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Dairy Production in the Tropics: A Case Study of Sebore Farms, Mayo-Belwa, Adamawa State of Nigeria

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ABSTRACT

This research was carried out to investigate the trend of dairy production in one of the tropical regions of the world using Sebero Farms, Mayo-Belwa, Adamawa State of Nigeria as a reference point. Heritability and repeatability of some dairy traits were analyzed as well the effects of genetic and non-genetic factors on dairy productivity of Sebore Farms. Records on calving which included, 100 white Fulani calves and 151 Friesian x White Fulani calves derived from data kept for individual lactating cow at Sebore Farms from 2015 to 2020, were used for the study. The General Linear Model (GLM) procedure of Statistical Analysis System was used to analyze the data. The heritability estimates of age at first calving and lactation length were 0.02±0.11 and 0.06±0.12 respectively for the White Fulani breed, while repeatability estimate for gestation length and calving interval in the same breed were 0.02±0.41 and 0.01±0.11 respectively. Repeatability estimates of the crossbred cows for age at first calving, lactation length and milk yield were 0.97±1.20, 0.26±0.31 and 0.05±0.41 respectively. In both breeds, age at first calving and parity significantly (P<0.05) affected total and daily milk yield. Year of calving was significant on total and daily milk in the crossbreed. However, in both breeds, season and calf sex had no significant (P>0.05) effect on daily and total milk yield. Age at first calving significantly (P<0.05) influenced calving interval in White Fulani and lactation length in the crossbreed. Both parity of dam and year of calving had significant (P<0.05) effects on all the parameters except for calving interval in the White Fulani. Season of calving and Calf sex had no significant (P>0.05) effect on lactation length and calving interval. Calf sex had significant (P<0.05) effect on gestation length in both genotypes. The generally low heritability values for age at first calving and lactation length in the White Fulani indicated that improvement in these traits can only be made possible by improved management practices rather than selective breeding.

Keywords: White Fulani; Productivity, Heritability; Friesian

INTRODUCTION

The dairy industry plays a crucial role in global agriculture and food production, providing a significant source of milk and dairy products to meet the nutritional needs of populations worldwide (United Nations Food Systems Summit, 2021). As demand for high-quality dairy products continues to rise, ensuring the productivity and efficiency of dairy cattle herds becomes imperative (United Nations, 2020). The productivity of a dairy herd is influenced by various factors, including genetic and non-genetic factors, which interact to determine the overall performance of the animals. Understanding the impact of these factors and their interactions is essential for the development of effective strategies to optimize dairy cattle productivity (Clay *et al.*, 2020).

STUDY PROBLEM

The productivity of dairy cattle in tropical regions, such as Nigeria, is influenced by a combination of genetic and non-genetic factors. However, the specific impact of these factors on dairy cattle productivity in the tropics remains poorly understood, leading to challenges in optimizing production and efficiency. This research aims to investigate and evaluate the interactions between genetic and non-genetic factors influencing dairy cattle productivity in Nigeria's tropical environment.

AIM AND OBJECTIVES

The general objective of this study is to evaluate the genetic parameters of dairy traits and also to determine the effects of genetic and non-genetic factors on the productivity of the dairy herd of Sebore Farms in Mayo Belwa, Adamawa State of Nigeria.

The specific objectives are to:

i. Determine the effect of genotype on milk yield of the White Fulani and Friesian x White Fulani crossbred cows.

ii. Estimate heritability and repeatability estimates of dairy traits in White Fulani and Friesian x White Fulani crossbred cows.

MATERIALS AND METHODS

Location of the study

The data for the study was collected from Sebore Farms, a privately owned commercial agricultural and dairy enterprise located at Km 12, Mayo-Belwa, Ngurore Road, Mayo-Belwa, Adamawa State Nigeria. Adamawa State lies between latitude 07º15′N and 10º58′N and longitude 11º29′ and 13º47′E (Adebayo, 2020).

The study area has both rainy and dry seasons (April to October and November to March respectively), it falls within Guinea and Sudan Savannah vegetation zones, with undulating landforms (Adebayo and Zemba, 2020; Akosim et al., 2020 and Tukur and Mahmud, 2020).

The study area has average daily minimum and maximum temperatures of 23.2 and 35.2ºC respectively. The average annual rainfall is 718.1 millimeters and relative humidity, 44.2 % (National Bureau of Statistics, 2010; Ovimaps, 2018).

