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Reproductive Efficiencies and Productive Potentials of Female Nigerian Indigenous Goat Breeds

[*1]Bitrus, I. [2]Ezema, C. [3]Makun, H. J. [2]Aronu, C. J. [5]Arinzechukwu, E.S [4]Gilbert, T. T. [5]Chindo, A. [1]Ishaya, W. W and [6]Peter, F.D.

[1*]Department of Animal Science, Taraba State University, Jalingo, Taraba state, Nigeria.

[2]Department of Animal Health and Production, University of Nigeria, Nsukka, Enugu state, Nigeria.

[3]National Animal Production Research Institute, ABU, Shika Zaria, Kaduna state, Nigeria

[4]Department of Veterinary Anatomy, University of Ibadan, Ibadan, Oyo State, Nigeria

[5]Department of Veterinary Pathology and Microbiology, University of Nigeria, Nsukka, Enugu state, Nigeria.

[6]Department of Animal Health, College of Agriculture Science and Technology, Jalingo, Taraba state

https:/orcid.org/0009-0000-5337-0919

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Abstract

Purpose: The overall objective of this study was to examine the reproductive and productive abilities of three Nigerian indigenous goat breeds.

Methodology: The study covered 108 primiparous does and nine bucks from Sahel (SH), Red Sokoto (RS), and West African dwarf (WAD) goat breeds. In different pens, the animals were bred in various combinations: RS x RS, WAD x WAD, SH x SH, RS x SH, RS x WAD, SH x RS, and SH x WAD. WAD x SH, WAD x RS. Estrus synchronization was done using prostaglandins. Mating occurred naturally when animals were on heat. Dams were given special care throughout pregnancy. The study measured dams' weights, litter size, and pre-weaning mortality rates in kids. The total kid crop and sexes were also assessed. We measured dam lactation weight loss, birth weight, and weaning weight. SPSS, ANOVA, and the Turkey statistical test were used for data analysis.

Findings: The result showed that there was a significant ($P<0.05$) difference in the weight of does at kidding. The weight of does at weaning varied significantly ($P<0.05$). Litter size significantly ($P<0.05$) affected the birth weight and weaning weight of kids. An increase in litter size per birth resulted in a significant ($P<0.05$) rise in kid mortality rates. Breed type significantly ($P<0.05$) affected doe production efficiency and weaning weight ratio. Although WAD x WAD goats had lower birth and weaning weights, hybrid vigour (birth and weaning weights) improved significantly ($P<0.05$) when cross-bred with SH or RS breeds. When crossed with SH or WAD goat breeds, RS breeds had the greatest positive effect on hybrid vigour (heterosis), followed by SH breeds. Both SH x RS and RS x SH progenies recorded higher hybrid vigour than the other nine bred line progenies.

Unique contribution to theory, practice and policy: This study found that Nigerian indigenous goat breeds had great reproductive efficiency and breeding potential if properly managed. Genetic variations observed in the study could improve Kids crop, birth weight, litter size, hybrid vigour, and pre-weaning survivorship due to their broad variety. This study recommends a careful selection and crossbreeding of Nigerian indigenous goat breeds with suitable pedigree in order to increase their productivity.

Key words: *Goat breeds, Production potentials, production efficiency.*

INTRODUCTION

Goat farming has historically been linked to poverty alleviation in various regions globally. Consequently, it is predominantly embraced by low-income families residing in rural areas, aiming to generate income or procure food, such as milk and meat (Devendra, 2013). However, this perception has changed in recent decades, spanning the last 30 to 40 years, as noted by Tovar-Luna (2009). Goats have since become a vital component of rural economies, providing meat, milk, household income, manure, and skin (Khowa *et al.*, 2023). Among small ruminant animals, goats are a highly popular choice due to the wide range of acceptability of their meat by people, as well as their greater economic potential, thanks to their high fertility and early maturity, larger litter size, shorter post-partum period and minimum kidding interval (Anoh *et al*., 2021). Goats are the most prolific of all domesticated ruminants under tropical and subtropical conditions.

