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REGULAR ARTICLES

Growth and reproductive performance of two rabbit breeds reared under intensive system in Ghana

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Abstract A study on the growth and reproductive performance of two rabbit breeds was undertaken. Data on 588 kits and 97 does of California White and 574 kits and 90 does of New Zealand White rabbits reared under hot and humid environment in Ghana were taken. The reproductive performance of the two breeds, in terms of litter size at birth and weaning, litter weight at birth and weaning, kindling interval, age at sexual maturity, and gestation length as influenced by breed, season of kindling (rainy and dry), year of kindling (2005–2012), and parity (first to sixth and over) were determined. The performance of California White in terms of litter size at birth, at weaning, kit weight at birth, and age at first kindling was 5.9±0.2, 4.6±0.1, 54.7±0.4 g, and 159.8±0.2 days, respectively. That of New Zealand White was 5.9±0.1, 5.1±0.1, 55.2±1.0 g, and 159.9±0.2 days, respectively. The results obtained also showed a significant breed effects on kit weight at birth, litter weight at weaning, and mortality; whereas no significant differences ($p>0.05$) were observed between the two breeds regarding the other traits measured. Parity had significant effects ($p<0.05$) on all the growth and reproductive parameters measured with the exception of age at first kindling. Year of kindling also had significant effect on litter weight at birth, kit weight at birth, and at weaning ($p<0.05$) but did not have any significant effect on the age at sexual maturity and mortality. Season also had significant ($p<0.05$) effects on kit weight at birth, gestation length, kindling interval, and mortality with better performance experienced during the rainy season.

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Introduction

Rabbit production in Ghana is gaining momentum and is seen as an important source of income and employment generation. The increasing human population in developing countries especially Ghana, coupled with the ever-increasing demand for animal source of protein which is hardly met from the principal livestock species (cattle, sheep, goats, pigs, and poultry), has, according to Biobaku and Dosunmu (2003) and Fayeye and Ayorinde (2003), made it imperative that attention be shifted to other micro-livestock such as rabbits. The reliance of rabbit production as a source of cheap animal protein in solving the problem of malnutrition cannot be overemphasized. This, according to Ghosh et al. (2008), is attributed largely to the rabbit's high rate of reproduction, early maturing ability, rapid growth rate, efficient feed utilization, and its ability to produce meat of high nutritional value. Its meat is also known to be highly digestible, wholesome, tasty, and low in cholesterol, sodium, and fat but with high protein content (Herbert 2011).

According to Odeyinka et al. (2008), the productive performance of commercial rabbits is largely dependent on the litter size at kindling and the survivability of the kits up to weaning. Additionally, the pre-weaning growth is very critical in meat rabbits due to its impact on the meat produced at the finisher stage of production (Gerencser et al. 2011). Furthermore, genetic and environmental factors have been implicated to influence the reproductive performance of rabbits (Apori et al. 2014; Lazzaroni et al. 2012). However, rabbit production in Ghana is reliant on the use of introduced exotic breeds whose performances are hindered by the warm and humid environments. In Ghana, the prominent exotic breeds are Blue

Vienna, Flemish Giant, Chinchilla, New Zealand White, and California White. Due to the variation in the productivity of these different exotic breeds in the tropics (Oke et al. 2010), it has become necessary to assess the performance of these available breeds under the Ghanaian environments. There has been a paucity or limited information on the productive performance of these breeds. The present study was therefore undertaken to assess the growth and reproduction performances of the California White and New Zealand White breeds (the common meat types) as influenced by year, season, and parity in order to identify which breed would be suitable and how these environmental factors affects efficient rabbit production in Ghana.

Materials and methods

Location of the study

The study was carried out at a private farm in the Awutu-Senya district of the Central Region of Ghana which lies within 5° 44′ N and 0° 54′ W. The area has an average annual rainfall range of between 1000 and 2000 mm. The wettest months within the area are May–June and September–October, while the drier periods occur in December–February and a brief period in August. The climate in the area is generally hot and tropical in nature with average mean annual minimum and maximum temperatures of 20 and 30 °C, respectively, and the relative humidity within the area was between 65 and 80 %.

