Varimax Rotated Principal Component Analysis of Productive Traits in Nigeria Indigenous Cattle Raised under Semi-Intensive Management System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The objectives of this study were to quantify the production traits using principal component analysis in Bunaji and Gudali cattle. Morphological traits of Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm) and lactation traits of TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days) were measured. To find the traits that were clustered together, data were fed to the principal component matrix of J.M.P genomics statistical software. In general, communalities varied from 0.32 to 0.91, and the proportion of variance accounted for by variables

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was 48 percent Bunaji, 0.31 to 0.99 for communalities, and 58 percent in Gudali cows. The information on principal component analysis will facilitate their efficient use in breeding programs for genetic gain and genetic improvement programs in indigenous Nigeria cattle.

Keywords: Varimax; cattle; milk yield; lactation; udder.

1. INTRODUCTION

Reproductive health and milk output are influenced by body weight and physical features [1,2].

A well-structured breeding program and favorable environmental conditions are important factors in dairy cattle sustainability for increased milk output. The extreme conditions of the tropical climate have limited the ability of indigenous cattle to produce a large amount of milk [2]. The non-congruent variation in body weight of cattle over time during lactation is linked to the energy balance in the cow [3]. In tropical cattle production, combining body linear measurements with lactation features may be more effective in describing economic qualities.

Heat stress, a lack of clear breeding goals, and the unstructured nature of data collection by farmers in different clusters all contributed to the failure of numerous breeding strategies in Africa for genetic enhancement of milk supply. Furthermore, the introduction of foreign cattle into Africa has hindered efforts to increase the productivity of African indigenous cattle [3]. Breeding techniques used recently in phenotyping, efficient animal data collection and the adoption of organized breeding schemes, could lead to a progressive improvement in our indigenous genetic resources. Understanding the relationship between and within production traits in cattle using robust statistical procedures such as multivariate methodologies is the first step towards genetic improvement of milk volume and components. Multivariate statistical approaches such as principal component analysis have been used to get a more trustworthy assessment of morphometric relationships among livestock breeds [4,5].

Principal components analysis is a mathematical process that reduces a large number of possible linked variables to a smaller number of uncorrelated variables, which are then sorted so that the first few keep the majority of the original variables' variance [6]. Hence, the objective of this study is to evaluative the relationship matrix in bodyweight, udder traits and milk yields traits using principal component analysis in Bunaji and Gudali cattle.

2. MATERIALS AND METHODS

2.1 Location of the Experiment

The research was conducted at the Dairy Breeding Unit of National Animal Production Research Institute (NAPRI), Shika, Zaria, Kaduna State. NAPRI is geographically located between latitude 11^0 and 12^0N and longitude 7^0 and 8^0 E at an altitude of 640m above sea level [7].

2.2 Animals and Management

Animals used for this research were sourced in National Animal Production Research Institute (NAPRI). They were raised under semi-intensive system of management.

2.3 Sampling size and Sampling Structure

A total of 100 lactating cows comprising of equal number of Sokoto Gudali and White Fulani were used for the study.

2.4 Trait Measurement

Nine metric characters including body weight and ten linear measurements were taken on each sampled animal. They include: BW: Body weight (kg), BL: Body length (cm), HW= Height at withers (cm), CW: Chest width (cm), HG: Heart girth (cm), RW: Rump width (cm), TL: Teat Length (cm), RUH: Rear udder height (cm), UC: Udder circumference (cm).

2.4.1 Bodyweight

Weights of the animals were taken using a spring balance and walk-in weighing scale (kg). Flexible tape rule was used to take the body measurement. During body measurement animals were made to stand upright and restrained by two assistants in such a way that their heads, necks, and chest were stretched almost in a straight line, each measurement were taken at least three times and the mean recorded

to the nearest cm. Reference marks were used for body measurement according to the method of [8,9].

2.4.2 Udder measurements

The Udder and teat measurements were measured using flexible tape (cm) as follows:

Udder Circumference (cm): measured at the widest point of the udder round it.

Udder height (cm): were measured as the distance from the ground to the udder floor at points directly in front of the fore and rear teat.

Teat length (cm): measured as the distance from the upper part of the teat, where it hangs perpendicularly from the Udder to the tip of the teat.

2.4.3 Milk yield characteristics

Milk yield characteristics were measured as follows:

Average Daily Yield (ADY): - As average of all test day yields within the milking period.

Total Yield (TYA): - As milk production during the lactation period up to the point where the production of the cow dropped below 100 ml.

Lactation Length (LL): - As the period from calving to the point when the milk yield of the cow falls below 100 ml.

2.5 Data Analysis

Principal component procedure (J.M.P. genomics) statistical software was applied using PROC PRIN procedures to determine which morphological and milk yield traits that have more clustering affinity together.

