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Full Length Research

Reproductive, growth and carcass performance of two breeds of rabbit and their reciprocal crosses in the south-south zone of Nigeria

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ABSTRACT: The study was conducted to evaluate reproductive, growth and carcass traits of two breeds of rabbit and their reciprocal crosses. Two purebred Chinchilla (CHA) and New Zealand White (NZW) and their reciprocal crossing; CHA sire x NZW dam (CHA x NZW) and NZW sire x CHA dam (NZW X CHA) were used in the study. Four genotypes "CHA x CHA, NZW x NZW, CHA x NZW and NZW x CHA" were generated to obtain one hundred and twenty-six (126) kittens. The growth traits studied was body weight (BWT) while reproductive traits studied were gestation length (GL), litter size at birth (LSB), litter size at weaning (LSW), average birth weight (ABWT), average weaning weight (AWWT) and percent mortality (% mortality). The carcass traits evaluated were dressed weight, dressing percentage, weights of liver, heart, lungs, kidney, foreleg, thoracic, loin, hind leg and skin. The data obtained were subjected to analysis of variance and significant means were separated using Duncan new multiple range test. The results indicated that genetic group had significant ($p<0.05$) influenced on growth, reproductive and carcass traits performances evaluated. The NZW x CHA genetic group had significantly ($p<0.05$) heavier body weight than the other three genetic groups CHA x CHA, NZW x NZW and CHA x NZW in both the pre-weaning and post-weaning phases of growth. Similar trends were observed for reproductive and some carcass (dress weight, fore leg, thoracic, loin, hind leg and skin) trait performances; the NZW x CH genetic group was superior to every other group. However, percentage mortality was highest in NZW x NZW (50.28±5.78) and lowest in NZW x CHA (5.71±8.69). It was concluded that NZW x CHA had the best performance in most of the traits measured (growth, reproductive and carcass traits) in the study area and therefore using NZW males to cross with CHA females is recommended in the study area to produce rabbits with better performances in term of reproduction, growth and carcass.

Keywords: Carcass, genetic group, growth, reproduction, rabbit, reciprocal crosses.

INTRODUCTION

The population growth in developing countries like Nigeria is rapidly increasing, and the supply of animal protein from conventional livestock species (cattle, sheep, goats, swine and poultry) had become impossible; thus the need for alternative source of protein to meet up the protein requirement of the teaming population. Rabbit production is a veritable way of alleviating animal protein deficiency in Nigeria (Obike and Ibe, 2010). This is because rabbit has immense potentials and good attributes which include high growth rate, high efficiency in converting forage to meat, short gestation period, high prolificacy and relatively low cost of production. In addition, rabbit has very high nutritional qualities which include low fat and cholesterol levels. Its protein level is high (about 20.8%) and its consumption is bereft of cultural and religious biases (Biobaku and Oguntona, 1997).

The production of rabbit meat is based on pure breed selected for meat traits and on their crosses (Maj et al., 2009). As production of livestock directly depends on reproduction, reproductive performance of rabbits becomes an important aspect in determining profitability and economic success of commercial rabbits breeding. Litter size (the number of kits born) is the most important economic character in rabbit production (Nofal et al., 2005; Odeyinka et al., 2008). Litter size is mainly controlled by heredity and can be improved by crossbreeding between breeds (Nofal et al., 2005). Pre-weaning survival percentage of kit rabbits is of vital importance in commercial rabbit farming, where it plays a major role in determining the net financial income of the farms (Rashwan and Marai 2000).

Factors such as breed, season, age and weight of females influence the reproductive performance of animals (Lazzaroni et al., 2012; Szendro, 2008). Cross breeding is one of the fast tools offered to a breeder to improve many traits in farm animals including rabbits (Nofal et al., 2005). The major essence of deliberate selection for breeding is to improve the quantitative traits.

Carcass traits are influenced by the adult weight and the maturity of rabbit at the age of slaughter (Piles et al., 2004). The production of rabbit meat is based on pure breeds selected for carcass traits and on their crosses. Selection for high growth rate in rabbits improves slaughter performance, but carries a high risk of lowering the quality of meat *(*Piles et al., 2004*).* Nofal et al. (2004) reported that genetic group had no effect on the majority of the carcass traits except on slaughter weight. However, Hassanien and Baiomy (2011) observed that though breed differences had no significant effect on most carcass trait, dressing yield of carcass was significantly higher in New Zealand White than Chinchilla breeds.

