Nigerian J. Anim. Sci. 2022, 24 (3): 79-90

Some productivity indices of heterogeneous rabbits under a pastured system

Oseni, S. O*. and Bashiru, H. A.

Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife, 220005, Osun State, Nigeria

***Corresponding Author:** soseni@oauife.edu.ng/ **Phone Number:** +2348066581894*

***Target Audience:** Rabbit breeders, animal geneticists, academia, researchers.*

Abstract

The study evaluated the productivity indices of heterogeneous rabbits under a pastured system. Data on 56 litters across three parities from 5 bucks and 22 does were analyzed. Fertility, reproductive and growth performance traits included number of mating per conception (NMC), litter size at kindling (LSK), litter sizes and weights at 7, 14, 21, 28, and 56-day post-kindling, survival rate (SR) and daily weight gain of kits from kindling to weaning. Data were analyzed using the General Linear Model (GLM) procedure of SAS®. A linear model that included fixed effects of LSK classes (low, medium and high), doe weight at conception (light, medium and heavy does) and parity (1^{st}, 2^{nd} or 3^{rd}) was used. Results showed that superior growth and reproductive performance in terms of LSK and number born alive were obtained in later parities (parities 2 and 3). Kit weight and daily gain at kindling and at 7, 14, 21, 28 and 56 d were significantly higher in low-sized litters when compared with medium- and large-sized litters ($P<0.05$). It was concluded that genetic improvement programmes for heterogeneous rabbit population should consider traits such as LSK, doe weight at conception, and VNB at kindling, for optimum productivity and that smallholder and commercial rabbit farmers should also consider these traits to maximize profits under low input systems.

***Key Words:** Doe productivity index; Heterogeneous rabbits; Litter size at kindling; Kit weight; Kit survival*

Description of Problem

Scientific reports on the performance evaluation of heterogeneous rabbits under conventional housing (cage system) abound [1, 2 and 3]. However, reports on the performance evaluation of these stocks under alternative systems (e.g. pastured system) are scanty. With the legislation on cage systems for livestock in Europe to promote humaneness, welfare and overall wellbeing of animals [4], it becomes expedient to explore and assess the performance of rabbits under pastured systems. Such assessments could be hinged on a number of explanatory variables including sire groups, doe body weight at conception, volume of nest built by the doe prior to kindling, as well as doe parity, under a pastured rabbit system. In particular, while nest building by the doe prior to kindling is critical to kits' survival [5,6], few studies have assessed the effect of the volume of nest built by the doe on pre-weaning litter traits. Therefore, the objective of the study was to evaluate the effect of doe body weight at conception, litter size at kindling, sire group, volume of nest built by the doe before kindling and parity on litter performance, kindling interval and annual doe productivity indices of a heterogeneous population of rabbits under a pastured rabbit system in Ile-Ife, southwestern Nigeria.

Materials and Methods

Experimental Location

This study was conducted at the Pastured Rabbitry Unit, Obafemi Awolowo University, Ile-Ife, Nigeria. Ile-Ife ecologically typifies the hot and humid tropical forest zone. The City has an undulating terrain underlain by metamorphic rocks and characterized by two types of soils, deep clay soils on the upper slopes and sandy soils on the lower parts. It has a mean rainfall of 1,000–1,250 mm usually from March through October and a mean relative humidity of 75% to 100% [7].

Experimental Animals

Rabbits for this study were obtained from composite populations reared in Ede and Ile-Ife, Osun State, southwestern Nigeria. Five bucks and 22 does of 6 to 7 months of age (non-specific crosses of California White, New Zealand White, Chinchilla, Flemish Giant, and Himalayan) and weighing between 1.6 and 2.8 Kg were used. Ethical care and guidelines for the use of animals in experiments were strictly followed.

Animal Care and Management

The pastured rabbit plot (Figure 1) is a rectangular area of 80 m × 45 m in dimension. The fence is made of bamboo sticks and reinforced with galvanized fencing wire such that it would prevent invasion by snakes or rodents. Drained (used) engine oil was sprayed on the bamboo sticks and applied around the plot to prevent infestation by termites and soldier ants, a perennial problem in the experimental site. The base of the fence was concretized about one-foot deep into the ground to prevent rabbits from digging out.

All the rabbits were housed individually in cages of dimension 76 × 62 × 42 cm, placed on the pasture with grasses including *Panicum maximum, Ipomoea involucrate, Desmodium scorpuirus, Pueraria phaseloides, Plastostoma africanum and Leptochloaca erulesscens*. All animals were identified by ear tattoo and cage tagging. The cages were made of galvanized wire mesh. Each cage has an aluminum tray for feeds while water was supplied automatically via water nipples. Cages were rotated within the pasture area weekly so the rabbits can have access to fresh pasture.