Goats are a major source of animals in Nigeria, with their widespread distribution in most rural communities and ease of management by both children and women who provide the bulk of labour in smallholder family farms, making them easily adaptable, as pointed out by Khowa *et al.* (2023). Their unique adaptive natural characteristics further contribute to their geographical distribution, allowing them to perform well even when poorly managed and cared for (Sejian *et al*. (2021). These unique breeds have been an integral part of the country's agrarian landscape for centuries, contributing significantly to the livelihoods and sustenance of rural communities (Monau *et al.*, 2020).

Over the last 20 years, goat population has grown at a desirable rate, increasing by almost 50% worldwide, in contrast to cattle, which has only increased by 9%, and sheep, which has declined by 4% (Morand-Fehr and Boyazogly, 1999; Devendra, 2001; Morand-Fehr, 2003). The Federal Ministry of Agriculture, Nigeria, reported a population of 76.29 million heads of goats in 2021 (www.statista.com), as opposed to 33.2 million and 18.2 million cattle (FAOSTAT, 2009). Most of the goats are found in the middle belt and north-western areas of Nigeria, with the three main breeds being the West African Dwarf (WAD), Sokoto Red, and West Africa long-legged goat or Sahel (Bourn *et al.,* 1994). While the WAD is the most common breed in the Southern part of Nigeria, Red Sokoto (RS) and Sahel (SH) are common to the Northern part of Nigeria (Ogah *et al.,* 2009; Ogah, 2010).

The field of goat production involves three primary systems: extensive, semi-intensive and intensive (Nwachukwu and Berekwu, 2020). However, there may be variations within each system that depend on the geographic region (Tovar-Luna, 2009). Local goat breeders possess knowledge of animal breeding based on various practices and ideas that influence the genetic composition of their herds (Marshall *et al.,* 2016). These traditional practices involve using animals with desired characteristics, such as color, size, behavioral patterns and disease or drought resistance, and selection practices for qualities such as offspring testing, pedigree keeping and social restrictions on the sale of genetically valuable breeding animals (Ogah, 2016).

Performance testing is a method of evaluating animals for specific production traits of economic importance. The primary economic traits in meat goat industries are reproduction, growth and carcass yield (Browning *et al.*, 2011). However, in most meat goat herds, animal selection is primarily based on pedigree and visual appraisal for conformation.

The reproductive output of the doe herd is a crucial component of profitability in commercial meat goat enterprises (Browning *et al.* 2009). The effects of breed on maternal performance in meat goat breeds have received little research attention (Shrestha and Fahmy, 2007; Browning Jr and Leite-Browning, 2020). Reproduction is the most critical trait in meat goat production for determining enterprise profitability for commercial producers because does are required to become pregnant, deliver live newborns and raise multiple kids with good growth to weaning (Browning *et al.*, 2011).

The aim of this study was to explore the unique characteristics of Nigerian indigenous goat breeds, delve into their reproductive potentials, and discuss the importance of reproductive efficiency in the context of sustainable goat farming. Through this investigation, we hope to provide valuable insights that can inform policies, practices and initiatives aimed at harnessing the full potential of these remarkable animals within Nigeria's agricultural landscape.

MATERIALS AND METHODS

Study Area and Site

The study herd was reared at the National Animal Production Research Institute (NAPRI), Shika, Ahmadu Bello University, Zaria, Nigeria. The climate of the site is humid and rainfall is well-distributed during the rainy season between May and October, with about 70% of the rain occurring during the months of July and August. The average temperature and humidity during the wet season are 24.7^{0}C and 72%, respectively. The early dry season begins in October with a period of cold dry weather known as harmattan, lasting until February. This is followed by a hot weather when temperatures fluctuate during the day (14-34^{0}C) and relative humidity between 10-20%.

Study Animals

One hundred and seventeen (117) animals, comprising of 108 primiparous does and 9 bucks, belonging to the Red Sokoto (RS), Sahel (SH), and West African Dwarf (WAD) goat breeds, ranging in age between 9 and 15 months and weighing between 19.5kg and 30kg, were utilized for this study. The WAD goats were acquired from flocks belonging to traditional goat keepers around village market communities of Ibadan, Oyo state, Nigeria, while the Red Sokoto goats were obtained from around village markets of Zaria communities of Kaduna state, Nigeria. The Sahelian goats were obtained from Sokoto State, Nigeria. Upon arrival of the adult goats, the animals were kept in the Small Animal Research Unit of NAPRI, Shika, ABU, Zaria, for acclimatization for a period of two (2) weeks. The animals were weighed, dewormed with Levamisole hydrochloride injection at the dose rate of 0.075ml/kg body weight, for possible gastrointestinal parasites known

to be endemic in the study area. At different times, they were also administered *Peste des Petit Ruminants* (PPR) and Haemorrhagic Septicaemia vaccines, all purchased from National Veterinary Research Institute, Vom, Plateau State, Nigeria. The animals were kept in pens and monitored for at least seven (7) days after which they were grouped and placed in various experimental pens to acclimatize to their new environment for a period of four (4) weeks.

