Asian Journal of
Biological
Sciences

OPEN ACCESS

Heritability and Repeatability Estimates of Linear Parameters in Muturu and Bunaji Breeds of Cattle in Nigeria

Suleiman Shaibu Sheidi, Adewale Johnson Atansuyi, Clifford Adinma Chineke and Bamidele Innocent Osho
Breeding and Genetics Unit, Department of Animal Production and Health, Federal University of Technology, Akure, Ondo State, Nigeria

ABSTRACT

Background and Objective: Indigenous cattle breeds, such as Muturu and Bunaji, are vital to the agricultural systems of many regions due to their adaptability, hardiness, and unique traits. The study aims to estimate the heritability and repeatability of linear body parameters in Muturu and Bunaji cattle breeds in Nigeria. It evaluates genetic and environmental influences to enhance breeding strategies for these indigenous breeds. **Materials and Methods:** A quantitative genetic analysis was conducted to estimate the heritability (h^2) and repeatability (R) of linear parameters in Muturu and Bunaji cattle breeds. The study utilized a mixed linear model to analyze data from 452 cattle comprising 226 each from Muturu and Bunaji cattle. Data on BWT and BLT for Muturu and Bunaji cattle breeds were analyzed using a t-test in SAS Version 9.4 (SAS, 2014), with significance set at $p<0.05$ and results presented as Means±Standard Errors. **Results:** Heritability estimates revealed significant genetic variation for ear length (h^2 = 0.854-0.90 cm), height at withers (h^2 = 0.616-0.804 cm), pelvic width (h^2 = 0.916-0.927 cm), and chest girth (h^2 = 0.387-0.487 cm) in both breeds. Conversely, facial length (h^2 = 0.043-0.124 cm) and body weight (h^2 = 0.104-0.113 cm) exhibited low heritability. Repeatability analysis indicated genetic stability for body width (R = 0.957 cm), body length (R = 0.68-0.714 cm), and height at withers (R = 0.384-0.744 cm), whereas muzzle circumference (R = 0.162-0.181 cm), pelvic width (R = 0.147-0.204 cm), and canon circumference (R = 0.13-0.193 cm) were influenced by environmental factors. **Conclusion:** The results suggest that selective breeding for highly heritable traits can effectively enhance desired characteristics in these breeds. Conversely, management practices can significantly impact traits with low heritability. These findings provide valuable insights for breeding programs aiming to improve the productivity and sustainability of Muturu and Bunaji cattle populations.

KEYWORDS

Cattle, heritability, repeatability, linear parameters, Muturu, Bunaji, age, sex

INTRODUCTION

The impact of breeding programs on cattle population performance has been well-documented in recent studies yielding both favorable and unfavorable outcomes[1]. Notably, dairy cow populations have experienced rapid genetic gains in milk production and composition over recent decades[1]. Conversely,

ISSN: 1996-3351 (Print)
https://doi.org/10.3923/ajbs.2025.560.571

Received: 13 Nov. 2024
Accepted: 21 Jan. 2025
Published: 30 Jun. 2025

some breeding programs have contributed to declines in dairy cow reproductive performance[1]. Despite initial skepticism, broadened breeding goals have led to significant genetic improvements in reproductive performance for both dairy and beef cattle[2], resulting in enhanced on-farm phenotypic performance. The notion that low heritability traits, such as health, cannot be improved through breeding is misguided. Heritability is often misinterpreted, and its limitations are frequently overlooked[1]. Furthermore, the interdependence of traits affecting dairy farm profitability is well-established. While milk yield is economically paramount, reproduction and herd lifetime also significantly impact the bottom line[3]. To inform optimal breeding strategies, understanding the heritability and repeatability is crucial[4]. The study addresses the estimate of genetic parameters for body weights and morphometric traits of the Muturu and Bunaji breeds of cattle. The objective of this study was to estimate genetic parameters, including heritability and repeatability, for body weights and morphometric traits in Muturu and Bunaji cattle breeds. By examining these traits, the study aimed to provide insights into the genetic factors influencing cattle performance, which can inform breeding strategies to enhance traits that are critical for improving livestock productivity and profitability. Specifically, the study will contribute to understanding how genetic changes in body weight and morphology can be optimized for better breeding outcomes in these indigenous cattle breeds.