Several researches have shown that crossing among different strains of rabbits had a significant effect on slaughter weight and carcass traits. Ozimba and Lukefahr (1990) reported that the New Zealand white were generally inferior to Chinchilla pure bred and Chinchilla x New Zealand White cross breed in carcass characteristics. On the other hand, Ortiz Hernandez and Rubio – Luzano (2001) found no significant difference in the carcass composition of New Zealand white and Chinchilla rabbit.

Genetic improvements of animals require a good understanding of basic concepts of animal breeding (Ibe, 1998). Previous works by Fayeye (2013) revealed significant heterosis for growth rate and body weight though at variable values of parental means. Chineke (2006) reported superiority of the crossbreds over pure breeds for mean body weight and linear body parameters. Rochambeau (1988) in a study conducted to compare pure breed rabbits and the terminal crosses involving these breeds, observed heteroic effect on litter growth rate. In similar experiment, Oseni et al. (1999) reported that crossbred rabbits showed superior performance over pure breeds in all pre-wearing litter traits studied. These findings suggested that cross breeding under tropical condition hold some promise in improving performance traits in rabbits.

Reciprocal crossing is the crossing between two or more breeds of animals in which their roles as male or female are reversed. Reciprocal crossing has been recognized as another feasible route to the economic exploitation of different breeds of rabbit (Kabir et al., 2016). There is paucity of information regarding effect of reciprocal crossing on reproductive, growth and carcass performance of rabbit breeds in south-south Nigeria; majority of the researches conducted concentrated on direct crossing of two or more breeds. Therefore, this study was conducted to evaluate reproductive, growth and carcass performance of two breeds of rabbits and their reciprocal crosses.

MATERIALS AND METHODS

Experimental site

This experiment was carried out at the Rabbitary Unit, Teaching and Research Farm, Akwa Ibom State University, Obio Akpa Campus. Obio Akpa is located between latitudes $5^{0}17^{1}$N and $5^{0}27^{1}$N and between longitudes $7^{0}27^{1}$E and $7^{0}58^{1}$E with an annual rainfall ranging from 3500 to 5000 mm, average monthly temperature of 25^{0}C, and relative humidity between 60 to 90% (Wikipedia, 2017).

Experimental animals and management

The rabbits used in the experiment were purchased from reputable rabbit farms in Uyo metropolis, Akwa Ibom state, Nigeria. On arrival, the rabbits were allowed to acclimatize for two weeks to the environment before commencing the study. The animals were given ivomectin injection subcutaneously to treat both external and internal parasites that may affect their reproductive performance. They were also treated prophylactically with Amprolium 200 for one week against Coccidiosis given via drinking water. Multivitamins were also given to the rabbits to boost them up for the study. Every other care as applicable to international, national and University guidelines for the care and used of animals were followed (SAMRC, 2004).

A total of forty (40) adult rabbits (New Zealand White and Chinchilla) comprising eighteen (18) New Zealand White does and eighteen (18) Chinchilla does, two (2) New Zealand White bucks and two (2) Chinchilla bucks were used. One New Zealand White buck was used to mate with nine New Zealand White does and the second New Zealand buck was used to mate with nine Chinchilla does. While one Chinchilla buck was used to mate with nine Chinchilla does and the second Chinchilla buck was used to mate with nine New Zealand White does. At the end of

Table 1. Mating scheme and number of progeny produced.

Genotype	Number of sire	Number of Dam	Number of Progeny
CH X CH	1	9	35
NZW X NZW	1	9	27
CH X NZW	1	9	31
NZW X CH	1	9	33

Note: CH = Chinchilla; NZW = New Zealand White.

breeding period, one hundred and twenty six (126) kits produced from crosses comprising of NZW x NZW, CHA x CHA, NZW x CHA and CHA x NZW (Table 1) were produced. The rabbits were kept in 4 hutches each measuring 170 cm by 32 cm and consisting of 10 cells, each of which measured 34 cm x 30 cm x 28 cm such that one rabbit was accommodated in one cell. Identification marks such as tags were placed on the cell in which each rabbit was accommodated.