Mating was routinely done in the morning. The does were randomly assigned to bucks at the ratio of 4:1 respectively. Twenty-two does were randomly allocated to five sire families. Each doe was taken to the cage of the buck and after mating, the doe was returned to her cage. Pregnancy tests were conducted 14-day post-mating by abdominal palpation. Non-gravid does were re-mated immediately. Five days to the expected kindling date, kindling boxes (measuring 40cm × 20cm × 20 Cm) were washed, disinfected, dried and placed inside the cages of gravid does. At kindling, the litter was inspected, and dead kits were removed. Does and bucks were fed supplementary concentrate pellets at 100g/adult animal/day. The gross and proximate composition of the supplementary concentrate pellets are presented in Table 1.

Figure 1: Pastured Rabbit Unit at Obafemi Awolowo University, Ile-Ife, Nigeria

Table 1: Composition of supplementary diet fed to experimental rabbits

Ingredients	Composition (%)
Maize	34.0
Wheat offal	32.0
Soybean meal	5.0
Palm kernel cake	23.8
Oyster	2.0
Bone meal	2.0
Methionine	0.1
Lysine	0.1
Premix	0.25
Salt (NaCl)	0.25
Fish meal	0.5

Proximate composition: Dry matter =90.95%; Ash =8.14%; Crude fibre =5.9%; Ether extract =7.8%; Crude protein =24.3%

Data collection

A summary of the records taken included number of matings to conception, gestation length, and live litter size and weight at kindling and subsequently at weekly intervals till weaning at 5 weeks and

thereafter, up to 8 weeks of age. In addition, records of litter weights, weekly gains and survival rates across the same intervals were taken consistently across three parities. Data collected also included doe body weight at conception (DWC; three classes: DWC≤1800 g; DWC >1800g but <2200 and DWC>2200 g), sire group (5 sire groups), parity (3 parities) and volume of nest built (4 classes: none, scanty, moderate and full). Litter size at kindling (LSK) classes were defined as low for LSK≤3 kits, medium for LSK of 4 to 5 kits and high for LSK≥5 kits, while survival rate (SR) was defined as litter sizes at 7, 14, 21, 28 and 56-day post-kindling, relative to the initial LSK.

Data analysis

Data were analysed using the GLM procedure of the Statistical Analysis System [8]. To evaluate factors affecting weight and survival traits (e.g. kit weight at kindling and kit weight at weaning and survival rate), the following fixed model was fitted:

$Y_{ijklm}=\mu + DWC_i + SG_j + P_k + LSK_l + VNB_m + \epsilon_{ijklmn}$, where Y_{ijklm} represents the response variable; μ is the overall mean, DWC is the doe body weight at conception, SG is the sire group, P is the parity group, LSK is the litter size at kindling category, VNB is the volume of nest built category at kindling and ϵ_{ijkl} the random error.

For Number of Mating per Conception (NMC), gestation length (GL) and prolificacy, the following fixed model was fitted:

$Y_{ijkl}=\mu + DWC_i + SG_j + P_k + \epsilon_{ijkl}$

where all the effects were defined as previously in the previous model. Comparison of means of response variables was done using the Duncan Multiple Range test as outlined by Steele *et al*. [9]. Productivity indices were calculated as follows:

(a) Number weaned/doe/year = Average litter size at weaning × number of litters/doe/year

(b) Number of fryers/doe/year =Average number weaned/doe x numbers of litter/doe/year x weaning survival

(c) Annual fryer yield (kg)/doe/year = Total number of fryers/doe/year × live market weight (kg)

(d) Kg meat/doe/year = Annual fryer yield (kg)/doe/year x dressing percentage

(e) DPI= $\frac{\text{LSW x PWS (\%) x MSW (kg) x DP (\%) x 365}}{\text{KI (days)}}$, following Oseni *et al*. [10]

Where

DPI = Doe productivity index

LSW =Average litter size at weaning

PWS= Post weaning survival (85% of LSW)

MSW =Mean slaughter weight (2.0 Kg)

DP= Dressing percentage (55%)

KI =Mean kindling interval (days)

Results

Effect of sire group, doe weight at conception, parity, litter size at kindling and volume of nest built on pre-weaning growth performance