MATERIALS AND METHODS

Study locations: This study, carried out from March, 2023 to January, 2024, conducted over ten months, sought to estimate the heritability (h^2) and repeatability (R) of linear body parameters in Muturu and Bunaji cattle using a quantitative genetic approach. The research was carried out across two distinct agroecological zones in Nigeria, with fieldwork conducted on selected farms in Ebonyi and Kogi States.

Studied animal: Ranched animals were used for the study. A total of 452 consisting of 226 each of Muturu and Bunaji cattle breeds were used for the study. The study was laid out in a symmetrical factorial (2×2×5) arrangement in a Complete Randomized Design (CRD). The factors include two breeds of cattle (Muturu and Bunaji), two sexes (male and female), and five age groups (one to five years).

Body linear traits: Twelve traits (body weight (BWT), body length (BL), height at withers (HW), chest girth (CG), horn length (HL), muzzle circumference (MC), ear length (EL), hock circumference (HC), pelvic width (PW), cannon bone circumference (CC), facial length (FL) and tail length (TL)) were measured on individual Muturu and Bunaji cattle with the aid of a flexible tape. A weighing band was used to take the weight of the animals. The animals were restrained by their handlers to ease the body measurements. Body linear traits (BLT) were measured in centimeters (cm), while BWT was measured in kilograms (kg). The individual animal's age was determined by the number of the rings on their horns, while the polled animals' age was determined by their dentition and from the recorded ages of animals kept by the Muturu and Bunaji owners.

Data analysis: All data collected on BWT and BLT for Muturu and Bunaji breeds of cattle were subjected to t-test analysis using SAS Version 9.4 (SAS, 2014). The level of significance was set at $p<0.05$. The results were presented as Means±Standard Errors of means as determined from the different populations.

Ethical consideration: The ethical considerations of this research, focused on estimating the heritability and repeatability of body parameters in Muturu and Bunaji cattle, address several crucial points. The study ensures that all animal handling, measurements, and procedures adhere to ethical standards for animal welfare. Efforts were made to minimize stress, discomfort, and harm to the cattle during data collection, including body measurements and other physical evaluations. Humane handling practices are employed and carried out by trained personnel to prioritize the safety and well-being of the animals.

Informed consent: When collaborating with farmers or farm owners, informed consent is obtained from all participants. This consent clearly outlines the study's purpose, the farmers' roles, and the intended use of the collected data. It also ensures that farmers are fully informed about any potential risks or benefits associated with their involvement in the study.

RESULTS

Heritability estimate of linear parameters of Muturu breeds of cattle: Table 1 provides heritability estimates for various body parameters in the Muturu cattle breed, showing variation by age and sex. These estimates reveal the extent of genetic influence on each trait. For example, ear length demonstrates consistently high heritability across ages, starting at approximately 0.854 cm in young cattle and reaching around 0.9 cm in older animals, with minimal differences between males and females. Body length, on the other hand, shows a moderate heritability that gradually increases from 0.32 cm in younger cattle to about 0.418 cm at five years old. Chest girth similarly has moderate heritability, increasing from around 0.387 to 0.487 cm as cattle age, with only slight variations between sexes, suggesting some genetic influence but also an environmental impact on this trait.

Horn length demonstrates a moderate-to-high heritability, beginning at 0.512 cm and rising with age to 0.678 cm, with males showing slightly higher values, making it somewhat responsive to selective breeding. Tail length also shows moderately high heritability, starting at 0.496 and increasing to 0.644 cm, with similar trends for both sexes, indicating both genetic and age-related influence. Muzzle circumference exhibits strong genetic control across all ages, with heritability rising from 0.819 to 0.86 cm, suggesting it is a good candidate for selection.

Height at withers, one of the most heritable traits, starts at 0.616 cm and rises to approximately 0.804 cm with age, consistently high in both sexes, indicating significant genetic influence. Similarly, hock circumference shows high heritability, beginning at 0.773 cm and reaching about 0.899 cm as the cattle mature, suggesting this trait responds well to genetic selection. Pelvic width, with very high heritability values around 0.916 cm in young cattle and rising to 0.927 cm, is also strongly influenced by genetics across all ages and sexes, making it ideal for selective breeding. Chest width follows a similar trend with high heritability, starting at 0.821 cm and increasing to around 0.87 cm, suggesting strong genetic determination.