Management of Experimental Animals

In each pen, twelve (12) primiparous does were kept with one (1) viable male (buck) of corresponding breed in the case of pure line breeding and opposite buck in the case of cross-breeding. The animals were given belted hay grasses (*Digitaria simutsi*, *Brachairia residensis, Brachiaria decumbensis*) cultivated within the study area and a concentrate mixture comprising of maize, maize offal, groundnut cake (GNC), bones, salt, cotton seed cake (CSC) and wheat offal grower's mash. Clean water was given to the animals at liberty. Only healthy animals were used for the study.

Mating Scheme

The mating scheme was done according to Nwachukwu *et al.* (2013) with slight modifications.

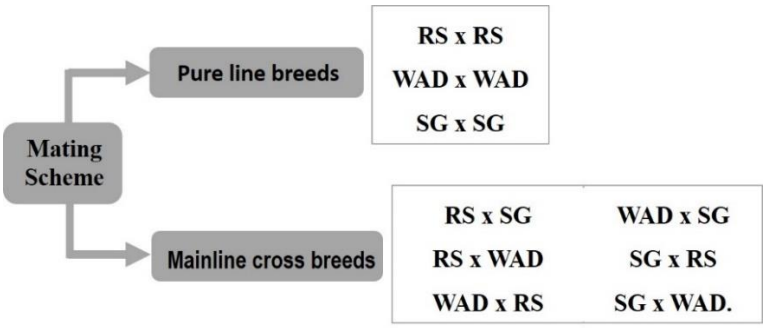

Figure 1: Schematic of mating scheme. RS = Red Sokoto goat; SH = Sahel goat; WAD = West African dwarf goat; x = cross-breeding

Synchronization, Heat Detection and Mating

Synchronization was performed to induce ovarian activities (cycling) among the does. A single 2ml dose of cloprostenol sodium (Synchromate R) was injected to achieve this. Bucks were also placed in each of the pen to initiate the cycling activities. Those on heat were identified by showing classical signs of oestrous. The procedure helped to ensure that kidding occurred within the same time frame.

Measurement of Live Body Weight and Litter Size

Weight of all the does were taken and recorded prior to pregnancy, weekly after pregnancy, during parturition and at weaning. Kids birth weights were taken and recorded within 12 hours of birth. Weaning weight of kids were taken and recorded at 3 months of age. Litter size was taken and recorded at birth.

Measurement of Kid Crop and Kid Birth Weight

The total kid crop per group was determined. The number of kids born alive, and sex were also determined and recorded. The mean birth weights of the kid crops from the three groups were compared.

Measurement of the Lactation Weight Loss and Birth Weights of Kids

At the commencement of the experiment and on a weekly basis during the gestation period, the initial body weights of the does were determined to monitor their weight changes. Furthermore, the body weights of the does were measured weekly after parturition to assess the impact of lactation on the weights of the dams. In addition, the weight of each kid was recorded within one hour after delivery and weekly for eight weeks. The weight at weaning was considered the final weight for the kids and kid mortality was recorded from kidding to weaning.

Measurement of lactation efficiency and weaning weights of kids

Using a spring balance, the weights of the kids were determined at the age of 12 weeks, which is when self-feeding takes effect and weaning occurs. The mean weaning weights per group were determined to reflect the lactation capacity of the dams.

Statistical analysis

Kids' crop, mean birth and weaning weights were assessed by cross-tabulating the kids according to sex and litter size for each breed, and analyzed using SPSS software version 22. ANOVA and Turkey statistical test SAS Studio were used to evaluate the weekly weight gains of the kids. A significant levels was accepted at p-value less than 0.05. The Turkey-Kramer means separation test was employed to compare least squares means (alpha = 0.01).