Table 2 shows the effect of sire group, doe weight at conception, parity, litter size at kindling and volume of nest built on litter weight at kindling, mean kit weight at kindling and at 28 and 56 days post-kindling, and daily gain from kindling to 56 days. There were significant effects of sire group ($P<0.05$) on kits' weight at kindling and at 28 and 56 days, and daily gain from kindling to 56 days. This indicated differences in kits' growth performance due to sire group effects. Doe weight at conception had a significant effect on litter weight at kindling ($P<0.001$). However, this effect was not significant ($P>0.05$) on other parameters evaluated. Parity had a significant effect

($P<0.05$) on all pre-weaning growth parameters evaluated with higher values obtained in the third parity, followed by the second parity. This indicated that multiparous does performed better than primiparous does with respect to all pre-weaning growth traits evaluated. Further, the LSK category significantly affected all pre-weaning growth performance traits evaluated. Kits from to low LSK category (≤ 3 kits) consistently had significantly higher growth performance while kits from large LSK category (> 5kits) consistently recorded lower growth performance.

Table 2: Effect of sire, doe weight at conception, parity, and litter size at kindling on pre-weaning growth performance traits of heterogeneous rabbits raised under a pastured rabbit system

	Litter weight at kindling (g)	Mean kit weight at kindling (g)	Mean kit weight at 28 days (g)	Daily gain to 28 days (g)	Mean kit weight at 56 days (g)	Daily gain to 56 days (g)
Sire group						
M01	211.25^{c}	37.169^{b}	217.88^{b}	7.78^{b}	548.45^{ab}	9.78^{ab}
M02	237.75^{abc}	46.689^{a}	276.69^{a}	9.88^{a}	589.36^{a}	10.52^{a}
M03	250.83^{ab}	38.391^{b}	223.27^{b}	7.98^{b}	554.56^{ab}	9.90^{ab}
M04	263.73^{a}	46.462^{a}	274.47^{a}	9.80^{a}	601.25^{a}	10.73^{a}
M05	218.83^{c}	39.028^{b}	241.22^{ab}	8.60^{ab}	523.75^{b}	9.34^{b}
P value	0.0109	0.0004	0.0265	0.0311	0.0374	0.0215
Doe weight at conception (g)						
Low (≤1800)	218.45^{b}	41.88	262.05	9.35	556.60	9.93
Medium (1801-2200)	231.96^{b}	42.32	268.27	9.58	564.88	10.08
High (>2200)						
	304.67^{c}	43.77	269.58	9.62	559.17	9.98
P value	<.0001	0.2102	0.366	0.544	0.512	0.633
Parity						
1	192.21^{c}	40.404^{b}	228.76^{c}	8.17^{b}	456.88^{c}	8.16^{c}
2	242.67^{b}	43.290^{a}	250.34^{b}	8.91^{ab}	589.14^{b}	10.52^{b}
3	280.79^{a}	44.158^{a}	274.60^{a}	9.87^{a}	672.28^{a}	12.01^{a}
P value	<0.0001	0.0174	0.0022	0.0441	0.0001	0.0201
LSK category						
Low (≤3)	270.54^{a}	56.50^{a}	332.08^{a}	11.86^{a}	697.29^{a}	12.45^{a}
Medium (4-5)	211.83^{b}	47.47^{b}	281.50^{b}	10.05^{b}	602.56^{b}	10.76^{b}
High (>5)	137.20^{c}	37.73^{c}	225.45^{c}	8.04^{c}	459.76^{c}	8.21^{c}
P value	<.0001	<.0001	0.0001	0.0001	0.0001	0.0001
Volume of nest built						
None (1)						
Scanty (2)	210.50^{b}	37.22^{b}	226.89^{b}	8.10^{b}	496.16^{ab}	8.86^{ab}
Moderate (3)	212.25^{b}	37.08^{b}	230.52^{b}	8.24^{b}	454.72^{b}	8.12^{b}
Full (4)	237.60^{ab}	44.89^{a}	271.38^{a}	9.70^{a}	515.88^{a}	9.21^{a}
	259.21^{a}	48.27^{a}	279.42^{a}	9.96^{a}	524.02^{a}	9.36^{a}
P value	0.0171	0.0186	0.0218	0.0311	0.0152	0.0186

Effect of sire, doe weight at conception and parity on reproductive parameters

Table 3 presents the effect of sire, doe weight at conception, and parity on LSK, NBA, NMC, and GL. There were significant differences among sire groups and across parities (P<0.05) for LSK and NMC. Further, parity and doe weight at conception had significant effects (P<0.05) on LSK and NBA. However, doe weight at conception and parity had no significant effects (P>0.05) on the NMC. Similarly, SG, DWC and parity had no significant effect (P>0.05) on GL.