All the rabbits in their respective cells were fed with forages such as *Ipomea batata*, *Centrosema spp*, *Peuraria phaseoloides* and commercial concentrates feed was also given with drinking water *ad-libitum*. The diet fed to the animals consisted of 18% CP, 2600 Kcal/kgME, and 8% CF as analyzed. Routine management operations were carried out on a daily basis. Pregnancy was detected by careful abdominal palpation on 14th and 21s^{t} days after mating, if confirmed pregnant, nest boxes were provided on 28th day of pregnancy.

Data collection

Measurement of reproductive and growth performance

Gestation length: This was measured by finding the interval between the date of last mating and date of kindling.

Litter size at birth: This was measured by direct counting of the kits immediately after kindling with still birth inclusive.

Litter size at weaning: This was the number of weaner's (young rabbits) in each litter at weaning time (6 weeks).

Birth weight: This was measured by transferring all the kits in a litter with gloved hands well rubbed on the body of the doe in question to the weighing scale. And the weight of the litter read off and divided by the total number of kits in the litter.

Body weight at weaning: This was measured by taking the weight of each kit in a litter at weaning time (6 weeks).

Weekly body weight: This was measured by weighing each kit in a litter on weekly basis for a period of twelve weeks using a measuring scale.

Measurement of carcass traits

The carcass evaluation was based on the method according to Larzul and de Rochambeau (2004). Five rabbits per genetic group (25 in all) were randomly selected and starved for twelve hours prior to slaughtering. The rabbits were killed by striking a hard, quick blow on the skull using one hand (to render the rabbit unconscious) before cutting the jugular vein to allow for free flow of blood. The head was later removed. The next step was to cut the fur around the hock joints of the hind shank to enhance proper skinning. After skinning evisceration took place by making a sharp clean incision down the abdomen, with care to ensure that the internal visceral were not punctured. Then the visceral organs were pulled out leaving the liver, kidneys and heart in place. Dressing percentage was calculated as the ratio of dressing weight to live weight. The eviscerated carcasses were weighed and divided into the following primal cuts.

Fore shank (including thoracic insertion muscle), thoracic cage (including first seven ribs without the insertion muscles of the forelegs), hind leg (including the sacral bone and the lumbar vertebrate after the 6th lumber vertebra) and internal organs (liver, heart, lung and kidney) weights were taken individually and calculated as % of live weight. The weights of the skin were also recorded. Sensitive weighing balance (S. Miller Digital Scientific Scale) was used in weighing the carcass parts. All reproductive and growth traits measurements were carried out early in the morning (6.00 am) before feeding.

Statistical analysis

The effect of sire breed and dam breed on reproduction, growth performance and carcass traits (gestation length, litter size at birth, birth weight, litter size at weaning, body weight at weaning, weekly body weight and carcass parts) were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Statistical Package for Social Science (SPSS) version 17.0 (2008). Significant means were separated using New Duncan Multiple Range Test. The model incorporated genetic

Table 2. Means (± s.e) Body weight (g) performance of 2 breeds of rabbit and their crosses.

Age (weeks)	CHA × CHA (g)	NZW × NZW (g)	CHA × NZW (g)	NZW × CHA (g)
1	84.62 ± 5.33^{c}	133.30 ± 3.39 ^{b}	111.75 ± 1.285^{c}	145.23 ± 4.39^{a}
2	127.83 ±7.09^{c}	182.61 ± 4.18^{b}	146.160 ± 2.96^{c}	201.08 ± 3.85^{a}
3	190.12 ±10.77^{c}	267.77 ± 11.16^{b}	188.20 ± 2.94^{c}	315.48 ±15.11^{a}
4	326.59 ±14.91^{c}	397.53 ± 9.09^{b}	266.60 ± 6.08^{c}	468.09±13.87^{a}
5	364.57 ± 16.77^{c}	445.88 ± 8.57^{b}	335.76 ± 6.06^{c}	522.26 ±12.82^{a}
6	418.78 ± 16.57^{c}	492.88 ± 7.554^{b}	394.04 ± 8.07^{c}	594.55±12.18^{a}
7	515.61±13.37^{b}	536.75±12.84^{b}	444.96 ± 7.60^{c}	654.86 ± 13.89^{a}
8	560.00±13.03^{b}	590.25±11.54^{b}	478.80 ± 9.63^{c}	727.34 ± 1 8.77^{a}
9	636.03±10.00^{b}	642.35±10.32^{b}	501.00 ± 10.07^{c}	816.23 ± 15.01^{a}
10	713.41±12.93^{b}	698.24±13.42^{b}	560.63 ± 10.00^{c}	939.72 ± 17.27^{a}
11	755.61±13.71^{b}	780.56±14.52^{b}	585 ± 11.98^{c}	1100.82 ± 18.16^{a}
12	877.40 ±46.09^{b}	843.40 ± 63.09^{b}	615.20±36.64^{c}	1210.00 ± 74.43^{a}
Mean	464.21 ± 73.93^{ab}	500.94±65.61^{ab}	385.67±50.50^{b}	641.30±97.47^{a}