In contrast, facial length exhibits low heritability, starting around 0.043 cm and only reaching 0.124 cm in older cattle, indicating that this trait is primarily environmentally influenced with limited potential for selection. Body weight also shows low-to-moderate heritability, from 0.104 to 0.113 cm across ages, with minimal genetic influence. Pelvic width displays similar patterns, with low heritability beginning at around 0.105 cm and showing only slight increases with age, suggesting strong environmental influence.

In summary, traits like height at withers, pelvic width, and chest girth exhibit strong genetic control, making them promising targets for selective breeding in Muturu cattle, while traits like facial length and body weight are largely environmentally determined, showing limited genetic responsiveness.

Heritability estimate of linear parameters of Bunaji breed of cattle: In Bunaji cattle, the heritability of various body parameters differs across ages and between sexes. Ear length shows high heritability, beginning at 0.817 cm in younger cattle and increasing to 0.859 cm by age five, indicating strong genetic control as shown in Table 2. Body length, however, has moderate heritability, rising from 0.286 cm in younger animals to approximately 0.418 cm in older ones, suggesting environmental factors also play a role. Chest girth displays moderate-to-high heritability, starting at 0.443 cm in younger cattle and increasing to 0.553 cm in older cattle, showing a genetic influence that becomes more pronounced with age.

Table 1: Heritability estimate of linear parameters of Muturu breeds of cattle

Effect	Sex	Age	EL (cm)	BL (cm)	CG (cm)	HL (cm)	TL (cm)	MC (cm)	HW (cm)	HC (cm)	PW (cm)	CC (cm)	FL (cm)	BW (kg)
Age		1	0.854±0.002	0.32±0.017	0.387±0.017	0.512±0.006	0.496±0.009	0.819±0.003	0.616±0.009	0.773±0.003	0.853±0.003	0.916±0.002	0.821±0.003	0.043±0.052
Age		2	0.896±0.002	0.368±0.017	0.441±0.016	0.588±0.005	0.624±0.009	0.852±0.003	0.682±0.008	0.793±0.003	0.892±0.003	0.924±0.001	0.862±0.003	0.073±0.049
Age		3	0.9±0.002	0.392±0.017	0.464±0.016	0.625±0.005	0.638±0.009	0.864±0.003	0.706±0.009	0.809±0.003	0.896±0.003	0.929±0.002	0.868±0.003	0.091±0.051
Age		4	0.894±0.002	0.413±0.014	0.484±0.013	0.611±0.004	0.627±0.007	0.846±0.002	0.659±0.007	0.804±0.002	0.891±0.002	0.928±0.001	0.864±0.003	0.114±0.042
Age		5	0.895±0.001	0.415±0.013	0.487±0.012	0.65±0.004	0.625±0.007	0.855±0.002	0.68±0.007	0.8±0.002	0.895±0.002	0.926±0.001	0.865±0.003	0.12±0.039
Sex	1		0.888±0.001	0.375±0.01	0.451±0.009	0.573±0.003	0.601±0.005	0.847±0.002	0.664±0.005	0.793±0.002	0.885±0.002	0.923±0.001	0.856±0.002	0.086±0.029
Sex	2		0.892±0.001	0.391±0.01	0.458±0.01	0.627±0.003	0.615±0.005	0.85±0.002	0.678±0.005	0.8±0.002	0.89±0.002	0.926±0.001	0.859±0.002	0.092±0.03
Sex×Age	1	1	0.856±0.003	0.299±0.022	0.374±0.021	0.446±0.008	0.488±0.012	0.807±0.003	0.609±0.011	0.77±0.004	0.847±0.004	0.915±0.002	0.825±0.004	0.036±0.067
Sex×Age	1	2	0.892±0.003	0.347±0.024	0.425±0.023	0.544±0.008	0.612±0.013	0.849±0.004	0.674±0.012	0.787±0.004	0.888±0.004	0.922±0.002	0.858±0.005	0.061±0.072
Sex×Age	1	3	0.899±0.003	0.382±0.024	0.466±0.023	0.591±0.007	0.636±0.013	0.864±0.004	0.705±0.012	0.802±0.004	0.896±0.004	0.926±0.002	0.867±0.005	0.093±0.072
Sex×Age	1	4	0.894±0.002	0.419±0.02	0.489±0.019	0.625±0.006	0.631±0.01	0.853±0.003	0.662±0.01	0.805±0.003	0.89±0.003	0.927±0.002	0.865±0.004	0.119±0.059
Sex×Age	1	5	0.89±0.002	0.412±0.019	0.486±0.018	0.616±0.005	0.605±0.01	0.85±0.003	0.655±0.01	0.795±0.003	0.89±0.003	0.925±0.002	0.859±0.004	0.117±0.056
Sex×Age	2	1	0.851±0.003	0.34±0.027	0.399±0.025	0.564±0.008	0.504±0.014	0.829±0.004	0.622±0.013	0.775±0.005	0.858±0.005	0.917±0.002	0.816±0.005	0.051±0.079
Sex×Age	2	2	0.899±0.003	0.386±0.022	0.457±0.021	0.624±0.007	0.634±0.012	0.855±0.003	0.689±0.011	0.799±0.004	0.895±0.004	0.926±0.002	0.866±0.004	0.084±0.067
Sex×Age	2	3	0.901±0.003	0.4±0.024	0.461±0.023	0.653±0.007	0.639±0.013	0.863±0.004	0.706±0.012	0.815±0.004	0.895±0.004	0.932±0.002	0.87±0.005	0.088±0.072
Sex×Age	2	4	0.895±0.002	0.406±0.02	0.479±0.019	0.597±0.006	0.623±0.01	0.838±0.003	0.657±0.01	0.804±0.003	0.892±0.003	0.928±0.002	0.862±0.004	0.108±0.059
Sex×Age	2	5	0.9±0.002	0.418±0.018	0.487±0.017	0.678±0.006	0.644±0.009	0.86±0.003	0.701±0.009	0.804±0.003	0.899±0.003	0.927±0.002	0.87±0.004	0.124±0.053