Table 3: Effect of sire, doe weight at conception and parity on litter size at kindling, number, born alive, number of mating to conception and gestation length of heterogeneous rabbits raised under a pastured rabbit system

	LSK	NBA	NMC	GL (days)
Sire group				
M01	5.88^{ab}	5.50^{ab}	1.50^{a}	31.50
M02	5.50^{b}	5.33^{b}	1.25^{ab}	31.25
M03	6.50^{a}	6.50^{a}	1.33^{ab}	30.50
M04	6.00^{a}	5.91^{b}	1.00^{b}	31.82
M05	5.67^{ab}	5.33^{b}	1.16^{ab}	30.67
P value	0.03696	0.0418	0.0476	0.0856
Doe weight at conception (g)				
Low (≤1800)	5.18^{b}	4.91^{b}	1.28	30.82
Medium (1801-2200)	5.81^{ab}	5.61^{b}	1.27	31.50
High (>2200)	7.33^{a}	7.33^{a}	1.20	31.12
P value	0.0361	0.0272	0.157	0.708
Parity				
1	5.22^{a}	4.93^{b}	1.07	31.50
2	5.87^{ab}	5.60^{ab}	1.33	31.27
3	6.50^{a}	6.50^{a}	1.29	31.10
P value	0.0416	0.0457	0.553	0.0768

^{abc}-Means along columns for each trait with different superscripts are significantly different (P<0.05)
LSK-Litter size at kindling; NMC-Number of matings to conception; NBA; Number of kits born alive; GL- Gestation length

Effect of doe weight at conception, parity, litter size at kindling and volume of nest built on the survival rate

Figure 2 shows the trend for the effect of doe weight at conception (low, medium, high categories) on survival rate of kits at 7, 14, 21, 28 and 56 days. At 28 and 56 days, kits born to does with low body weight markedly had lower survival rate compared to kits born to does with medium and high body weight. An implication of this could be that does with body weight less than 1800g should not be used for breeding purposes especially under small-scale or low-input systems.

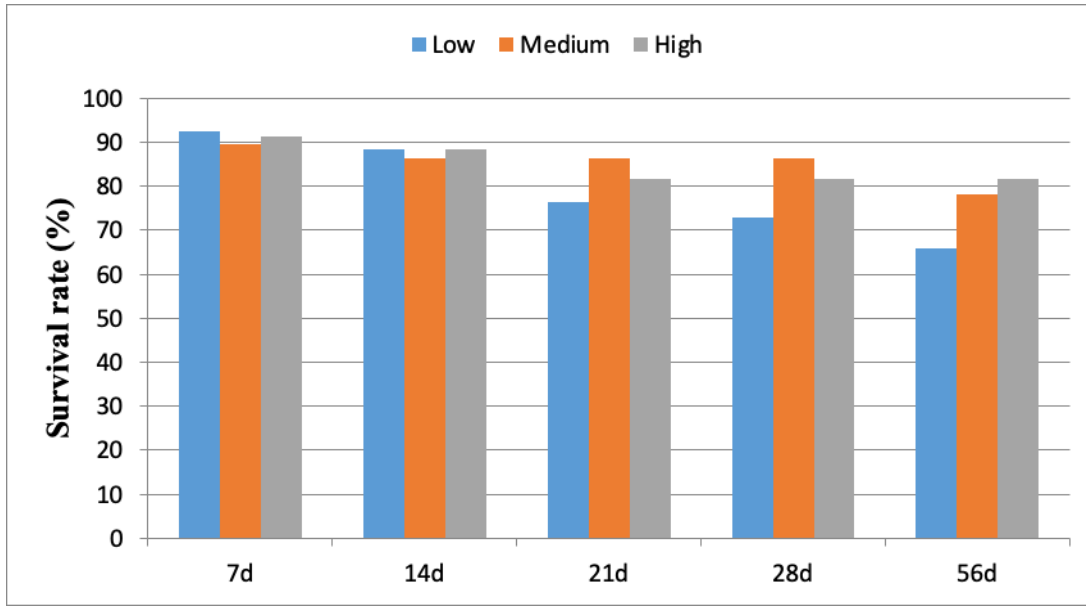

Figure 2: Effect of doe weight at conception on survival rate of kits at 7, 14, 21, 28 and 56 days

Figure 3 shows the trend for the effect of parity on the survival rate of kits at 7, 14, 21, 28 and 56 days. Kits born in the third parity had higher survival rate followed by kits born in the second parity while kits born in the first parity had the least survival rate.