Mean with different superscripts in the same row are significantly different (p<0.05), CH = Chinchilla; NZW = New Zealand White.

groups as fixed factors while reproduction, growth performance and carcass traits (gestation length, litter size at birth, birth weight, litter size at weaning, body weight at weaning, weekly body weight and carcass parts) were dependent variables. The linear model was as follows:

$Y_{ij} = \mu + Bi + E_{ij}$

Where: Y_{ij} = measurement on traits, μ = population mean, B_i = effect of ith genetic groups (CHA x CHA, NZW x NZW, NZW x CHA, and CHA x NZW) and E_{ij} = random error effect (Kaps and Lamberson, 2004).

RESULTS AND DISCUSSION

Production traits

The mean weekly body weights of kits from the four genetic groups are presented in Table 2. The result showed that NZW X CHA genotype had significantly (p<0.05) higher weight (145.23 g) followed by NZW X NZW (133.30 g) and CHA X NZW (111.75 g) which were statistically similar; while CHA X CHA had the least weight (84.62 g) at the end of week one. At week two, NZW X CHA still showed significantly (p<0.05) higher body weight (201.08±3.85 g) than other genetic groups. CHA X CHA and CHA X NZW which were statistically similar and had significantly (p< 0.05) lower body weight (127.83±7.09 and 146.160±2.96 g, respectively) than NZW X NZW (182.61±4.18 g). This trend was observed throughout the pre-weaning period of 6 weeks. The post weaning phase of growth still indicated that NZW X CHA genetic group was significantly (p<0.05) superior in body weight to other genetic groups studied. CHA X CHA and NZW X NZW were statistically similar and significantly (p<0.05) higher than CHA X NZW. The overall means of body weight in the four genetic groups were estimated at end of the experiment using the values of weeks 1 to 12 as replicates (Table 2). The results indicated that CHA X CHA, NZW X NZW and NZW X CHA (464.21±73.97, 500.94±65.61, 641.30±97.47 g respectively) were statistically similar and significantly (p<0.05) superior to CHA X NZW (385.67±50.50 g). However, NZW X CHA still showed higher performance numerically, indicating that this genetic group is best suited in the study area.

The result obtained from this study are similar to those reported by Ologbose et al. (2018) and Oke et al. (2010) who all observed significant differences in body weight of different breeds of rabbits. But the results of this study on body weight performance is contrary to the reports of Ozimba and Lukefahr (1991) who observed no significant differences for growth traits of different breeds of rabbit in a comparative study. The animals increased in body size and other body dimensions as they grew in age indicating that, the animals were in normal physiological and health conditions. Ologbose et al. (2018) had earlier indicated that the genotype and environmental factors such as nutrition, disease, and general management could lead to variation in growth rate or weight gain of rabbit within the same breed or among different breeds. However, variation in body weight in this study could be as a result of genetic variation in the various genotypes used. Body weight is said to be highly heritable (Ologbose et al., 2018) and hence, the selection of heavier individuals in a population should result in genetic improvement of the trait.

Reproduction traits

The means of the reproductive traits of the four genetic groups of rabbit are presented in Table 3. The results indicate that there were no significant (p>0.05) differences among the genetic groups in litter size at birth (LSB). The

Table 3. Means (± s.e) of reproductive traits of 2 breeds of rabbit and their crosses.