Management of the animals

Two locally adapted breeds (New Zealand and California Whites) were studied. Each doe and its litter were fed together in their cage until the kits were weaned at 42 days of age. The weaned rabbits were, however, kept in groups of four and five in standard galvanized iron cages measuring 75×45×35 cm and provided with similar management throughout the study period. In the morning, concentrate mixture (16 % crude protein and 2400 kcal metabolizable energy) was given at the rate of 75 g/day up to 6 weeks of age and 100 g/day from 7 to 14 weeks of age. For the lactating does and kits, a concentrate mixture of 200 to 250 g/day was given, according to their body weight and litter size. In addition, the does were supplemented with green fodder of guinea grass, *Euphorbia* spp. and *Desmanthus virgatus*. They were provided with potable water ad libitum. A standard prophylactic endo- and ectoparasitic control schedule was applied. Bucks started their reproductive lives at 8 months of age during which they were assigned to the females for natural mating. Mating was planned to avoid close relatives mating in order to reduce the level of inbreeding.

Data collection

Reproductive and growth performance records on 588 kits and 97 does of California Whites and 574 kits and 90 does of New Zealand Whites obtained from 2005 to 2012 were used. The reproductive performance in terms of litter size at birth and weaning, litter weight at birth and weaning, kindling interval, age at sexual maturity and gestation length as influenced by breed (New Zealand and California Whites), season of kindling (rainy and dry seasons), year of birth (2005 to 2012), and parity (first to sixth and over) were determined. Also, the growth performance in terms of weight at weaning, pre- and post-weaning growth rate as influenced by both the genetic and environmental factors mentioned previously were also determined. All kit weights in each litter were obtained within 24 h following kindling and in groups. To study the effect of season of kindling on both the reproductive and growth performance, the calendar year was divided into two seasons: the rainy season (April–November) and dry season (December–March). Age at sexual maturity was calculated as the age at which the doe had its first kit. Kindling interval was also calculated as the time elapse between two successive kindling. Gestation length was estimated as the period between conception and kindling. Litter size at birth and weaning was determined by counting the number of kits per litter. On the day of kindling, gloved hand was used to pick the kits from one litter from the kindling box and placed on weighing scale. The litter weight was calculated as the weight of the kits from a particular doe. This was done by weighing the kits using a top-loading sensitive electronic balance of 500 g capacity. Weaning weight was taken when the kits were 42 days old, and in this case, they were weighed individually. Growth rate was calculated as the weight gained over a period. After weaning, the body weights were taken individually with a 2 kg capacity sensitive top-loading balance.

Data analysis

A fixed effect model was fitted using the generalized linear model (GLM) procedure of GenStat (Discovery Edition) to investigate the fixed effects of season of kindling (two classes), year of birth (eight classes), parity (six classes), and breed (two classes) on the growth and reproductive performance. Where differences in means were observed, the means were separated using the least significant difference at 5 % level of significance. The statistical model for the birth weight and other reproductive traits was as follows:

$$\mathrm{Yijk} = \mu + \mathrm{Si} + \mathrm{Pj} + \mathrm{Yk} + \mathrm{Bl} + \mathrm{eijkl}$$

Where

Yijkl Any of the reproductive traits
μ Overall mean of the trait
Si Fixed effect of *i*th season of kindling (1, 2)

Pj Fixed effect of jth parity of doe (1, 2, 3, 4, 5, 6+)
Yk Fixed effect of kth year of birth (1, 2…8)
Bl Fixed effect of lth breed (1, 2)
Eijk Random error associated with each observation

Results and discussion

The growth and reproductive performance of the rabbits as influenced by breed, parity, year, and season of kindling are presented in Tables 1 and 2. There were significant ($p<0.05$) breed effects on kit weights at birth, litter size at weaning, and mortality with New Zealand White breeds being superior to their California White counterparts. The New Zealand White breed has been identified as a suitable dam breed due to its favorable maternal qualities (Ozimba and Lukefahr 2009), hence its superior reproductive performance. This agrees with the results of Ghosh et al. (2008) but, however, disagrees with the findings of Sivakumar et al. (2013), Oke and Iheanocho (2011), Das and Yadav (2007), and Kumar et al. (2006) who found no significant differences among similar breeds maintained under similar environments.