RESULTS

Table 1: Kid crop according to breed/genotype

	SEX		LITTER TYPE			
BREED	**M**	**F**	**Single**	**Twin**	**Triplet**	**TOTAL**
SH x SH	5(5.7%)	7(11.7%)	1(3.7%)	11(10.0%)	0(0.00%)	**12(8.1%)**
RS x RS	11(12.5%)	8(13.3%)	4(14.8%)	12(11.0%)	3(25.0%)	**19(12.8%)**
WADxWAD	18((20.5%)	9(15.0%)	4(14.8%)	23(21.1%)	0(0.00%)	**27(18.2%)**
SH x RS	8(9.1%)	5(8.3%)	4(14.8)	9(8.3%)	0(0.00%)	**13(8.8%)**
SH x WAD	8(9.1%)	8(13.3%)	3(11.1%)	10(9.2%)	3(25.0%)	**16((10.8%**
RS x SH	10(11.4%)	9(15.0%)	7(25.9%)	12(11.0%)	0(0.00%)	**19(12.8%)**
RS x WAD	14(15%)	2(3.3%)	0(0.00%)	16(14.7%)	0(0.00%)	**16(10.8%)**
WAD x SH	3(3.4%)	5(8.3%)	4(14.4%)	4(3.7%)	0(0.00%)	**8(5.4%)**
WAD x RS	11(12.5)	7(11.7%)	0(0.00)	12(11.0%)	6(50.0%)	**18(12.2%)**
Total	**88(59.5%)**	**60(40.5%)**	**27(18.2%)**	**109(73.6%)**	**12(8.1%)**	**148(100%)**

RS = Red Sokoto goat; SH = Sahel goat; WAD = West African dwarf goat; SEM = Standard error of mean; LOS = Level of significance; M = male; F = female.

The findings of the research indicate that among the nine cross-lines, a total of 148 kids were produced. Of these, West African Dwarf goats, Red Sokoto goats, and Sahelian goats accounted for 18.2%, 12.8%, and 8.1%, respectively. The remaining six crosses revealed that does crossbred with WAD breeds gave rise to a higher number of kids than other crosses, except for the WAD x Sahel cross, which accounted for only 5.4%. Additionally, the study demonstrated that the litter size of the three pure breeds of goats varied from single to triplets, with twins being the most common. Sahel goats had twins in 10.0% of cases, Red Sokoto goats had twins in 11.0% of cases, and West African Dwarf goats had twins in 21.1% of cases, compared to the crosses of all nine lines that were carried out. Triplet litter sizes were the least common.

Table 2: Effect of litter size on the Dams and the kids

Productive Parameters	**Single**	**Twin**	**Triplet**	**SEM**
Doe Weight at Kidding (kg)	30.05^{a}	25.65^{b}	28.50^{ab}	0.881
Doe Weight at Weaning (kg)	25.03^{a}	23.06^{a}	14.87^{b}	0.853
Kid Birth Weight (kg)	2.030^{a}	1.663^{b}	1.365^{c}	0.106
Kid Weaning Weight (kg)	8.615^{a}	5.819^{b}	2.458^{c}	0.812
Kid Mortality (%)	0.038^{b}	0.189^{b}	0.583^{a}	0.001

- Mean with different superscripts ($^{a,\ b}$) across the groups (row) indicate significant difference, P<0.05

The study (Table 2) revealed a significant (P<0.05) difference in the weight of does at kidding. Specifically, does that kidded single kids had a higher weight value than those that had twins. Moreover, the weight of does at weaning differed (P<0.05) significantly across the different number of kids per doe per kidding. The findings showed that does that kidded single kids were

heavier at weaning than those that kidded twin and triplet kids. Additionally, a significant (P<0.05) difference in the birth weight of kids was observed. Single birth kids weighed more heavily at birth than twin and triplet birth kids.

