is the variance due to buck for *yy* traits.

Results

Effect of genotype on the least-squares means of individual and litter birth weights, body weights of kits at 21st and 35th days

Genotype had significant ($P < 0.05$) effect on individual and litter weight at birth, 21st and 35th day body weights of the crossbred kits as shown in Table 2. The cross from CFW x DBT had the highest least-squares mean of litter birth weight, body weight at 21 and 35 days (91.90 g ± 9.84; 420.10 g ± 28.93; 246.35 g ± 12.53; 368.25 g ± 17.36, respectively), while alternated mating group (DBT x CFW) resulted into kits with the lowest least-squares mean of individual birth 133 weight as well as body weight at 21st and 35th day (74.25 g ± 1.78; 391.70 g ± 26.29; 218.10 g ± 5.14; 332.60 g ± 12.54, respectively). NZW x RX and LABxNZW recorded statistically similar least-squares individual birth weight mean (84.75 g ± 2.09 and 84.60 g ± 4.24) in BW 21 and BW35 and not LITBW.

Effect of gestation length on the least-squares means of individual and litter birth weights, body weights of kits at 21st and 35th days

The duration of gestation exerted significant influence ($P < 0.05$) on the individual birth weight, litter birth weight, weight at 21 and 35 days as presented in Table 3. The gestation length of doe varied from 29

Table 3 Effect of gestation length on least-squares means of body weights of crossbred kits

Gestlngth	INDBW (g)	LITBW (g)	BW21 (g)	BW35 (g)
29	66.75 ± 0.51^{d}	379.60 ± 21.85	207.20 ± 5.00^{c}	319.40 ± 12.43^{b}
30	72.16 ± 1.09^{c}	396.84 ± 19.57	213.76 ± 3.97^{c}	329.04 ± 10.40^{b}
31	89.42 ± 2.39^{b}	381.82 ± 21.45	245.45 ± 4.51^{b}	366.24 ± 7.91^{b}
32	88.25 ± 1.91^{b}	392.30 ± 24.61	236.60 ± 4.57^{b}	362.50 ± 8.35^{b}
34	217.00 ± 3.00^{a}	434.00 ± 0.00	395.50 ± 1.50^{a}	564.00 ± 1.00^{a}

INDBW individual birth weight, *LITBW* litter birth weight, *BW21* body weight at 21st day, *BW35* body weight at 35th day, *Gestlngth* gestation length

a, b, c, d means with different superscripts within the same column are significantly different at $P < 0.05$

Table 2 Effect of genotype on least-squares means of body weights of crossbred kits

Genotype	INDBW (g)	LITBW (g)	BW21 (g)	BW35 (g)
NZWxREX	84.75 ± 2.09^{b}	375.95 ± 22.13^{ab}	233.25 ± 4.81^{b}	357.80 ± 10.07^{ab}
DBTxCFW	74.25 ± 1.78^{d}	391.70 ± 26.29^{ab}	218.10 ± 5.14^{c}	332.60 ± 12.54^{b}
LABxNZW	84.60 ± 4.24^{b}	357.15 ± 26.20^{b}	232.05 ± 8.16^{b}	349.50 ± 13.90^{ab}
CFWxDBT	91.90 ± 9.84^{a}	420.10 ± 28.93^{a}	246.35 ± 12.53^{a}	368.25 ± 17.36^{a}
REXxLAB	78.95 ± 3.34^{c}	396.45 ± 13.07^{ab}	225.80 ± 6.56^{bc}	345.75 ± 11.33^{ab}

INDBW individual birth weight, *LITBW* litter birth weight, *BW21* body weight at 21st day, *BW35* body weight at 35th day

a, b, c, d means with different superscripts within the same column are significantly different at $P < 0.05$

to 34 days. Does that kindle within short period (29) days had the least birth weight (66.75 g ± 0.51), pre-weaning litter weight (379.60 g ± 21.85), that is, body weight at 21 days (207.20 g ± 5.00) and post-weaning weight (body weight at 35 days: 319.40 g ± 12.43). Does with the longest gestation length (34 days) had the highest birth weight (217.00 g ± 3.00), body weight at 21 days (395.50 g ± 1.50) and body weight at 35 days (564.00 g ± 1.00).