Age	CHA × CHA	NZW × NZW	CHA × NZW	NZW × CHA
LSB(g)	5.83 ± 0.98	5.50 ± 0.34	4.50 ± 0.67	5.17 ± 0.67
LSW(g)	4.30 ± 0. 89^{b}	2.67 ± 0.21 ^{b}	4.00 ± 0.52^{b}	4.95 ± 0.54^{a}
ABWT(g)	32 .55 ± 0.02^{b}	35 50 ± 0.01^{b}	33. 05 ± 0.01^{b}	37.00 ± 0.03^{a}
GL(days)	31.67 ± 1.14^{a}	31.37 ± 0.67^{a}	30.50 ± 0.56^{b}	28.33 ± 0.67^{a}
AWWT(g)	418.78 ± 16.56^{b}	532.88 ± 7.56^{b}	394.04 ± 8.07^{b}	594.55 ±12.18^{a}
% MORT	25.10 ± 3.87^{b}	50.28 ± 5.78^{a}	8.87 ± 4.05^{c}	5.71 ± 8.69^{c}

Mean with different superscripts in the same row are significantly different (p<0.05), LSB = Litter size at birth, LSW=litter size at weaning, ABWT= average birth weight, AWWT= average weaning weight, CH = Chinchilla; NZW = New Zealand White.

result of this study is contrary to reports of Fadare and Fatoba (2018) who observed significant differences between genetic groups in litter size between Califonia white, New Zealand white, Havana black and Palomina brown in Akoko South West Local Government Area of Ondo state, Nigeria. However, it agrees with the work of MaryKutty and Nandakumar (2000) who reported non-significant effect of breed on litter size and litter weight at births among New Zealand White, Grey Giant and Soviet Chinchilla under humid tropics of Kerala, India.

Significant (p<0.05) differences were observed among genetic groups in litter size at weaning (LSW); ZW X CHA crosses had significantly (p<0.05) higher litter size at weaning (4.95±0.54) than other genotypes which were similar statistically. The average birth weight (ABWT) also followed the same trend as litter size at weaning. The kits from NZW X CHA crosses had significantly (p<0.05) heavier body weight at birth, while other genotypes were similar. Litter size at weaning is considered to be the best trait to use as selection criteria for improving reproductive performance (Moustafa et al., 2014; Fadare and Fatoba (2018). This is because the productivity of rabbit depends primarily on the number of young kits surviving the pre-weaning stage. The ability of the doe to produce thrifty young at birth and to raise this young to weaning determines her productivity (Sorensen et al., 2001). Thus, to maintain efficiency in rabbit production, high litter size at weaning is necessary. The report from this study is in line with the reports of Fadare and Fatoba (2018) who observed that litter size and litter weight at weaning were affected by breed.

The best gestation length (shortest) of 28.33±0.67 days was recorded for NZW X CHA crosses which was significantly (p<0.05) different from other genotypes which were statistically similar (31.67±1.14, 31.37±0.67 and 30.50±0.56 days) for CHA X CHA, NZW X NZW and CHA X NZW, respectively. Variations in gestation length of rabbit due to differences in breed had earlier been reported by Apori et al. (2015).

The result (Table 3) indicated that there were significant (p<0.05) differences between the genetic groups in percentage mortality. It was observed that NZW X NZW genetic group had the highest percentage mortality (50.28±5.78%) followed by CHA X CHA genetic group (25.10±3.87%); the crosses CHA X NZW and NZW X CHA genetic groups had similar (p>0.05) percentage mortality, 8.87±4.05 and 5.71±8.69%, respectively. The high percentage mortality observed in NZW X NZW genetic group could be attributed to poor mothering ability, which could have resulted from inability of the does to produce sufficient fur in the nesting boxes for the naked kits at birth. It may also be attributed to tropical environmental condition which may not favour the genotype. Earlier reports by Topczewska et al. (2013) and Fadare and Fatoba (2018) indicated variation between rabbit breeds in percentage mortality. The results also indicate better survivability of the crossbred than the purebreds. This may be attributed to good mothering ability of Chinchilla does to their kits, and maybe they were able to acclimatize to the experimental site a little better than other genetic groups used.