Table 3: Mean birth weight and weaning weight of breed/genotype according to litter type

GENOTYPE		LITTER SIZE					
		Single		Twin		Triplet	
Sire	Dam	BW (kg)	WW (kg)	BW (kg)	WW (kg)	BW (kg)	WW (kg)
SH	**SH**	2.5±.0	12.5±.0	2.35±.12	8.36±.53		
RS	**RS**	1.93±.39	11.75±.96	1.53±.07	6.9±.58		
WAD	**WAD**	1.38±.13	7.5±.64	1.26±.04	6.20±.19		
SH	**RS**	1.90±.11	10.25±2.1	1.96±.09	8.26±.67		
SH	**WAD**	1.87±.38	8.67±.73	1.45±.12	7.26±.44	1.31±.06	7.0±.50
RS	**SH**	2.37±.13	8.5±.74	2.31±.13	8.26±.96		
RS	**WAD**			1.39±.06	7.56±.29		
WAD	**SH**	2.4±.21	7.88±.85	1.44±.13	6.83±.60		
WAD	**RS**			1.66±.10	7.17±.59	1.45±.07	5.17±.73

- BW= Birth weight.
- WW= Weaning weight

As indicated in Table 3, single birth SH x SH kids recorded higher birth weight (2.50 ± 0.0 kg), followed by RS x SH (2.37 ± 0.13 kg). The twin birth SH x SH kids and RS x SH kids recorded (2.35 ± 0.12 kg) and (2.31 ± 0.13 kg) respectively, thereby suggesting that single birth kids were heavier than twin and triplet births at birth. The weaning weight of kids also varied (P<0.05) significantly across the different litter size. The outcome indicated that the single birth SH x SH kids recorded the highest weaning weight (12.5 ±0 kg), followed by RS x RS kids (11.75 ± 0.96 kg) and SH x RS (10.25 ± 2.10 kg). On the other hand, the weaning weights of twin and triplet birth kids were within the range of 5.17 ± 0.73 kg to 8.36 ± 0.53 kg). Furthermore, it was observed that kids' weight decreased with an increase in the number of births per kidding.

The study also revealed that kids mortality significantly (P<0.05) increased with an increase in the number of kids per birth (table 2). Specifically, single birth kids recorded the least (0.038%) kids mortality as compared to twins and triplets with (0.189%) and (0.583%) respectively. This observation implies that kids mortality increased with an increase in the number of kids born by the does. Moreover, triplet birth kids had a higher kid mortality than those of twins and single kids.

Table 4: Mean weekly weight gains of kids (mean ± S.E.M.)

Weeks	SH x SH	RS x RS	WAD x WAD	SH x RS	SH x WAD	RS x SH	RS x WAD	WAD x SH	WAD x RS	P-Value
BW	2.27±.09	1.76±.15	1.22±.07	1.86±.07	1.52±.09	2.43±.10	1.46±.07	1.99±.20	1.57±.11	.000*
1	3.02±.14	2.48±.21	1.77±.14	2.34±.08	2.10±.14	3.21±.15	1.97±.17	2.39±.23	2.24±.16	.000*
2	3.75±.24	3.26±.28	2.36±.18	3.41±.23	2.73±.25	4.19±17	2.72±.14	3.34±.24	2.78±.20	.000*
3	4.40±.31	3.83±.33	2.94±.19	3.83±.73	3.37±.88	4.91±.78	3.30±.58	3.75±.66	3.16±.76	.000*
4	4.81±.34	4.41±.46	3.29±.18	4.40±.21	3.72±.32	5.38±.28	3.79±.20	3.96±.22	3.58±.28	.000*
5	5.52±.42	4.94±.48	3.51±.17	4.88±.28	4.19±.28	5.71±.33	4.21±.21	4.49±.27	4.03±.29	.000*
6	5.94±.44	5.55±.63	3.87±.18	5.66±.46	4.47±.27	6.38±.41	4.75±.25	4.85±.29	4.52±.38	.000*
7	6.27±.46	6.29±.68	4.35±.16	6.52±.52	5.15±.28	6.99±.51	5.43±.28	5.07±.29	5.15±.50	.001**
8	6.60±.52	6.68±.69	4.80±.21	6.99±.53	5.68±.33	7.20±.53	6.14±.37	5.52±.40	5.83±.54	.012**
9	6.91±.52	7.26±.82	5.26±.23	7.87±.70	5.96±.32	7.56±.55	6.51±.37	5.92±.37	6.21±.59	.013**
10	7.41±.61	7.73±.91	5.53±.32	8.13±.73	6.36±.28	8.04±.75	7.11±.36	6.24±.35	6.49±.57	.023**
11	7.97±.68	8.09±.92	5.84±.31	8.59±.81	6.74±.31	8.45±.78	7.48±.39	6.78±.46	6.78±.56	.030**
WW	8.50±.71	8.70±.93	6.43±.30	9.30±.99	7.37±.27	9.09±.88	7.99±.35	7.36±.42	7.16±.52	.034**

- **. Significant at the 0.01 level (2-tailed).
- *. Significant at the 0.05 level (2-tailed).

