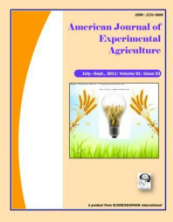

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Variation in Growth and Linear Body Measurements of Rabbits Due to Generation Differences, Housing Systems, Sex and Season

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Authors' contributions

This work was carried out in collaboration between all authors. Authors ABJA, MOO and OSS designed and supervised the study. Author OYAA performed the field work, collected data and helped with the first draft of the manuscript. Author BOA performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

The aim of the study is to determine the effect of generational differences, housing systems, sex and seasonal variations and their interactions on the growth and linear body parameters of rabbits. A total of ninety-six (96) weaner rabbits (Chinchilla and New Zealand White crossbred) were used for this study and were divided into forty-eight (48) per generation. These forty-eight weaner rabbits were further divided into four males in three replicates (12) as well as four females in three replicates (12) for cage (24) and also repeated in deep litter system (24). This experiment was carried out in four seasons with seasonal divisions being made according to the climatic conditions prevalent in southwest Nigeria namely early dry season (EDS) from September to November, late dry season (LDS) from December to February, early rainy season (ERS) from March to May and late rainy season (LRS) from June to August. This experiment was carried out for two generations and data obtained were analysed using Analysis of Variance in a 2 x 2 x 2 x 4 factorial arrangement. The study showed that most of the body linear measurements investigated increased significantly in the first than the second generation and during the

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ERS and LRS than the EDS and LDS; a significantly higher body weight was recorded in LDS. The linear body measurements and body weight were significantly higher in the cage than the deep litter system in the first generation while animal reared in cage were significantly lower than deep litter system in second generation with respect to these characters. Sex showed no significant effect ($p>0.05$) on the linear body measurements. Production of rabbits during the early dry season is recommended for breeding purpose and the use of the cage system for enhanced slaughter results and carcass quality. Deep litter system is recommended for profit maximization.

Keywords: Rabbit; season; body weight; body measurements; rabbit housing.

1. INTRODUCTION

In recent years, advocacy of "free-range" systems as an alternative to confinement rearing has become a major issue in animal welfare and sustainable agricultural system. Some concerns have also been raised that wire floors are not a suitable substrate for rabbits and may result in increased incidence of ulcerative pododermatitis (sore hocks) [1,2]. Rabbits are traditionally reared in cages after weaning until they reach market age. Perhaps, if such rabbits are reared on deep litter (a low cost housing system), the cost on cages (construction and repairs) can be minimized and the net profit from rabbit rearing can be increased. The information on the performance of rabbits reared on the deep litter system in comparison with those reared traditionally in cages is scanty. Conducive rearing environment is fundamental to optimum growth performance of rabbits and also plays a significant role in the expression of their full genetic potential. The Nigerian climatic environment is characterized by high ambient temperature and relative humidity typical of a tropical region [3], which tends to exert deleterious effect on optimum performance of livestock. Rabbits raised in these tropical environments are thus susceptible to climatic stress, diseases and management problems among others thereby limiting their productivity. Hence, this study was undertaken to find the effect of seasonal variations and housing systems on the growth and linear body measurements of rabbits.

2. MATERIALS AND METHODS

The research was carried out at the Rabbitary Unit of the Teaching and Research Farm, University of Agriculture, Alabata road, Abeokuta, Nigeria. (7º10'N and 3º2'E). The area lies in the South West part of Nigeria and has a prevailing tropical climate with a mean annual rainfall of about 1037mm. The mean ambient temperature ranges from 28ºC in December to 36ºC in February, with a yearly average of 34ºC. The Relative Humidity ranges from 60% in January to 94% in August with a yearly average of about 82% [4]. The vegetation represents an inter-phase between the tropical rainforest and derived savannah. A total of ninety-six (96) weaner rabbits (Chinchilla and New Zealand White crossbred) were used for this study and were divided into forty-eight (48) per generation. These forty-eight rabbits were divided equally into the cage and deep litter systems. Each system consisted of three replicates of four rabbits of each sex. The experiment was conducted in four seasons namely: early dry season (EDS) - September to November, late dry season (LDS) - December to February, early rainy season (ERS) - March to May and late rainy season (LRS) - June to August. The hutches and equipments used were thoroughly washed and disinfected before stocking the rabbits. The wooden cages used for the study have the following dimensions; length: 105 cm, width: 85 cm and height: 60 cm. The wooden cages were placed inside a house, the