Carcass traits

The results of carcass performance according to genetic group (CHA X CHA, NZW X NZW, CHA X NZW and NZW X CHA) are presented in Table 4. The results indicate that mean values obtained for dressing percentage, liver, heart, lungs and kidney were not significantly different (p>0.05) and were within normal ranged expected of normally reared rabbits (Ekpo et al., 2016). Dressing weight was significantly (p<0.05) influenced by genetic groups. The NZW X CHA genetic group had higher dressed weight (636.40±3.93 g) than other genetic groups. It was followed by NZW X NZW (447.00±2.19 g) which was significantly (p<0.05) higher than CHA X CHA and CHA X NZW (379.20±41.98 and 301.20±0.17g) which were statistically (p>0.05) similar. The foreleg, thoracic, loin, hind leg and skin were equally influenced by genotype. NZW X CHA genotype recorded significantly (p<0.05) higher values of these parts than the other genetic groups. Various authors had earlier reported significant differences between rabbit breeds and cross breeding combinations of different origin for carcass traits (Ouyed and Brun, 2008; Bawa et al., 2009; Kabir et al., 2016). The variation observed in the present study with respect to live bodyweight, dress weight, foreleg, thoracic, loin, hind leg

Table 4. Means (± s.e) of carcass traits of 2 breeds of rabbit and their crosses.

Parameters	Genotypes			
	CHA X CHA	**NZW X NZW**	**CHA X NZW**	**NZW X CHA**
BWT(g)	877.40 ± 46.09^{b}	843.40 ± 63.09^{b}	615.20 ± 36.64^{c}	1210.00 ± 74.43^{a}
Dress weight(g)	379.20 ± 41.98^{c}	447.00 ± 2.19^{b}	301.20 ± 3.17^{c}	636.40 ± 3.93^{a}
Dressing %	43.66 ± 3.07	52.53 ± 2.19	49.15 ± 5.39	51.96 ± 3.93
Liver(g)	2.63 ± 0.13	3.20 ± 0.26	3.02 ± 0.17	2.23 ± 0.21
Heart(g)	0.39 ± 0.05	0.35 ± 0.24	0.35 ± 0.23	0.34 ± 0.20
Lung(g)	0.64 ± 0.04	0.94 ± 0.08	1.00 ± 0.12	0.64 ± 0.12
Kidney(g)	0.97 ± 0.04	0.98 ± 0.06	0.81 ± 0.07	0.67 ± 0.06
Foreleg(g)	29.80 ± 3.35^{b}	29.80 ± 3.10^{b}	24.80 ± 2.08^{b}	39.40 ± 1.07^{a}
Thoracic(g)	57.00 ± 5.32^{b}	63.00 ± 5.48^{b}	49.80 ± 4.38^{b}	115.00 ± 10.48^{a}
Loin(g)	89.40 ± 16.46^{b}	97.00 ± 15.70^{b}	62.20 ± 4.16^{b}	110.00 ±7.58^{a}
Hind leg(g)	67.20 ± 7.95^{b}	75.00 ± 4.42^{a}	55.20 ± 3.54^{b}	77.00 ± 3.39^{a}
Skin(g)	77.60 ± 6.14^{b}	74.00 ± 7.31^{b}	67.40 ± 37.42^{b}	97.60 ± 1.86^{a}

Row means under the same factor with different superscripts differs significantly ($p<0.05$), CH = Chinchilla; NZW = New Zealand White.

and skin with NZW X CHA being significantly better than other genetic group is at variance with the reports of Oke et al. (2010) and Kabir et al. (2016) who observed higher mean values for live body weight and carcass weight in the CHA X NZW crossbreed. This could be attributed to environmental conditions of the different locations in which the studies were carried out. The non – significant differences observed for weights of liver, heart, lungs and kidney among the genetic group is in line with the reports of Kabir et al. (2016). However, it has been stated earlier by Kabir et al. (2012) that values of carcass traits are difficult to be compared objectively with reports in literature because of differences in pre-slaughter weights, breeds, methods of slaughter and evaluations as well as the statistical model used.

Conclusion

NZW X CHA had a significantly higher performance in body weight at all phases of growth (pre-weaning and post-weaning). Reproductive parameter measured (LSB, LSW, ABW, GL, AWWT, % mortality) as well as carcass traits also indicated that NZW X CHA genetic group was significantly superior to others. Therefore, the NZW x CHA genotype is best suited in the south-south zone of Nigeria and is recommended for rearing by farmers to help in mitigating the problem of animal protein deficiency of individuals in the study area.

CONFLICT OF INTERESTS

Authors have declared that no conflicting interests exist.

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