In Table 4, the findings revealed that the RS x SH kids had the highest birth weight (2.43 ± 10kg) which was significantly (P<0.05) greater than that of SH x SH kids (2.27 ±0.09kg) and WAD x SH (1.99 ± 20kg). However, the lowest birth weight was recorded for WAD x WAD (1.22 ± 0.07kg). At the fourth week, there were significant (P<0.05) changes in the weights of the kids. RS x SH (5.18 ± 38kg) had the highest weight gain followed by SH x SH kids (4.81 ± 34kg), RS and RS (4.41 ± 46kg), while WAD x WAD had the least weight change.

The results at week eight revealed significant (P<0.05) weight changes across the nine lines of the kids produced. RS x SH kids had the highest weight gain (7.20 ± 0.53kg), followed by SH x RS (6.99 ± 0.53kg) and RS x RS (6.68 ± 0.69kg). The least weight change was observed in WAD x

WAD (4.80 ± 21kg) at week eight. By week twelve at weaning, there were still significant (P<0.05) weight changes across the nine genotypes. SH x RS kids recorded the highest weight gain (9.30 ± 99kg), followed by RS x SH kids (9.09 ± 0.35kg), RS x RS (8.70 ± 0.93) and SH x SH (8.50 ± 71kg). The lowest weight gain was observed for WAD x WAD kids (6.43 ± 0.30kg) at weaning.

In general, it was observed that despite the lowest birth and weaning weights (BW= 1.22 ± 0.07kg, WW= 6.43 ± 0.30kg) recorded by WAD x WAD progenies, there was a significant improvement in the hybrid vigor (birth and weaning weights) of progenies of WAD goats that were cross-bred with either SH or RS breeds, SH x WAD (BW= 1.5 ± 0.9kg, WW= 7.37 ± 0.27kg), RS x WAD (BW= 1.46 ± 0.07kg, WW= 7.99 ± 0.35kg) and WAD x SH (BW= 1.99 ± 0.20kg, WW= 7.36 ± 0.42kg). It was also observed, as indicated in Table 4 that Red Sokoto goat breeds had the most positive influence on hybrid vigor (heterosis) when cross-bred with either Sahelian or West African Dwarf goat breeds, followed closely by Sahelian breeds. However, SH x RS and RS x SH progenies exhibited higher hybrid vigor compared to all other progenies of the nine crosses.

Table 5: Mean ± SD of birth weight and weaning weight of breed/genotype according to sex

GENOTYPE		SEX Male		Female	
Sire	**Dam**	**BW (kg)**	**WW (kg)**	**BW (kg)**	**WW (kg)**
SH	**SH**	2.66±.19	8.25±.25	2.17±.10	9±.85
RS	**RS**	1.63±.15	10±1.6	1.49±.12	7.88±.85
WAD	**WAD**	1.32±.05	6.48±.23	1.19±.07	6.09±.43
SH	**RS**	1.96±.12	9.16±1.3	1.92±.06	8.53±.78
SH	**WAD**	1.48±.14	7.37±.46	1.52±.17	7.5±.55
RS	**SH**	2.45±.15	7.91±1.1	2.21±.09	6.81±.51
RS	**WAD**	1.42±.06	8.79±.30	1.23±.07	7.79±.0
WAD	**SH**	1.94±.48	7.5±1.0	1.91±.24	7.4±.73
WAD	**RS**	1.69±.08	6.52±.67	1.42±.12	7.13±.94

The findings of the study presented in Table 5. Demonstrated that male SH x SH offspring weighed the heaviest at birth (2.66 ± 0.19 kg) followed by male RS x SH offspring (2.45 ± 0.15 kg), while the WAD x WAD male offspring had the lowest birth weight (1.32 ± 0.5 kg). Additionally, the study revealed that female RS x SH offspring had the highest birth weight (2.21 ± 0.9 kg), followed by SH x SH offspring (2.17 ± 0.1 kg), with WAD x WAD female offspring having the lowest birth weight (1.32 ± 0.05 kg).