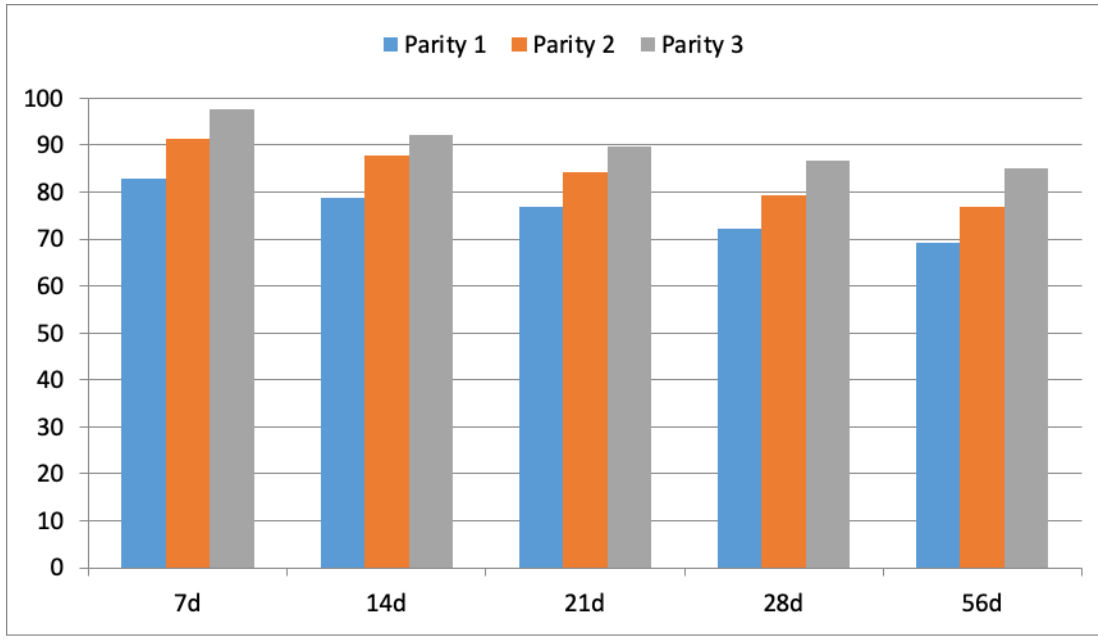

Figure 3: Effect of parity on survival rate of kits at 7, 14, 21, 28 and 56 days

Figure 4 shows the trend for the effect of litter size at kindling on survival rate of kits at 7, 14, 21, 28 and 56 days. Kits from low-sized litters consistently had higher survival rate at 7, 14, 21, and 56 days than kits from medium- and large-sized litters. Interestingly, kits from low-sized litters had 100%, 94%, 89%, 86% and 85% survival rates at 7, 14, 21, 28 and 56 days respectively.

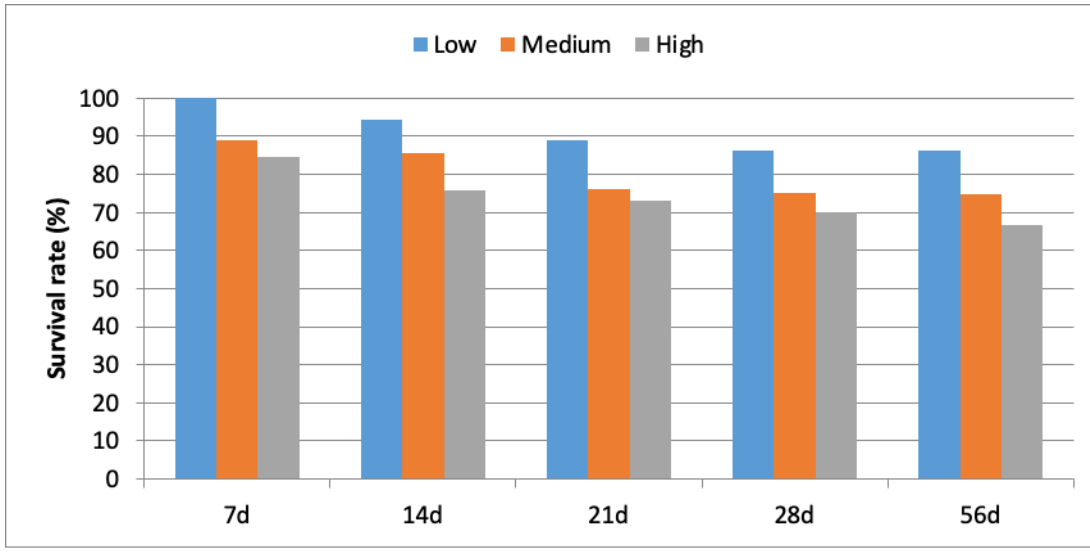

Figure 4: **Effect of litter size at kindling on survival rate of kits at 7, 14, 21, 28 and 56 days**