walls of which are built, in their lower part, with concrete block and the remaining upper half with wire mesh. The deep litter system was carried out in a similar building like that of the cage system. This house was also washed and disinfected prior to the laying of wood shavings on the floor and stocking of rabbits. The litter was changed regularly to prevent the buildup of pathogens, consequently resulting in disease outbreak. A good hygienic environment was maintained throughout the experiments and all necessary medications were given as routine management practices. Each animal was served 0.1 kg concentrate (Table 1) in the morning followed by 0.1kg of forage such as *Tridax procumbens* or *Euphobia heterophylla* in the afternoon. Water was supplied *ad libitum* throughout the experimental period; weights and linear body measurements were taken weekly. A total of forty-eight weaner rabbits from the litters obtained in the first generation were used to carry out the experiment in the second generation. They were also divided equally into the cage and the deep litter system with equal number of replicates. The experiment was carried out in four seasons as described in the first generation. All the routine and occasional management practices as described for the first generation were observed.

Table 1. Composition of experimental diet

Ingredients	% Composition
Maize	45.00
Wheat offal	36.00
Soya bean meal	6.50
Groundnut cake	7.00
Fish meal	1.00
Bone meal	2.50
Oyster shell	1.50
Premix	0.25
Salt	0.25
Total	100
Calculated Analysis	
Crude protein (%)	17.10
Energy (MJ/kg)	10.89
Crude fibre (%)	4.75
Ether extract (%)	3.76

3. DATA COLLECTION AND STATISTICAL ANALYSIS

The parameters measured to determine the growth performance were average weekly weight gain, pre-weaning and post-weaning daily weight gain. The following linear body measurements were also taken on each animal after weighing: keel length, head length, breast girth, tail length and height at withers. Average weekly weight gain was determined using a weighing scale. Linear body measurements were determined with the use of measuring tape Keel length was measured as the distance between the neck and the beginning of the tail dorsally. Head length was measured as the distance between the tip of the nose and the beginning of the neck and breast girth represented the chest circumference [5]. Tail length was measured from the beginning of the tail to its end; height at withers was measured as the height of the rabbit from the ground level to the peak of the back when standing. The experimental design used was a 2 x 2 x 2 x 4 factorial arrangement in a CRD, and the factors were generations, housing systems, sex and seasons respectively. Data obtained from this study were subjected to analysis of variance (ANOVA) techniques using

least squares [6]. In case of significant effects, means were separated and compared by the Duncan Multiple Range Test at 5% level of probability [7]. Interactions were tested as shown in the statistical model.

3.1 Statistical Model

$$Y_{ijklm} = \mu + A_i + B_j + C_k + D_l + AB_{ij} + AC_{ik} + AD_{il} + BC_{jk} + BD_{jl} + CD_{kl} + ABC_{ijk} + ABD_{ijl} + BCD_{jkl} + ABCD_{ijkl} + \sum_{ijklm}$$

Where:

Y_{ijklm} = Individual observation
μ = opulation mean
A_i = Effect due to i^{th} generation (i = 1,2)
B_j = Effect due to j^{th} housing system (j = 1,2)
C_k = Effect due to k^{th} sex (k = 1,2)
D_l = Effect due to l^{th} season (l = 1,2,3,4)
AB_{ij} = Interactive effect between i^{th} generation and j^{th} housing system
AC_{ik} = Interactive effect between i^{th} generation and k^{th} sex
AD_{il} = Interactive effect between i^{th} generation and l^{th} season
BC_{jk} = Interactive effect between j^{th} housing system and k^{th} sex
BD_{jl} = Interactive effect between j^{th} housing system and l^{th} season
CD_{kl} = Interactive effect between k^{th} sex and l^{th} season
$\sum_{ijklm}$ = Experimental error.