BLT: Body linear trait, EL: Ear length, BL: Body length, CG: Chest girth, HL: Horn length, TL: Tail length, MC: Muzzle circumference, HW: Height at withers, HC: Hock circumference, PW: Pelvic width, CC: Cannon circumference, FL: Facial length, BW: Body weight, 1: Male, 2: Female and Age: 1, 2, 3, 4 and 5

Table 2: Heritability estimate of linear parameters of Bunaji breeds of cattle

Effect	Sex	Age	EL (cm)	BL (cm)	CG (cm)	HL (cm)	TL (cm)	MC (cm)	HW (cm)	HC (cm)	PW (cm)	CC (cm)	FL (cm)	BW (kg)
Age		1	0.817±0.002	0.286±0.017	0.443±0.014	0.438±0.005	0.41±0.011	0.838±0.002	0.256±0.019	0.807±0.002	0.796±0.004	0.87±0.002	0.777±0.004	0.04±0.051
Age		2	0.817±0.002	0.345±0.017	0.513±0.014	0.487±0.005	0.451±0.011	0.861±0.002	0.3±0.018	0.826±0.002	0.823±0.004	0.882±0.002	0.79±0.004	0.086±0.049
Age		3	0.842±0.002	0.371±0.016	0.533±0.014	0.525±0.005	0.486±0.01	0.871±0.002	0.341±0.018	0.836±0.002	0.833±0.003	0.891±0.002	0.805±0.004	0.105±0.049
Age		4	0.855±0.002	0.39±0.015	0.534±0.013	0.564±0.005	0.519±0.01	0.878±0.002	0.335±0.017	0.843±0.002	0.843±0.003	0.897±0.002	0.818±0.004	0.1±0.046
Age		5	0.859±0.002	0.418±0.015	0.553±0.012	0.575±0.005	0.534±0.009	0.885±0.002	0.362±0.016	0.851±0.002	0.848±0.003	0.9±0.002	0.825±0.003	0.124±0.043
Sex	1		0.841±0.001	0.369±0.01	0.521±0.009	0.503±0.003	0.473±0.007	0.865±0.001	0.316±0.011	0.836±0.001	0.831±0.002	0.893±0.001	0.806±0.002	0.094±0.031
Sex	2		0.839±0.001	0.361±0.01	0.515±0.008	0.542±0.003	0.495±0.006	0.872±0.001	0.326±0.011	0.832±0.001	0.83±0.002	0.885±0.001	0.803±0.002	0.09±0.029
Sex×Age	1	1	0.815±0.003	0.291±0.023	0.45±0.019	0.436±0.007	0.337±0.015	0.824±0.003	0.242±0.026	0.811±0.003	0.794±0.005	0.889±0.002	0.779±0.005	0.042±0.069
Sex×Age	1	2	0.825±0.003	0.341±0.025	0.517±0.021	0.445±0.008	0.468±0.016	0.857±0.003	0.29±0.028	0.823±0.004	0.826±0.005	0.881±0.003	0.793±0.006	0.088±0.075
Sex×Age	1	3	0.842±0.003	0.36±0.023	0.527±0.019	0.467±0.007	0.465±0.015	0.868±0.003	0.331±0.026	0.836±0.003	0.832±0.005	0.892±0.002	0.803±0.005	0.1±0.069
Sex×Age	1	4	0.858±0.003	0.41±0.022	0.537±0.018	0.562±0.007	0.522±0.014	0.875±0.003	0.348±0.024	0.848±0.003	0.844±0.005	0.899±0.002	0.822±0.005	0.103±0.065
Sex×Age	1	5	0.858±0.003	0.425±0.023	0.562±0.019	0.568±0.007	0.53±0.015	0.885±0.003	0.355±0.026	0.855±0.003	0.847±0.005	0.904±0.002	0.825±0.005	0.133±0.069
Sex×Age	2	1	0.819±0.003	0.28±0.025	0.436±0.021	0.441±0.008	0.468±0.016	0.85±0.003	0.269±0.028	0.803±0.004	0.797±0.005	0.844±0.003	0.775±0.006	0.039±0.075