The study area occupies an area of 1,768 square kilometers and has an estimated population of about 204,200 people as of 2016 (Wikipedia, 2023). The vegetation of the area, availability and abundance of water influence the distribution of livestock in the area. The area is one of the principal livestock producing areas in the Sta

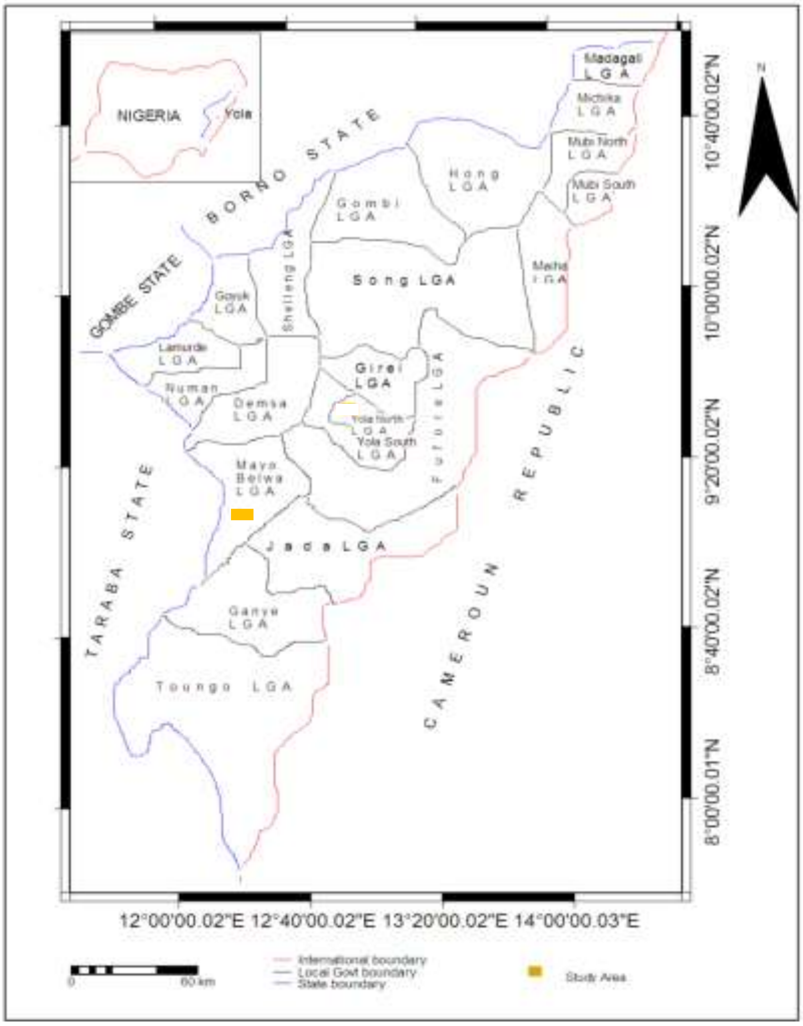

Fig. 1: Map of Adamawa State showing Study Area (Source: Adebayo, 2020)

Data Collection and Analysis

The data used for this study spanned from 2015 to 2020 which were derived from the productivity records of 100 White Fulani Cows and 151 Friesian x White Fulani crossbred cows.

Statistical Analysis

The General Linear Model of SAS (2002) was used to perform an analysis of variance (ANOVA) on the dairy productivity data, and Duncan's Multiple Range Test was employed to separate the means that exhibited significant differences (Duncan, 1955).

Examination of Hereditary (genetic) and Non-hereditary (non-genetic) Influences

The data were examined for fixed factors using the Statistical Analysis System's General Linear Model (GLM) procedure (SAS, 2002). The genotype (White Fulani and Friesian x White Fulani crossbreed), age at first calving, parity of the dam (1,2,3,4), year of calving (1,2,....6), and season of calving (1,2,3) were the fixed effect factors evaluated for the herd's dairy productivity.

Estimation of Genetic Parameters

The data were used to estimate genetic parameters of heritability and repeatability after being corrected for known effects of fixed factors.

Heritability and Repeatability Estimates

Heritability and repeatability estimates were obtained using the Reduced Sire Model (Becker, 1985).