3. RESULT S

Table 1 presents the PCA for Bunaji cows indicating share of factor loadings, eigenvalues, and total variation . Five components were extracted from the initial 12. PC1 showed eigenvalue of 1.36 and 11% of total variation, it loaded heavily for HG , Rumwi, and negatively for TYA. Principal component 2 had 10% of the total variation and 1.22 Eigenvalue and loaded for TL negatively and positively for Udder circumference (UC). Principal components 3, 4 and 5 each accounted for 9% of total variation each with Eigenvalues of 1.13, 1.12 and 1.03 respectively. PC3 loaded for Body length negatively, PC4 loaded negatively for CW and positively for ADY and PC5 loaded for CW and negatively for Lactation Length (LL). Communality estimates ranged from 0.32 to 0.89.

Principal component analysis of morphometric and milk traits in the Gudali is presented in Table 2. Six principal components were extracted in this study, share of total variance and Eigenvalue were (11, 10, 10, 9, 9 and 9%) and (1.27, 1.24, 1.20, 1.10, 1.09 and 1.04) respectively. Principal Component 1 loaded for TL, Rear Udder height (RUH) and TYA, PC2 loaded CW and negatively for HG, PC3 loaded BW, BL and negatively for LL, PC4 loaded for HG, PC5 loaded for Rumwi and UC and PC6 loaded negatively for CW and ADY. Communality ranged from 0.31 to 0.99.

Table 1. Principal component analysis of studied traits for Bunaji cows

Traits	PC1	PC2	PC3	PC4	PC5	Communality
BW	-0.32	-0.17	-0.34	0.02	0.13	0.48
BL	0.25	0.19	-0.48	0.13	-0.11	0.56
HW	0.21	-0.37	0.08	0.37	-0.27	0.74
CW	0.08	0.07	0.24	-0.42	0.59	0.32
HG	0.53	-0.25	0.08	0.14	0.20	0.44
Rumwidth	0.49	-0.05	0.19	-0.31	-0.04	0.58
TL	-0.06	-0.45	0.36	0.30	-0.03	0.91
RUH	0.20	0.23	-0.18	0.30	0.02	0.88
UC	0.19	0.56	0.07	0.19	-0.12	0.52
TYA	-0.42	0.17	0.34	0.19	-0.05	0.64
ADY	0.04	0.33	0.37	0.45	0.34	0.89
LL	0.05	0.16	0.35	-0.33	-0.62	0.59
Eigenvalue	1.36	1.22	1.13	1.12	1.03	
% Variance	11	10	9	9	9	

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TYA: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).

Table 2. Principal component analysis of studied traits for the Gudali

Traits	PC1	PC2	PC3	PC4	PC5	PC6	Communality
BW	0.07	0.27	0.50	-0.33	-0.24	-0.20	0.54
BL	-0.01	0.03	0.61	0.18	0.00	-0.02	0.37
HW	-0.37	-0.19	0.21	0.24	0.30	-0.06	0.65
CW	-0.16	0.52	-0.13	0.22	0.07	0.47	0.49
HG	0.04	-0.55	-0.06	0.47	-0.20	0.23	0.31
Rumwidth	0.08	0.23	-0.06	0.30	0.51	-0.43	0.55
TL	0.45	-0.30	0.02	-0.20	-0.10	-0.18	0.99
RUH	0.57	-0.03	0.18	0.39	0.10	0.12	0.98
UC	0.28	-0.09	0.01	-0.25	0.64	0.06	0.35
TYA	0.48	0.37	0.08	0.22	-0.20	0.19	0.52
ADY	0.04	-0.12	0.16	-0.39	0.26	0.63	0.54
LL	0.24	0.14	-0.50	-0.13	-0.08	-0.08	0.89
Eigenvalue	1.27	1.24	1.20	1.10	1.09	1.04	
% Variance	11	10	10	9	9	9	

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TYA: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).

4. DISCUSSION

The obtained total sum of variance (48 and 58%) accounted for by the five PC in Bunaji and the six PC in Gudali, respectively, were lower than the percentage of variance reported by [8]. The six PCs in Gudali (58%) were within the range 55.3-95.2% reported by [9] in Bunaji but comparable to 52.48% in Red Sokoto and 54.49% [10]. Based on morphometric composition, the loading of PC1 for TYA and ADY across all breeds supports the assertion of a positive relationship between milk yield and general body condition [7]. Factors 2, CW and Rumwi were associated with variables that described general body volume and broadness, especially around the thoracic cavity. This breadth adds some validity to the factor analysis's applicability [8]. The components of the Gudali were found to be closer to those of the pooling. However, there is no discernible pattern for comparable major components among breeds. This could help establish credibility. Since principal components are uncorrelated by definition [9,10,11], the selection to improve body size which is an important target for beef production implies little or no variation in milk production across and within breeds.

5. CONCLUSION

The findings of this study indicate that Gudali cattle is highly variable and could be exploited for genetic improvement for milk production in a structured breeding programs The novel information presented here contributes to a better understanding of principal component analysis in the genetic improvement of our indigenous livestock.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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