The reproductive performances of the two breeds in this present study (Table 1) were comparable to those obtained for similar breeds under similar environments by Kumar et al. (2006) and Sivakumar et al. (2013) in India and Fayeye and Ayorinde (2010) and Akpo et al. (2008) in Nigeria. However, other authors (Das and Yadav 2007; Ghosh et al. 2008; Saidj et al. 2012) found higher values of litter size at birth and weaning among these breeds, under similar climatic conditions. The objective of rabbit farming in Ghana is for meat production, and, therefore, the selection is geared toward growth traits. Looking at the growth performances of the California and New Zealand White rabbits in Ghana, there is the need to incorporate other reproductive traits in future selection programmes so as to realize the full genetic potential of these breeds under the prevailing environment, considering the high fitness (reproductive) traits associated with especially the New Zealand White breed.

Parity of doe is the number of times a doe has kindled. In this present study, parity was found to have significant ($p<0.05$) influence on litter size at birth, kit and litter weights at birth, kindling interval, body weights at 12 and 14 weeks, and post-weaning growth rate (Tables 1 and 2). Litter size was highest at fifth parity but decreased thereafter, an observation which collaborated the findings of Das and Yadav (2007) that after the fifth parity, does lose their reproductive fitness. There

Table 1 The reproductive performances of meat type rabbits as influenced by breed, parity, year, and season of kindling

Effects	No	Litter size at birth/no	Litter size at weaning/no	Litter wt. at birth/g	Kit weight at birth/g	No	Age at first kindling/days	Kindling interval/days	Gestation length/days
Year									
2005	60	5.9±0.1	4.1±0.2	331.5±3.6^{a}	58.7±1.0^{a}	10	160.5±0.5	95.3±1.3	30.6±0.2
2006	58	5.9±0.1	4.7±0.2	320.8±7.8^{ab}	54.9±1.0^{bc}	10	158.4±0.5	93.8±1.0	30.0±0.2
2007	70	6.1±0.1	4.7±0.2	316.0±7.6^{ab}	53.0±1.0^{c}	10	158.8±0.5	95.1±1.2	29.4±0.2
2008	75	5.9±0.1	4.7±0.2	318.3±7.8^{ab}	54.5±1.0^{bc}	15	158.8±0.5	95.0±1.1	30.3±0.2
2009	65	5.9±0.1	4.6±0.2	308.1±7.5^{b}	53.2±1.0^{c}	15	160.5±0.5	92.7±1.0	29.8±0.2
2010	70	6.0±0.1	4.3±0.2	323.6±7.5^{ab}	56.9±1.0^{ab}	10	158.6±0.5	92.3±1.2	30.0±0.2
2011	75	6.1±0.2	4.7±0.2	321.8±8.3^{ab}	54.0±1.0^{c}	8	158.8±0.5	93.4±1.1	30.2±0.2
2012	101	6.1±0.1	4.6±0.2	315.9±7.7^{ab}	52.6±1.0^{c}	12	158.8±0.5	94.5±1.0	30.3±0.2
Season									
Rainy	300	5.9±0.1	4.6±0.1	320.1±4.1	55.4±0.5	56	159.9±0.3	93.5±0.4	29.5±0.2
Dry	274	6.0±0.1	4.5±0.1	319.3±3.7	54.2±0.5	34	159.7±0.3	95.7±0.5	30.5±0.1
Parity									
1st	70	5.9±0.1^{b}	4.8±0.2	313.5±6.5^{c}	53.5±0.8^{b}	15		95.0±0.4	29.6±0.2
2nd	98	6.0±0.1^{b}	4.5±0.2	319.0±6.4^{c}	50.3±0.8^{c}	15		96.5±0.3	30.0±0.2
3rd	85	5.5±0.1^{c}	4.8±0.2	297.5±7.0^{d}	54.5±0.9^{b}	14		95.7±0.4	30.7±0.2
4th	98	6.0±0.1^{b}	4.5±0.2	316.1±6.7^{c}	54.5±0.9^{b}	13		94.4±0.5	30.4±0.2
5th	100	6.4±0.1^{a}	4.4±0.2	341.1±6.7^{a}	58.3±0.9^{a}	20		94.5±0.4	30.0±0.2
≥6th	123	5.8±0.1^{b}	4.3±0.2	330.9±7.0^{b}	57.8±0.9^{a}	13		94.7±0.5	29.7±0.2
Breed									
California	588	5.9±0.2	4.6±0.1^{b}	319.5±2.8	54.7±0.4^{b}	97	159.8±0.2	94.4±0.3	30.1±0.2
New Zealand	574	5.9±0.1	5.1±0.1^{a}	319.2±2.7	55.2±1.0^{a}	90	159.9±0.2	94.6±0.3	30.1±0.1