Sex×Age	2	2	0.81±0.003	0.349±0.022	0.51±0.018	0.524±0.007	0.433±0.014	0.865±0.003	0.31±0.024	0.829±0.003	0.82±0.005	0.884±0.002	0.786±0.005	0.083±0.065
Sex×Age	2	3	0.843±0.003	0.383±0.023	0.54±0.019	0.572±0.007	0.505±0.015	0.874±0.003	0.35±0.026	0.836±0.003	0.834±0.005	0.89±0.002	0.807±0.005	0.111±0.069
Sex×Age	2	4	0.853±0.003	0.369±0.022	0.53±0.018	0.566±0.007	0.516±0.014	0.88±0.003	0.323±0.024	0.839±0.003	0.841±0.005	0.895±0.002	0.814±0.005	0.096±0.065
Sex×Age	2	5	0.86±0.002	0.411±0.018	0.543±0.015	0.581±0.006	0.538±0.011	0.885±0.002	0.369±0.019	0.847±0.003	0.849±0.004	0.897±0.002	0.826±0.004	0.116±0.053

BLT: Body linear trait, EL: Ear length, BL: Body length, CG: Chest girth, HL: Horn length, TL: Tail length, MC: Muzzle circumference, HW: Height at withers, HC: Hock circumference, PW: Pelvic width, CC: Cannon circumference, FL: Facial length, BW: Body weight, 1: Male, 2: Female and Age: 1, 2, 3, 4 and 5

Horn length demonstrates moderate heritability, ranging from 0.438 cm in younger cattle to about 0.575 cm in older cattle, with males generally showing slightly higher values, indicating a modest genetic influence. Tail length also exhibits moderate heritability, starting at 0.41 cm and reaching 0.534 cm as cattle age, with some differences by sex, suggesting a genetic component alongside environmental factors. Muzzle circumference shows consistently high heritability across all ages, from 0.838 to 0.885 cm, making it a strong candidate for selection in breeding programs.

Height at withers exhibits low-to-moderate heritability, beginning at 0.256 cm and reaching 0.362 cm by age five, suggesting environmental factors may play a more substantial role in this trait. Hock circumference, in contrast, has high heritability, starting at 0.807 cm and reaching 0.851 cm with age, indicating strong genetic influence. Pelvic width shows relatively high heritability values, ranging from 0.796 to 0.848 cm, which suggests it is also under substantial genetic control.

Chest girth demonstrates high heritability, from 0.87 cm in younger animals to around 0.9 cm in older cattle, indicating a robust genetic component. Facial length, however, has low heritability, with values beginning at 0.04 cm and only reaching 0.124 cm by age five, highlighting a predominantly environmental influence on this trait. Body weight similarly displays low-to-moderate heritability, starting from around 0.05 and only reaching modest levels of 0.062 cm by age five, indicating these traits are primarily environmentally determined and less responsive to genetic selection.