Effect of litter size on the least-squares means of individual and litter birth weights, body weights of kits at 21st and 35th days

Table 4 shows that litter size exerted a significant influence ($P < 0.05$) on the individual and litter weights at birth, body weight at 21st and 35th days. Body weights of crossbred kits decreased as the litter size increased. Kits in the smallest litter group of 2 had the highest individual birth weight (148.75 g ± 39.42), body weight at 21st and 35th days (318.00 g ± 44.75; 454.50 g ± 63.23, respectively), whereas kits that belonged to largest litter size group of 7 had the least individual birth weight, body weight at 21st and 35th day (69.93 g ± 0.93, respectively) but highest litter birth weight of (440.96 g ± 20.8).

Phenotypic and genotypic correlations of individual and litter birth weight, body weight at 21 and 35 days for all crossbred kits

The correlation coefficient of all crossbred kits at the different stages of life is shown in Table 5. Genotypic correlation values were arranged diagonally to the right (upwards), while the phenotypic correlation values were arranged to the left (downwards) of the diagonal. Highly significant ($P < 0.01$) and strongest genotypic relationship ($r = 0.91$) existed between the body weight at day 21 and 35, while nonsignificant ($P > 0.05$) and negative genotypic relationship ($r = -0.04$) existed between the individual birth weight and litter birth weight of kits. Also, the strongest phenotypic relationship ($r = 0.92$) occurred between the body weight at day 21 and 35, while the negative phenotypic relationship ($r = -0.19$) existed between the litters birth weight and the individual birth weight of all the crossbred kits.

Table 5 Phenotypic and genotypic correlations of body weight for all crossbred kits

	INDBW	LITBW	BW at day 21	BW at day 35
INDBW		−0.04ns	0.87**	0.74**
LITBW	−0.19ns		−0.32**	−0.45**
BW at day 21	0.78**	−0.53**		0.91**
BW at day 35	0.69**	−0.59**	0.92**	

INDBW individual birth weight, *LITBW* litter birth weight, *BW21* body weight at 21st day, *BW35* body weight at 35th day

ns not significant ($P > 0.05$), **highly significant ($P < 0.01$)

Discussion

Genotype exerted significant influence on the individual and litter weight at birth, 21st and 35th day as the set of genes received from parent and the environment provided for gene expression could be attributed to the differences in genotypic performances of the kits. The highest body weight was recorded among kits involving the crossing of California and Dutch breeds of rabbit. This could be reasonably due to the fact that the two rabbit breeds possess major genes that improved growth performance better than others. This result corroborated with the results of Obike and Ibe (2010) who recorded higher values for Dutch breed. It also agreed with the findings of Ajayi et al. (2018) who recorded the highest kit pre- and post-weaning body weight with DBTxDBT genotype. Hence, the superior performance observed in the crossbred of Californian with Dutch breed crosses when compared to others could form a basis for selection process in rabbit production. Does that kindled within short period had the least birth weight and even as they mature to the 5th week compared to others. The low birth weight associated with the short gestation length is most likely due to the fact that the fetus should be growing as their age increases. Therefore, a reduction in the length