4. RESULTS AND DISCUSSION

The effect of generation and housing system on body weight and linear body measurements is presented in Table 2 as all the growth parameters measured were significantly ($p<0.05$) affected by the generation by housing system interaction. [8] Opined that linear body measurements can be used in assessing growth rate, weight, feed utilization and carcass characteristics in farm animals. It was observed that the values of all the growth parameters were significantly ($p<0.05$) higher in rabbits in the cage system of housing than those in the deep litter system with the head length and body weight recording 12.26cm and 1831.00g respectively in the first generation and higher significant ($p<0.05$) differences were observed in all the mean values of the growth parameters under the deep litter system with the head length and body weight recording 12.19 cm and 1878.00g respectively in the second generation. Linear body measurements were significantly higher in the cage system than in the deep litter during the first generation. This may be attributed to the ability of the experimental rabbits in this generation to be able to utilize their feed very well because nutrient intake has been described as a major determinant of nutritional status and growth performance in farm livestock [9]. Also, the result obtained in this study for the first generation of rabbit is in agreement with [10], they obtained higher weight gains in animals housed in classical cages rather than in pens with floor netting, probably due to increased locomotor activity. It has been suggested that the consumption of litter material is also responsible for the poorer body weight gain of pen-housed animals [11,12]. [13] Deduced that the difference between the body weights of the rabbits in cages and those in pen house (with wheat straw as deep litter) could mainly be caused by the different locomotor activities and mortality.

Table 2. Interactive effect of generation and housing system on body weight and linear body measurements

Parameters	Generation 1		Generation 2		SEM
	Cage	Deep litter	Cage	Deep litter	
Head length (cm)	12.26[a]	11.43[b]	10.94[c]	12.19[a]	0.09
Keel length (cm)	25.10[a]	23.98[b]	23.83[b]	24.95[a]	0.23
Breast girth (cm)	22.07[a]	21.39[c]	21.62[b]	22.15[a]	0.20
Tail length (cm)	8.78[b]	8.54[c]	8.06[d]	8.91[a]	0.09
Height (cm)	11.69[b]	11.41[c]	10.73[d]	11.89[a]	0.13
Ear length (cm)	10.35[a]	9.99[b]	9.30[c]	10.35[a]	0.11
Body weight (g)	1831.00[b]	1469.00[d]	1498.00[c]	1878.00[a]	9.15
Mean weight gain(g/day)	87.62[a]	83.21[c]	83.74[b]	83.93[b]	9.76

a, b, c: Means on the same row with different superscripts are significantly different at ($p<0.05$)

Linear body parameters were better in rabbits housed on the deep litter system compared to those placed in the wooden cage system in the second generation. This was reflected in the significant values of the body weight and the linear body parameters probably suggesting the superiority of the deep litter system over the wooden cage system. This result is not surprising since the deep litter system would reduce environmental stress [14,15] and provide comfort to the feet and legs thus minimizing pododermatitis (sore hocks), [16]. The result is also in agreement with [17] who reported that rabbits held on straw bedded floor showed a higher growth performance than those housed in cages. [18], while studying the effect of housing system (cage versus underground shelter) on performance of rabbits on farms, reported higher growth rates and body weights in rabbits reared in underground shelter, when compared to those reared in cages on account of lower temperatures in underground shelter. Final body weight was much higher for rabbits from generation 2 from the deep litter system, although. Is this because their initial BW was higher? The differences in the weight gain appearing in generation 1 which disappeared in generation 2 may be due to a compensatory effect and also for the fact that their mean weight gain was smaller than those of generation 1 housed in cages. This might also be due to what [19] explained as the "instinctive wisdom" of the rabbit which helps it to select good balanced diet in which the deep litter system enables the rabbit to increase its feed by eating fibrous litter material from the floor to balance its fibre requirements. [20] However stated that higher heat load or stress could be anticipated for the caged rabbits due to the physical response of the rabbits to heat stress associated with the cage system and this might be responsible for this variation.

No significant difference was observed in the means of the growth parameters of both sexes which were similar to the trend observed in the first generation. But the males recorded lower values for head length and height at withers (Tables 3 and 4). Sex effect was not significant on growth performance indicating the absence of sex dimorphism in the experimental rabbits [21]. This result agrees with the investigations of [22-25]. They reported that unlike in most domestic livestock species, sex does not strongly influence growth and carcass characters in rabbits. Similarly, the non-significant housing system by sex interaction indicated that both sexes were well and equally adapted to the deep litter and cage systems.

Generation by season interaction was found to be significant ($p<0.05$) in all the parameters. The lowest and highest values for most of the parameters were recorded in EDS and LRS of the first generation respectively with the exclusion of body weight and mean weight gain (Table 5). In the first generation, an increasing value for head length (9.14 cm, 11.64 cm,

13.01 cm and 13.61 cm in the EDS, LDS, ERS and LRS respectively) was observed. This trend was also observed in other growth parameters of the rabbits but a significantly ($p<0.05$) higher value (601.23g) was observed for body weight in LDS. While in the second generation, the highest values for all the parameters were recorded in ERS except for body weight which had its highest value in LDS (599.23g). The head length, breast girth and body weight in ERS (12.39 cm, 23.15 cm and 567.67 g respectively) compared favorably with their counterparts in LRS (12.41 cm, 22.88 cm and 566.96 respectively); this trend was also observed in EDS (22.63 cm and 7.63 cm) and LDS (22.55 cm and 7.73 cm) for the keel length and tail length respectively.