Figure 5 shows the trend for the effect of maternal care (volume of nest built) on survival rate of kits at 7, 14, 21, 28 and 56 days. Expectedly, kits from dams with no nest prior to kindling recorded lowest survival rate at all ages. This observation draws attention to the complexity of maternal traits, including nest building, and its effect on economic traits of rabbits including pre-weaning kit survival [6].

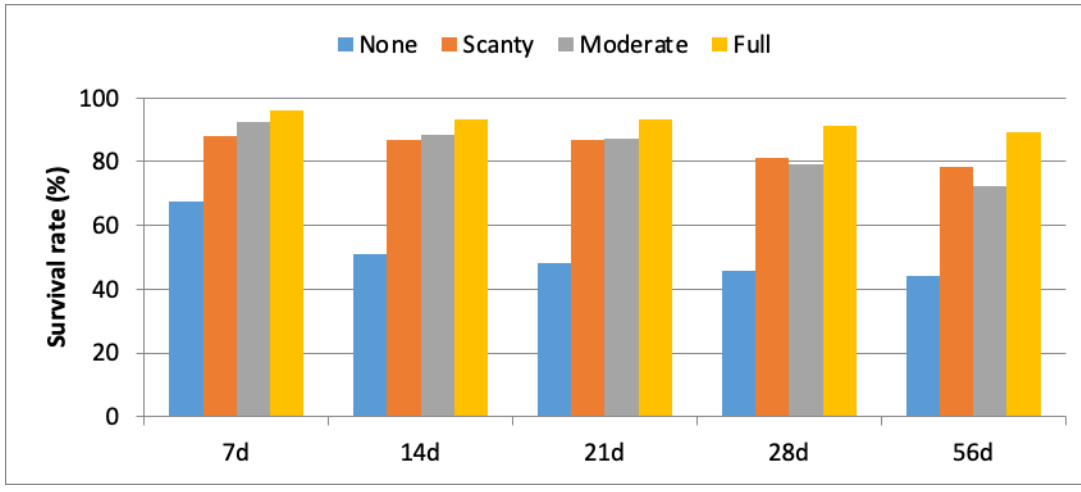

Figure 5: Effect of maternal care (volume of nest built) on survival rate of kits at 7, 14, 21, 28 and 56 days

Effect of sire on kindling interval and doe productivity index

Table 4 presents the effect of sire group on kindling interval and doe productivity index of heterogeneous rabbits raised under a pastured rabbit system. There were highly significant differences ($P<0.01$) in the kindling interval and doe productivity indices due to sire groups. Further, sire differences resulted in significant difference ($P<0.05$) in number weaned per doe per year, number of fryers per doe per year, annual fryer yield (kg) per doe per year, and meat yield (Kg) per doe per year. The kindling interval in the present study ranged from 73.55 days to 82.25 days. Does mated to Sire M02 had the shortest kindling interval while the interval was prolonged in does mated to Sires M01 and M05. Doe productivity indices ranged from 14.44 to 24.83 Kg, while number weaned per doe per year ranged from 20.75 to33.50. Further, number of fryers per doe per year ranged from 17.64 to 28.48 while annual fryer yield per doe per year ranged 31.75 Kg to 51.25 Kg. Consistently, does mated to Sire M04 had the highest doe productivity index, number weaned per doe per year, number of fryers per doe per year, annual fryer yield (kg) per doe per year, and meat yield (Kg) per doe per year while does mated to M01 had the least.