$Y_{ij} = \mu + S_i + e_{ij}$

Where

Y_{ij} = Single observation

μ = Overall mean

S_i = random effect of i^{th} sire

e_{ij} = random residual error

The SAS (2002) Statistical package was used to generate the variance components of sire and error. The ratios of these variances would be used to estimate heritability and repeatability values as follows:

Heritability values were computed from the sire and error variances as follows:

$$h^2 = \frac{4\sigma^2 s}{\sigma^2 s + \sigma^2 e}$$

Where:

h^2 = heritability estimates from paternal half-sib analysis

$\sigma^2 s$ = sire variance component

$\sigma^2 e$ = error variance component

Similarly, Repeatability value for a trait was computed as:

$$R = \frac{\sigma^2 B}{\sigma^2 B + \sigma^2 W}$$

Where:

R = Repeatability

$\sigma^2 B$ = variance between sire

$\sigma^2 W$ = variance within sire

RESULTS AND DISCUSSION

RESULTS

Lactation Yield and other Productivity Indices of White Fulani and Friesian x White Fulani Crossbred Cows

In Table 1, the productivity records (gestation length, lactation length, calving interval, and age at first calving) of two dairy genotypes (White Fulani and Friesian x White Fulani crossbreed) on Sebore Farms from 2015 to 2020 are displayed along with their respective least square means ± standard errors of lactation yield. The Friesian x White Fulani performed significantly ($P<0.05$) higher than the White Fulani breed in lactation yield, lactation length, calving interval and age at first calving. The Friesian x White Fulani had superior performance of 1105.15kg (Total Milk Yield), 4.82kg (Daily Milk Yield), 228.95 days (Lactation Length), 366.49 days (Calving Interval) and 38.50 months (Age at First Calving) as against the lower performance obtained for the White Fulani which had 675.36 kg (Total Milk Yield), 3.52kg (Daily Milk Yield), 191.05 days (Lactation Length), 382.35 days (Calving Interval) and 46.15 months (Age at First Calving). Gestation Length obtained for the Friesian x White Fulani crossbreed and White Fulani were 270.91 and 270.85 days respectively.

Least Square Means of Genetic and Non-genetic factors affecting milk yield of Cows

The milk yield of White Fulani and Friesian x White Fulani cows on Sebore Farms is affected by genetic and non-genetic factors, as indicated by Tables 2 and 3, respectively, with the least square means ± SEM for each. Age at first calving and dam parity had a significant (P<0.05) impact on the total and average daily milk yields in both genotypes. Additionally, in Friesian x White Fulani, the year of calving had a significant impact on the average and total daily milk yields (P<0.05). However, neither the calving season nor the calf's sex showed a significant impact (P>0.05) on the two genotypes' milk yield. In both genotypes, it appears that lower parities were associated with higher milk yield; however, In the calving year, the Friesian x White Fulani cows showed no discernible pattern.

Table 1: Lactation yield and other productivity indices of White Fulani and Friesian x White Fulani crossbred cows

Traits	White Fulani	Friesian x White Fulani
Daily Milk Yield (kg)	3.52 ± 0.01^{b}	4.82 ± 0.02^{a}
	(87)	(148)
Total Milk Yield (kg)	675.36 ± 0.42^{b}	1105.15 ± 0.03^{a}
	(87)	(148)
Lactation Length (days)	191.05 ± 0.25^{b}	228.95 ± 0.26^{a}
	(87)	(148)
Age at First Calving	46.15 ± 2.46^{a}	38.50 ± 0.26^{b}
(months)	(100)	(152)
Gestation Length (days)	270.85 ± 0.15^{b}	270.91 ± 0.11^{a}
	(100)	(151)
Calving Interval (days)	382.35 ± 0.57^{a}	366.49 ± 0.65^{b}
	(67)	(116)

( ) = values in parenthesis are number of observations. a,b = Means with different superscript within a row are significantly different (P<0.05)

Table 2: Least Square means ± SEM of genetic and non-genetic factors affecting milk yield of White Fulani Cows

Factors	No. of Observation	Total Milk Yield (kg)	Daily Milk Yield (kg)
Age at first calving (genetic)		*	*
44.20 – 45.26	11	687.00 ± 14.75^{a}	3.59 ± 0.05^{a}
45.40 – 45.97	22	600.79 ± 7.85^{c}	3.49 ± 0.01^{c}
46.07 – 46.57	35	609.05 ± 7.99^{bc}	3.49 ± 0.02^{bc}
46.87 – 47.83	19	631.35 ± 11.59^{b}	3.55 ± 0.03^{b}
Parity of Dam (non-genetic)		*	*
1	24	655.95 ± 5.48^{c}	3.45 ± 0.02^{b}
2	28	655.15 ± 5.75^{c}	3.45 ± 0.02^{b}
3	18	715.05 ± 8.15^{a}	3.65 ± 0.40^{a}
4	17	691.85 ± 9.95^{b}	3.64 ± 0.05^{a}
Year of Calving (non-genetic)		**NS**	**NS**
2015	13	659.99±8.03	3.48±0.03
2016	15	688.95±8.89	3.60±0.03
2017	12	671.97±5.02	3.51±0.02
2018	15	672.75±12.1	3.48±0.05
2019	16	677.79±14.2	3.52±0.05
2020	16	678.86±10.1	3.55±0.05
Season of Calving (non-genetic)		**NS**	**NS**
DCH	31	675.99±7.55	3.52±0.03
DHH	18	669.62±9.49	3.51±0.05
RS	38	677.25±6.28	3.55±0.02
Sex of Calf (non-genetic)		**NS**	**NS**
Male	41	673.79±6.05	3.52±0.02
Female	46	675.33±6.08	3.53±0.02