Means within the same column with different superscripts ($^{a,b,c\ d}$) are significantly different ($p<0.05$)

Table 2 The growth performances of the meat type rabbit as influenced by breed, parity, year, and season of kindling

Effects	No	Weight at weaning/g	Pre-weaning growth wt/g/day	Weight at 12 weeks/kg	Post-weaning growth weight/g/day	Weight at 14 weeks/kg	Mortality/%
Year							
2005	60	600.4±2.2	12.9±0.1	1.3±0.3[a]	16.4±0.4[a]	1.4±0.3[a]	17±0.2[a]
2006	58	601.8±2.3	13.0±0.2	1.3±0.3[a]	15.6±0.4[b]	1.4±0.3[a]	12±0.2[d]
2007	70	605.4±2.2	13.2±0.2	1.3±0.2[a]	16.0±0.4[a]	1.4±0.4[a]	12±0.2[d]
2008	75	602.8±2.3	13.1±0.1	1.2±0.1[b]	14.7±0.4[c]	1.3±0.3[b]	12±0.3[d]
2009	65	602.2±2.2	13.1±0.1	1.2±0.1[b]	14.2±0.4[c]	1.3±0.3[b]	12±0.2[d]
2010	70	598.5±2.2	12.9±0.1	1.3±0.1[a]	16.2±0.4[a]	1.4±0.4[a]	15±0.3[b]
2011	75	602.0±2.4	13.1±0.1	1.3±0.1[a]	15.5±0.4[b]	1.4±0.3[a]	14±0.2[c]
2012	101	600.2±2.2	13.0±0.1	1.3±0.1[a]	15.6±0.4[b]	1.4±0.3[a]	15±0.3[b]
Season							
Rainy	300	602.4±1.0	13.2±0.3	1.3±0.3	15.3±0.2	1.4±0.2	12±0.1[b]
Dry	274	601.1±1.0	13.2±0.3	1.3±0.1	15.5±0.2	1.4±0.1	15±0.1[a]
Parity							
1st	70	601.8±1.9	13.3±0.1	1.3±0.2[a]	15.4±0.3[b]	1.4±0.2[a]	14.0±0.2[d]
2nd	98	600.8±1.9	13.1±0.1	1.3±0.1[a]	16.3±0.3[a]	1.4±0.1[a]	19.0±0.2[a]
3rd	85	596.2±2.0	12.9±0.2	1.3±0.1[a]	15.5±0.3[b]	1.4±0.3[a]	17.0±0.2[b]
4th	98	596.7±2.0	12.9±0.1	1.3±0.2[a]	15.2±0.3[bc]	1.4±0.2[a]	14.0±0.2[d]
5th	100	599.2±1.9	12.9±0.1	1.2±0.1[b]	15.2±0.3[bc]	1.3±0.1[b]	16.8±0.2[b]
≥6th	123	601.7±2.0	13.1±0.2	1.2±0.1[b]	14.7±0.3[c]	1.3±0.3[b]	15.0±0.2[c]
Breed							
CA	588	601.6±0.7	13.0±0.2	1.3±0.2	15.4±0.1	1.4±0.1	18.0±0.2[a]
NZ	574	601.1±0.8	13.0±0.1	1.3±0.1	15.6±0.1	1.4±0.2	15.0±0.2[b]