Table 4: Sire effect on kindling interval and doe productivity index of heterogeneous rabbits raised under a pastured rabbit system

Sire group Parameter	M01	M02	M03	M04	M05	P value
KI (days)	82.25^{a}	73.55^{b}	77.33^{ab}	78.25^{ab}	80.67^{a}	<0.0001
DPI	14.44^{c}	17.89^{b}	17.68^{b}	24.83^{a}	17.99^{b}	<0.0001
Number weaned/doe/year	20.75^{b}	22.25^{b}	23.33^{b}	33.50^{a}	25.00^{ab}	0.046
Number of fryers /doe/year	17.64^{b}	18.91^{b}	19.83^{b}	28.48^{a}	21.25^{ab}	0.046
Annual fryer yield (kg)/doe/year	31.75^{b}	34.04^{b}	35.70^{b}	51.2^{a}	38.25^{ab}	0.046
Kg meat/doe/year	17.46^{b}	18.72^{b}	19.64^{b}	28.19^{a}	21.04^{ab}	0.046

KI- Kindling interval; DPI- Doe productivity index

Discussion

The higher pre-weaning growth performance recorded for kits from low-sized litters compared with kits from large-sized litters could ostensibly be due to reduced maternal care and higher intra-litter competition for resources for rabbits born in high LSK when compared to rabbits born in low-sized litters [2]. The volume of nest built by the doe prior kindling, a proxy indicator of maternal care [5, 6] significantly influenced pre-weaning growth performance traits evaluated ($P<0.05$). Kits from dams with moderate or full nests had superior growth performance. One possible implication of this observation is that nest-building could be integrated into breeding programmes as part of the selection criteria for improved maternal care for pre-weaning growth performance. The mean daily weight gain recorded for the low LSK rabbits (11.86 g per day) at 28 days is slightly lower than 12.5 g reported by Oseni and Ajayi [2] for heterogeneous rabbits under a conventional rabbit housing system in southwestern Nigeria. Further, values of 10.05g per day

and 8.04g per day obtained for kits from medium and high LSK, respectively is considerably higher than 6.79 g and 4.78 g reported by these authors. Significant effect of sire on litter weight at kindling, mean kits' weight at kindling and at weaning observed in this study is in agreement with the findings of Cherfaoui-Yami *et al.* [11] who reported no significant difference in litter weight at kindling, kits' weight at kindling and at weaning for Algerian local rabbit population.

The mean LSK of 5.90 kits obtained in this study is slightly higher than 5.00 kits reported by Oseni and Ajayi [2] for heterogeneous rabbits under indoor systems in southwestern Nigeria but similar to 5.70 kits reported by Oseni *et al.* [12] for New Zealand rabbits under tropical conditions in southwestern Nigeria. However, 6.74 kits reported by Iraqi *et al.* [13] for Gabali rabbits in Egypt and 6.85 -7.18 kits reported by Cherfaoui-Yami *et al.* [11] for Algerian local rabbits are higher than the values obtained in the present study. These trends could be attributable to differences in rabbit genotypes and management systems. The higher value of LSK obtained in the second and third parities is in consonance with the findings of Das and Yadav [14] that LSK was significantly higher in the later parities compared to the earlier ones, indicating that prolificacy and litter traits improved with doe age and parity. The number of matings per conception was not significantly influenced by parity ($P>0.05$). However, doe weight at conception influenced LSK. Heavier does significantly had higher LSK which is in consonance with the findings of Oseni and Ajayi [2] that established profound effects of DWC on LSK. Significant effect of sire on fertility and reproductive traits evaluated observed in this study is in agreement with the findings of Cherfaoui-Yami *et al.* [11] who reported no significant difference in litter size at kindling, fertility rate and number born alive for Algerian local rabbit population. The range of kindling interval observed in the present study is similar to the mean of 79 days reported by Odubote and Akinokun [15] for New Zealand rabbits raised in Nigeria but shorter compared to the mean of 102.3 days reported by Ajayi *et al.* [16] for heterogeneous rabbit population in southwestern Nigeria.

Conclusion and Applications

The following conclusions were drawn from the study:

1. There were sire differences in pre-and-post weaning performance, kindling interval and doe productivity indices
2. Kits born in low-sized litters had superior growth performance in terms of weight at kindling, daily weight gain and survival rate
3. Heavier does at mating profoundly had superior reproductive performance for kit survival and body weight gain
4. Sire effect resulted in significant difference in number weaned per doe per year, number of fryers per doe per year, annual fryer yield (kg) per doe per year, and meat yield (Kg) per doe per year.

Acknowledgement

The study was funded under the TETFund IBR Code ***11-801-BSG*** administered by the TETFund Office, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. This is acknowledged with gratitude.