*=(P<0.05), NS = Not significant, a,b = Means with different superscripts in a column within factor sub-group are significantly different (P<0.05), DCH = Dry Hot Season, DHH = Dry Harmattan Season, RS = Raining Season, SEM = Standard Error of Mean

Table 3: Least Square means ± SEM of genetic and non-genetic factors affecting milk yield of Friesian x White Fulani Cows

Factors	No. of Observation	Total Milk Yield (kg)	Daily Milk Yield (kg)
Age at first calving (genetic)		*	*
38.47 – 38.63	12	1101.05±30.81[a]	4.85±0.11[a]
38.70 – 38.80	55	1110.09±9.00[a]	4.86.±0.02[a]
38.83 – 38.97	67	1116.50±10.35[a]	4.88±0.03[a]
39.00 – 39.17	14	1031.55±12.65[b]	4.55±0.04[b]
Parity of Dam (non-genetic)		*	*
1	34	1118.1±6.71[d]	4.52±0.02[d]
2	47	1078.8±5.76[c]	4.75±0.02[c]
3	35	1183.5±12.2[a]	5.15±0.03[a]
4	23	1151.5±16.88[b]	4.95±0.05[b]
5	9	1139.1±17.1[b]	4.89±0.06[b]
Year of Calving (non-genetic)		*	*
2015	27	1075.8±9.05[c]	4.79±0.08[ab]
2016	25	1137.5±20.6[ab]	4.97±0.07[a]
2017	27	1143.1±18.1[a]	4.95±0.06[a]
2018	22	1097.5±15.5[bc]	4.75±0.05[b]
2019	25	1071.5±11.5[c]	4.71±0.03[b]
2020	20	1092.7±13.9[c]	4.78±0.04[b]
Season of Calving (non-genetic)		**NS**	**NS**
DCH	50	1105.01±10.75	4.34±0.05
DHH	32	1099.52±14.66	4.33±0.09
RS	65	1110.35±10.25	4.35±0.05
Sex of Calf (non-genetic)		**NS**	**NS**
Male	66	1108.85±10.61	4.83±0.03
Female	81	1101.91±8.41	4.83±0.02

*=($P<0.05$), NS = Not significant, a,b = Means with different superscripts in a column within factor sub-group are significantly different ($P<0.05$), DCH = Dry Hot Season, DHH = Dry Harmattan Season, RS = Raining Season, SEM = Standard Error of Mean

Estimates of Genetic Parameters of Dairy and Reproductive Traits of White Fulani and Friesian x White Fulani crossbred Cows

The estimates of repeatability and heritability of a few dairy traits in White Fulani and Friesian x White Fulani crossbred cows from Sebore Farms in Mayo-Belwa, Adamawa State, are displayed in Table 4.

Because of the small sample size and data pattern, estimates for the majority of the traits could not be determined. Measuring heritability was limited to the age at first calving (0.02±0.11) and the length of lactation (0.06±0.12). These estimates had standard errors higher than the primary estimates, making them not only extremely low but also extremely unreliable. For gestation length, milk yield, and calving interval, repeatability estimates were low; for lactation length, they were moderate; however, for age at first calving, they were high (0.97±1.20).