Regarding weaning weight, the results showed that RS x RS male offspring had the highest weight (10.0 ± 1.60 kg) despite their relatively lower birth weight. SH x RS male offspring had the second highest weaning weight (9.16 ± 1.3 kg). The female SH x SH offspring had the highest weaning weight (9.00 ± 0.85 kg) followed by SH x RS female offspring (8.53 ± 0.78 kg). WAD x WAD male and female offspring recorded the lowest weaning weight (6.48 ± 0.23 kg) and (6.09 ± 0.43 kg), respectively.

The results revealed that crossing goats with either male or female Red Sokoto breeds had a positive effect on the birth and weaning weights of male offspring, while crossing with either male or female Sahelian goat breeds had a positive effect on the female offspring. In general, male offspring had higher birth and weaning (3-months) weights than their female counterparts, especially among cross-bred offspring, indicating that gender had a positive effect on the birth and weaning weights of offspring.

Table 6: Doe Production efficiency, Average weight gains and weaning weight ratio based on genotype

Parameters	RS x WAD	Pure RS	SH x WAD	SH x RS	Pure WAD	Pure SH	WAD x RS	WAD x SH	RS x SH	SEM	LOS
Doe Production Efficiency (%)	39.05 a	38.16 a	37.00 ab	35.68 ab	32.87 ab	31.93 ab	31.90 ab	30.90 ab	26.91 b	0.806	**
Average Weight Gain	7.365 ab	8.854 a	7.334 ab	8.639 a	6.155 b	8.560 a	6.445 b	7.161 ab	7.580 ab	0.203	**
Weaning Weight Ratio	118.6 b	211.1 a	123.1 b	107.7 b	112.1 b	144.3 b	138.5 b	114.2 b	111.3 b	3.909	**

- RS = Red Sokoto goat; SH = Sahel goat; WAD = West African dwarf goat; SEM = Standard error of mean; LOS = Level of significance.
- **. Significant at the 0.01 level (2-tailed).
- *. Significant at the 0.05 level (2-tailed).

In terms of doe production efficiency, genotype had a significant (P<0.05) effect (Table 6). Does crossbred with bucks of other breeds had higher production efficiency than pure breeds, except for pure RSG does, which had more production efficiency than the other pure breeds and some other cross lines. There was also a significant (P<0.05) effect of genotype on doe average weight gain. RS and SG does had the highest mean weight gains during lactation compared to WAD does. Additionally, there was a significant (P<0.05) effect of genotype on doe weaning weight ratio (Table 6), with RS does having the highest weaning weight ratio (211.1) compared to the other two pure breeds does, Sahel and WAD, with 144.3 and 112.1, respectively.

DISCUSSION

The current study demonstrated that the weight of does at kidding was higher than at weaning. Dams that delivered single kids had greater weight than those that delivered twin and triplet kids. The birth weight of goats is an essential trait in goat production, as there is a positive correlation

between birth weight and growth rate, age at maturity, and mature body weight (Banergee 1989). The weight of dams at kidding was a significant source of non-genetic variation affecting body weights, leading to higher body weights recorded during the lactation period among does that kidded single kids compared to those that kidded twin and triplet kids during this study. Marai *et al.* (2008), reported that maiden does with higher body weight at kidding produced kids with more birth weight, and there is a linear association between maiden doe weights at kidding and birth weight of their kids (Singh, *et al*., 2021).

The results of this study indicated that kids born singly had higher birth weight than twin and triplet-born kids. This is evidence that litter size is the principal effect on birth and weaning weight as well as pre-weaning weight gains (Robertson *et al.*, 2020). Tesema *et al.*, (2020) also observed that litter size is a source of variation for birth and weaning weights. Atoui *et al.* (2022) noted in another study that the kid birth type had an effect on the body weights of Tunisian local goats' kids at all ages. Therefore, birth weight of a kid is a reproductive trait that can be affected by factors such as litter size (Yilgwan *et al.*, 2012). This study also strongly agrees with the findings of Al-Khamaiseh *et al*. (2020) on the effect of litter size on the birth weight of kids.