Table 4 Effect of litter size on body weight of crossbred kits

Litter size	INDBW (g)	LITBW (g)	BW21 (g)	BW35 (g)
2	148.75 ± 39.42^{a}	297.50 ± 78.81^{b}	318.00 ± 44.75^{a}	454.50 ± 63.23^{a}
3	119.33 ± 2.03^{b}	358.00 ± 0.00^{ab}	275.67 ± 2.85^{b}	420.00 ± 6.51^{ab}
4	92.60 ± 1.63^{c}	334.20 ± 25.80^{b}	253.00 ± 3.82^{c}	375.60 ± 11.54^{bc}
5	90.76 ± 1.85^{c}	366.00 ± 22.68^{ab}	245.56 ± 5.18^{c}	375.76 ± 8.64^{bc}
6	72.77 ± 1.06^{d}	390.80 ± 15.58^{ab}	215.83 ± 3.53^{d}	330.50 ± 8.33^{cd}
7	69.93 ± 0.93^{d}	440.96 ± 20.80^{a}	209.57 ± 3.70^{d}	319.11 ± 9.22^{d}

INDBW individual birth weight, *LITBW* litter birth weight, *BW21* body weight at 21st day, *BW35* body weight at 35th day

a, b, c, d means with different superscripts within the same column are significantly different at $P < 0.05$

of days in utero resulted in a decrease in weight of kits. This study was in agreement with the findings of Ayoola et al. (2016) but opposed to the study of Orunmuyi et al. (2006) who stated that gestation length did not significantly exert any influence on weaning weight of rabbits. The significant effects of litter size on the individual and litter birth weights as well as bodyweight at 21st and 35th days were similar to the findings of Castellini et al. (2003) and Ayoola et al. (2016) who also established the fact that there was a significant effect of litter size on the body weight of kits from birth to weaning. The heavier birth weight of kits in the smaller group may be contributed by sufficient intra-uterine nourishment available to cater for the growth and development of the feti unlike the largest litters where there was competition for nutrients. So, kits in the least litter develop rapidly than those in the largest litter even in its post-uterine life due to easier access to a big amount of nutritious milk. This was backed up by findings of Chineke (2005) who also affirmed that litter size was a significant source of variation for individual kit weight and litter weight. Therefore, the growth performance of the kits can be improved upon if kits in the largest litters could be even-up among does with smallest kit groups.

The phenotypic and genotypic relationships in the body weights at 21 and 35 days of the crossbred kits showed that there was very strong degree of linear bond. High individual birth weight of kit resulted into an increase in body weight at 21 days. Since there were no environmental disturbances (change in diet or diseases attack), the increased body weight at day 21 brought about corresponding high body weight at 35 days. The weight at these days was most likely influenced by same genes in the same direction. This study agreed with the investigations of Kuthu et al. (2017) who documented strong genotypic correlation between the birth weight and weaning weight of Teddy goats. Also, weak and negative genotypic as well as phenotypic correlation was observed between the individual birth weight and litter birth weight which indicated that both weights were controlled by the same gene, that is, an increased litter weight did not translate to similar increase in individual kits weight which is in line with the findings of Ehiobu and Kyado (2000).

Conclusions

The study revealed that kits involving California and Dutch breed of rabbits possess the best body weight due to the presence of some major genes that enhance their growth performance when compared to other crosses. Hence, the Dutch breed could form a basis for selection process in rabbit production. High positive significant correlation coefficient values recorded between the body weight of kits at 21 and 35 days indicated that growth rate of kits in terms of their body weight at 21 days would culminate into better body weight gain at 35 days of age provided there are no environmental factors that could cause setback in growth pattern of the kits.

Abbreviations

FAO: Food and Agricultural Organization; DBT: Dutch-belted; NZW: New Zealand white; CFW: California white; INDBW: Individual birth weight; LITBW: Litter birth weight; BW: Body weight; SAS: Statistical Analysis System.

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Author contributions

CA conceived the concept of the study, designed and coordinated the experiment. IS collected the data and analyzed it; she was a major contributor to writing the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

All experimental procedures were approved by the Animal Welfare Committee of Federal University of Technology, Akure, after due proposal has been presented and approved. The rabbits were owned by the Department of Animal Production and Health, Federal University of Technology, Akure, and its use was approved by the Department during the proposal presentation.

Consent for publication

Not applicable.

Competing interests

No competing interests are related to this study.

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