Table 4: Heritability (h^2) and Repeatability (R) Estimates of some Dairy and Reproductive Traits of Cows

Dairy Traits							
Parameters	**Genotype**	**AFC**	**LL**	**GL**	**CI**	**MY**	**Range(h^2)**
h^2	WF	ND	ND	ND	ND	ND	**0 - 0.19 (low)**
	F X WF	0.02±0.11	0.06±0.12	ND	ND	ND	**0.20-0.39 (moderate)**
R	WF	ND	ND	0.02±0.41	0.01±0.11	ND	
	F x WF	0.97±1.20	0.26±0.31	ND	ND	0.05±0.41	**0.40-above (high)**

h^2 = heritability, R = repeatability, WF = White Fulani, F x WF =Friesian x White Fulani, ND = Not determined, AFC =Age at First Calving, LL = Lactation length, GL = Gestation length, CI = Calving Interval, MY = Milk yield

DISCUSSION

Average Daily and Total Milk Yield of Sebore Farms Herd

This study demonstrated that Friesian x White Fulani crossbred cows outperformed White Funali pure breeds in terms of milk yield which further shows the significant impact of genotype and benefit of crossbreeding. The overall milk yield for White Fulani cows and Friesian x White Fulani crossbred cows found in this study closely matches Bala's *et al*., (2017) findings presenting similar dairy production trends in a commercial farm also located in the tropics.

Estimates of Genetic Parameters of Dairy traits at Sebore Farms

Estimates of heritability (h^2) of Age at First Calving and Lactation Length

In this study, the heritability value derived for age at first calving in the Friesian x White Fulani crossbred cows is lower than the value of 0.127 obtained by Petrovic *et al*. (2001) in Black and White Cattle in Serbia and also slightly lower than the value of 0.093 obtained by Pantelic *et al*. (2008) in Simmental cows. Berry *et al*., (2013) reported heritability estimate value of 0.07 for age at first calving. Selection cannot improve the crossbred cow population at Sebore Farms; this is indicated by the low heritability estimate of 0.02 for age at first calving that was derived in this study. Age at first calving must therefore be improved through environmental improvement via sound management practices.

Gwaza *et al.* (2007) noted that environment had greater influence on age at first caving therefore, improvement on the trait is achievable through good management practices.

Similar to the low value of 0.06 found in this study, Zivanovic (2002) observed a heritability estimate of 0.014 for lactation length in his research of Black and White Cattle of Serbia. Pantelic *et al.,* (2008) found that the lactation length of Serbian cattle was 0.01, whereas Usman *et al.,* (2012) found that the lactation length of Pakistani Friesian cows was 0.184. For Sahiwal cows, Lakshmi *et al.,* (2009) reported an estimate of 0.181. Lactation length is more influenced by the environment, as evidenced by the low heritability estimates for lactation length. Rather than selection, new management strategies like better nutrition and illness prevention may make improvement of lactation length possible.

Estimates of Repeatability (R) of Gestation Length, Calving Interval and Age at First Calving

Only the gestation length and calving interval in the White Fulani breed had repeatability values in this study, and both showed low repeatability (0.02±0.41 and 0.01±0.11, respectively). These values are less than what other researchers found for certain purebred cattle. For instance, repeatability values for Ethiopian Boran were estimated by Halie-Mariam and Kassa-Mersha (2004) to be 0.14, for the Friesian breed to be 0.17, and for Gir cattle in India to be 0.37 by Usman *et al.,* (2012).

The crossbred population's high repeatability value for the trait of Age at First Calving agrees with the value reported for the same trait in Ethiopian crossbred cattle by Haile-Mariam and Kassa-Mersha (2004). Additionally, the study's moderate repeatability value for lactation length agrees almost entirely with the values of 0.21 and 0.25 for Red Sindhi and Sahiwal cattle of India reported by Sarwar (1991) and Gandhi and Gurnani (1992), respectively.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The genetic factors of White Fulani and Friesian x White Fulani crossbred cows of Sebore farms as well as non-genetic factors affecting the productive performance of the farm were evaluated in this study. The Friesian x White Fulani crossbred cows showed superior performance in milk production over the White Fulani Pure breed cows indicating the advantages of crossbreeding as compared to the use of the pure breed.

In the genetic factors age at first calving significantly affected milk yield, calving interval, lactation and gestation lengths in the two breeds (genotypes). In the crossbred cows, year of calving and calf sex did not significantly affect calving interval and lactation length in both genotypes (White Fulani and Friesian x White Fulani crossbreed) but sex of calf influenced gestation length in the two genotypes in which cows with male calves had longer gestation length.

Heritability estimates derived for age at first calving and lactation length were very low. Repeatability estimate for lactation length was moderate but high for age at first calving.

Recommendations

On the basis of the findings of this present study, the following recommendations can be made:

Improvement in age at first calving and lactation length could be achieved in this herd through improved managerial practices.

Unbiased comparison of the productive performances of the White Fulani and Friesian x White Fulani cows in Sebore Farms can be carried out only when the records are adjusted for all the known factors which affect performance differently in the two breeds.

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