The decrease in birth weight with an increase in litter size, as noticed in this study, could be attributed to intrauterine nutrition. The number of fetuses increase with multiple numbers of caruncles attached to each fetus. Therefore, when feed supply to the fetuses reduces, the birth weight of kids also reduces. The result of this study supports the hypothesis that regardless of parity, litter weight in lactating goats increased at a reduced rate with an increase in litter size (Mellado *et al.*, 2011). This study is consistent with a study conducted on black Bengal goats by Paul *et al.* (2014), where the result showed that birth weight of kids was significantly affected by litter size ($p<0.01$). The study also agrees with the findings of Al-Khamaiseh *et al.* (2020), but disagrees with the observations of Chowdhury *et al.*, (2002), on the effect of litter type on birth weight of kids.

More specifically, reduced birth weight in multiple births may be attributed to competition for space among the offspring. Conversely, single births have greater access to milk suckling from the dam, which may explain their heavier weaning weight (Lok *et al.*, 2017). Olusanya (2011) reports that offspring from multiple births may be at a disadvantage compared to singletons.

The result of the current study also showed that male offspring from the nine-lines had higher birth and weaning weights compared to females. This difference may be attributed to the vigorous suckling behavior of male offspring, which may be influenced by male hormones (Lok *et al.*, 2017). Olusanya (2011) notes that male offspring often have superior weaning weights. This finding is consistent with studies on Red Sokoto and West African Dwarf goats by Nwachukwu *et al.* (2012), Granadina graded goats by Sanchez *et al.* (1994), Barbari in farmers flock by Singh and Rai (2006), Jamunapari by Singh *et al.* (2010), Mehsana goat by Patel and Pandey (2013), West African dwarf goat by Ofori and Hagan (2020), Damascus goat, Black Bengal goats by Al-

Khamaiseh *et al.* (2020), and by Chowdhury *et al.* (2002). Our study further shows that triplet births had higher kid mortality compared to twin and single births. This finding is consistent with the observations of Ebozoje and Ngere (1995), who found that kid mortality was affected by the type of birth.

Crossbreeding Sahelian does with Red Sokoto bucks resulted in offspring with improved birth weight and weaning weight. This suggests that crossbreeding is more efficient than pure breeding. This finding is consistent with the observations of Momani *et al.* (2012) in Mali, who found that Sahelian goats crossed with Anglo-Nubian bucks showed greater production efficiency. However, in this study, purebred Sahelian and Red Sokoto crosses also showed good production efficiency compared to pure West African Dwarf breed crosses.

Red Sokoto and Sahelian does had higher average weekly weight gain during lactation compared to WAD does. This finding is consistent with the observations of Adamu *et al.* (2020) regarding Red Sokoto does, but disagrees with the same study regarding WAD does.

Red Sokoto and Sahelian breeds exhibited the highest average weekly weight gain during lactation as compared to the WAD breed. This discovery is consistent with the findings of Adamu *et al.* (2020) regarding Red Sokoto does. However, it disagrees with the same study concerning WAD does. Red Sokoto does had the highest weaning weight ratio compared to Sahelian and WAD does, which aligns with the conclusions of Adamu *et al.* (2020) regarding the comparative analysis of live weight changes during lactation between Red Sokoto and West African Dwarf does. At kidding, Sahelian and Red Sokoto does weighed more than WAD does. Generally, the weight of does at weaning differed significantly ($P<0.05$) among Sahel, Red Sokoto, and WAD goat breeds.

Summarily, the study revealed that, the WAD goat breed had the highest fertility, resulting in the highest number of offspring. Crossbreeding between purebred Red Sokoto and Sahelian breed goats produced the second highest number of kids. Crossbreeding resulted in higher birth and weaning weights and superior heterosis. An inverse correlation existed between litter size and offspring weights, with an increase in litter size leading to a drop in weights. Male progeny had higher birth and weaning weights than females, and the genotype of the parents influenced the birth weight of kids.

In conclusion, the Nigerian government should harness the reproductive capabilities of native goat varieties to enhance their economic sustainability in meat production, hence the wide variation observed in birth weight, birth type, and pre-weaning survivability presents a promising opportunity for improving these traits through genetic breakthroughs in the goat population.

RECOMMENDATION

This study recommends the adoption of a systematic approach involving a careful selection and crossbreeding of Nigerian indigenous goat breeds with favourable pedigrees as a means to augment the overall productivity of these breeds.

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