Table 3. Effect of sex on body weight and linear body measurements in first generation

Parameters	Sex		SEM
	Male	Female	
Body weight (g)	1660.00	1640.00	12.94
Head length (cm)	11.87	11.83	0.09
Keel length (cm)	24.57	24.52	0.24
Breast girth (cm)	21.74	21.71	0.21
Tail length (cm)	8.69	8.63	0.09
Height (cm)	11.60	11.51	0.13
Ear length (cm)	10.23	10.11	0.10

Table 4. Effect of sex on body weight and linear body measurements in second generation

Parameters	Sex		SEM
	Male	Female	
Body weight (g)	1750.00	1707.00	12.94
Head length (cm)	11.55	11.57	0.09
Keel length (cm)	24.47	24.32	0.23
Breast girth (cm)	21.94	21.84	0.20
Tail length (cm)	8.49	8.48	0.10
Height (cm)	11.27	11.36	0.14
Ear length (cm)	9.84	9.81	0.11

The results obtained in this study revealed that the growth parameters of rabbits were significantly higher in ERS and LRS; hence for optimum performance rabbits should be reared between March and August this agrees with the works of [26] that the rainy season remained the best season that favours farmer's productivity. [27] Also confirmed that the best season that favoured productivity in rabbits is the wet seasons due to the abundance of feed and moderately cool temperatures. A higher significant body weight recorded in season 2 was in contrast to that reported in literature. Previous studies have shown that growth performance of rabbits decreased during periods of elevated environmental temperatures [28,29] due to low feed intake, a common phenomenon in heat-stressed rabbits. Such a decline in consumption will consequently impair hormonal equilibrium [30,31] and affect the physiological mechanisms associated with growth.

Table 5. Interactive effect of generation and season on body weight and linear body measurements

Parameters	Generation 1				Generation 2				SEM
	Season 1	Season 2	Season 3	Season 4	Season 1	Season 2	Season 3	Season 4	
Head length (cm)	9.14^{g}	11.64^{d}	13.01^{b}	13.61^{a}	10.43^{f}	11.01^{e}	12.39^{c}	12.41^{c}	0.10
Keel length (cm)	17.21^{g}	23.68^{e}	27.98^{b}	29.31^{a}	22.63^{f}	22.55^{f}	26.73^{c}	25.66^{d}	0.29
Breast girth (cm)	15.78^{g}	20.56^{f}	24.25^{b}	26.31^{a}	20.77^{e}	20.77^{e}	23.15^{c}	22.88^{d}	0.24
Tail length (cm)	5.72^{g}	8.24^{e}	9.97^{b}	10.72^{a}	7.63^{f}	7.73^{f}	9.41^{c}	9.17^{d}	0.12
Height (cm)	7.19^{h}	10.71^{e}	13.78^{b}	14.52^{a}	10.22^{f}	9.98^{g}	12.78^{c}	12.27^{d}	0.17
Ear length (cm)	6.81^{h}	9.58^{e}	11.83^{b}	12.49^{a}	8.90^{f}	8.69^{g}	11.10^{c}	10.62^{d}	0.14
Bodyweight (g)	583.44^{c}	601.23^{a}	571.57^{d}	565.84^{g}	557.02^{h}	599.23^{b}	567.67^{e}	566.96^{f}	18.27
Mean weight gain (g/day)	85.95^{d}	91.57^{a}	79.17^{g}	84.96^{e}	79.63^{f}	89.67^{b}	77.82^{h}	88.22^{c}	13.88

a, b, c: Means on the same row with different superscripts are significantly different at ($p<0.05$)

Key: Season 1 = September – November (Early dry season); Season 2 = December – February (Late dry season); Season 3 = March – May (Early rainy season); Season 4 = June – August (Late rainy season)

5. CONCLUSION

The linear body measurements of rabbits increased significantly in the first generation than the second generation and during the rainy season than the dry season. Also, most of the linear body parameters measured in this study were significantly higher in rabbits housed on the deep litter system while sex had no significant effect on the growth parameters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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