References

1. Oseni, S. O. (2008). A proposal for the genetic improvement of rabbits for smallholder units in Nigeria. G.

Xiccato, A. Trocino and S.D. Lukefahr (eds.). *Proceedings of the 9th World Rabbit Congress*, Verona, Italy, June 10 – 13, 2008, pp 1585 – 1589 (Italy). https://polipapers.upv.es/index.php/wrs/article/view/720/707

2. Oseni, S. O. and Ajayi, B. A. (2010). Descriptive characterization of a Nigerian heterogeneous rabbit population - factors affecting litter traits. *World Rabbit Science*, 18: 111 – 116. https://polipapers.upv.es/index.php/wrs/article/view/720/707
3. Oseni, S. O. and Lukefahr, S. D. (2014). Rabbit production in low-input systems in Africa: situation, knowledge and perspectives. *World Rabbit Science*, 22(2): 147 – 160 https://polipapers.upv.es/index.php/wrs/article/view/1348/3219
4. Caporale, V., Alessandrini, B., Dalla-Villa, P. and Del Papa, S. (2005). Global perspectives on animal welfare: Europe. *Revue scientifique et technique (International Office of Epizootics*), 24(2): 567-577. https://citeseerx.ist.psu.edu/ viewdoc/ download? doi=10.1.1.1074.3659&rep=rep1&type=pdf
5. Farkas, P., SzendrŐ, Z., Matics, Z., Radnai, I., Nagy, I., and Gerencsér, Z. (2018) Preference of rabbit does among different nest materials. *World Rabbit Science*, 26: 81–90. https://polipapers.upv.es/index.php/wrs/article/view/7373/9743
6. Bilkó, Á., Petróczi, I., Bárdos, B., Nagy, I. and Altbacker, V. (2022). Composition of the wild rabbit nest and its implication for domestic rabbit breeding. *Applied Sciences*, 12, 1915. https://doi.org/10.3390/app120419.
7. Odekunle, T. O. (2004). Rainfall and the length of the growing season in Nigeria. *International Journal of Climatology*, 24: 467–47 https://iri.columbia.edu/~ ousmane/print/Onset/Odekunle04_IntJClim.pdf
8. SAS (2004). SAS/STAT User's Guide (Release 8.03). SAS Inst. Inc., Cary NC, USA.
9. Steel, R. G. D., Torrie, J. H. and Dickey, D. A. (1997). Principles and procedures of statistics: A biometrical approach. McGraw-Hill, New York.
10. Oseni, S. O., Odubote, I. K, Akinokun, J. O. and Somade, B. (1997). Productivity levels of three breeds of rabbits and their crosses over a three-year period in the humid tropics. *Archiv für Tierzucht (Archives of Animal Breeding*) 40 (5): 469 – 476 https://agris.fao.org/agris-search/search.do?recordID=DE1997A11183
11. Cherfaoui-Yami, D., Berchiche, M. and Lebas, F. (2021). Influence of male on reproductive performance of Algerian local population rabbit. *Proceedings 12th World Rabbit Congress* - November 3-5 2021 - Nantes, France, Communication R-07, 4 pp. + presentation. http://world-rabbit-science.com/WRSA-Proceedings/Congress-2021-Nantes/Papers/Reproduction/R-07.pdf
12. Oseni, S. O., Ajayi, B. A. and Popoola, M. A. (2016). Performance indices of New Zealand white does in south-western Nigeria *Proceedings 11th World Rabbit Congress* - June 15-18, 2016 - Qingdao - China, 103-106 http://world-rabbit-science.com/WRSA-Proceedings/Congress-2016-Qingdao/Papers/G-Genetics/G21-Oseni.pdf
13. Iraqi, M. M. (2008). Estimation of heritability and repeatability for maternal and milk production traits in New Zealand white rabbits raised in hot climate conditions. *Livestock Research for Rural Development, Volume 20, Article #133.* Retrieved July 4, 2022,

from http://www.lrrd.org/lrrd 20/8/iraq 20133.htm

14. Das, S. K. and Yadav, B. P. S. (2007). Effect of mating system, parity and breed on the reproductive performances of broiler rabbits under the agro - climatic condition of Meghalaya. *Livestock Research for Rural Development. Volume 19, Article #25*. Retrieved July 4, 2022, from http://www.lrrd.org/lrrd19/2/das19025. htm
15. Odubote, I. K. and Akinokun, J. O. (1991). Reproductive and bodyweight performance of the New Zealand white rabbits in the humid tropics of Nigeria. *Nigerian Journal of Animal Production,* 18:1-5. DOI: https:// doi.org/10.51791/ njap.v18i.1965
16. Ajayi, B. A., Oseni, S. O. and Popoola, M. A. (2015). Doe productivity indices and sire effects of a heterogeneous rabbit population in South-western Nigeria**.** *International Journal of Applied Agricultural and Apicultural Research,* 11 (1&2): 1-9 https://www.researchgate.net/publicatio n/306038606.