Means within the same column with different superscripts ([a,b,c,d]) are significantly different ($p<0.05$)

CA California White, *NZ* New Zealand White

is therefore the need to replace old does to ensure increased litter size and hence efficient reproductive performance. In a similar way, litter weight was highest at fifth parity, an indication of the need to replace old does for increased reproductive fitness. The present results agree with earlier observations by Ouyed et al. (2011) and Das and Yadav (2007). Sivakumar et al. (2013), however, did not find any significant effect ($p>0.05$) of parity on the growth and reproductive performances of similar rabbit breeds studied.

The season of kindling had no significant effect ($p>0.05$) on all the reproductive parameters measured which agrees with the observation by Kumar et al. (2006) who also reported a nonsignificant seasonal effect on reproductive performance of California White breeds kept in the high altitude conditions of Tamil Nadu. The results, however, disagree with the observations by Apori et al. (2014) and Iyeghe-Erakpotobor et al. (2005). Differences in performance due to season have been attributed to differences in environmental and nutritional conditions (presence of available feed resources) and mothering ability.

The kindling interval and age at sexual maturity values obtained in this study were comparable to the values (92–96 and 157–162 days) for kindling interval and age at sexual maturity, respectively, obtained for the same breeds kept under similar environments (Sivakumar et al. 2013; Oke and Iheanocho 2011; Singh et al. 2007; Kumar et al. 2006; Chineke et al. 2006; Iyeghe-Erakpotobor et al. 2005). The mean kindling intervals of 94.4 and 94.6 days obtained for California White and New Zealand White in this study were ideal since shorter intervals are desirable to increase number of litters per doe per year. In this present study where the kits were weaned at 6 weeks, and the does allowed a dry period of 1 week and a gestation length of about 8 weeks, the does could kindle about 3.5 times in a year. With an average litter size of 5.9, a doe is expected to produce about 20 kits in a year, making rabbit farming very profitable. The significant ($p<0.05$) seasonal, breed, parity, and year effects on mortality agree with the findings of Sivakumar et al. (2013) and Oke and Iheanocho (2011).

Year of birth and parity significantly ($p<0.05$) influenced the post-weaning growth performance of the kits. However, there was no trend especially regarding effect of year. At the farm, rabbits were slaughtered when they were 14 weeks old with a mature body weight of about 1.4 kg which is far below mature weight of about 2.0 kg obtained for same breeds kept in temperate regions (Pinheiro et al. 2011). There is therefore the need to upgrade so as to realize the full growth potential of these introduced breeds under the tropical environments. With regard to season, it was realized that there were more deaths during the dry season due probably to very low-quality grass for supplementation, albeit insufficient nutrition which could be responsible for the poor pre- and post-weaning survival. Again, the poor post-weaning survival rate experienced in the dry season might be due to the fact that most dams that conceived in the rainy season kindled in the rainy season but weaned kits close to the dry season. These weaned kits had to spend the first part of their adult life (post-weaning) in the dry season when supplementary feed (cut grass) was poor, albeit poor nutrition. In this regard, mating must be timed such that kindling and weaning take place during periods of abundance of fresh and lush grass for supplementation. There were also fewer deaths from the New Zealand Whites as compared to their California White counterparts. This observation agrees with the findings of Das and Yadav (2007) and Oke and Iheanocho (2011) that New Zealand White breeds were more adaptable to the tropical environments.

Conclusion

The growth and reproductive performance of California White and New Zealand White breeds compared favourably with similar studies under the tropical environments, hence their use for meat production could be profitable. The results also showed that in Ghana, efficient and profitable rabbit production could be done throughout the year irrespective of the season provided there would be available feed throughout the year (especially during the dry season). The influence of the non-genetic factors on the performance of the breeds is an indication of the need to incorporate these factors in any future rabbit breed improvement strategy.

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