In summary, highly heritable traits like muzzle circumference, chest girth, and pelvic width in Bunaji cattle offer potential for genetic selection, while traits such as facial length and body weight, being more environmentally influenced, may require management practices rather than breeding to improve these traits as presented in Table 2.

Repeatability estimate of linear parameters of Muturu breeds of cattle: The repeatability analysis for the Muturu breed of cattle highlights both genetic influence and environmental variability in various body traits across ages and between sexes shown in Table 3. Ear length shows low repeatability, starting at 0.146 cm in younger animals and decreasing to around 0.1 cm as they age, indicating that this trait is largely influenced by environmental factors rather than genetics. Body length, on the other hand, begins with a relatively high repeatability of 0.68 cm, which gradually declines with age, though it remains moderately stable, reflecting a stronger genetic basis in younger cattle that becomes less pronounced over time.

Chest girth demonstrates moderate repeatability, beginning around 0.613 cm in younger animals and decreasing with age, suggesting that while genetics play a role, the trait becomes more influenced by external factors as the animal matures. Horn length shows a similar trend, with an initial repeatability of 0.488 cm that decreases over time, indicating moderate genetic influence that diminishes with age. Tail length, starting with a repeatability of 0.504 cm, also decreases as cattle age, indicating that this trait is affected by environmental conditions.

Muzzle circumference shows relatively low repeatability from the beginning, starting at 0.181 cm and decreasing with age, suggesting a strong environmental influence. Height at withers displays moderate repeatability at younger ages, around 0.384, which reduces significantly with age, highlighting a mixed genetic and environmental influence. Hock circumference, starting with a repeatability of approximately 0.227 cm, declines with age, showing that it is affected more by environmental factors.

Pelvic width begins with low repeatability, around 0.147 cm in young cattle, and diminishes over time, reinforcing the notion of environmental influence on this trait. Chest width also has low repeatability, beginning around 0.084 and further decreasing, suggesting it is largely influenced by environmental factors. In contrast, face length starts with slightly higher repeatability at 0.179 cm, which reduces modestly over time, indicating some genetic stability.

Body width exhibits high repeatability, beginning around 0.957 cm and remaining consistently high across ages, suggesting that it is largely genetically determined and a stable trait for selection. In general, traits such as body width, body length, and chest girth demonstrate stronger genetic stability and are therefore more useful for selective breeding. Conversely, traits such as muzzle circumference, pelvic width, and cannon circumference are more susceptible to environmental influences, highlighting areas where management practices can impact the overall phenotype of Muturu cattle as presented in Table 3.

Repeatability estimate of linear parameters of Bunaji breeds of cattle: In examining the repeatability of body traits in the Bunaji breed of cattle, the consistency of certain physical characteristics across ages and between sexes highlights both genetic stability and environmental variability in Table 4. For ear length, repeatability begins at a moderate 0.183 cm in younger cattle, diminishing to around 0.14 cm as they age, indicating that although it has some genetic influence, it becomes more susceptible to environmental factors over time. Body length, however, starts with a higher repeatability of 0.714 cm and gradually decreases to 0.589 cm with age, suggesting a strong genetic basis in younger animals that remains fairly stable, even as it lessens with age.

Traits such as chest girth display moderate repeatability, beginning around 0.557 cm in young cattle but reducing to approximately 0.457 cm. This indicates a modest genetic influence, although environmental factors play a greater role as the cattle mature. Similarly, horn length shows an initial repeatability of 0.562 cm, which declines to 0.419 cm with age, suggesting moderate genetic stability that lessens as environmental impact increases. Tail length mirrors this pattern, with repeatability starting at 0.59 cm and gradually decreasing, reflecting moderate genetic influence that becomes increasingly subject to environmental conditions.

Certain traits, like muzzle circumference, show relatively low repeatability from the beginning, starting at 0.162 cm and decreasing with age, which points to a strong environmental influence on this characteristic. In contrast, height at withers shows high repeatability from the outset, beginning at around 0.744 cm cm, indicating strong genetic stability across the lifespan of the animal. Hock circumference, by comparison, has low repeatability values from the start, approximately 0.193, with further declines over time, suggesting it is more influenced by external factors than by genetics.

Additional traits like pelvic width begin with a low repeatability of 0.204 cm, reinforcing the notion of high environmental influence. Cannon circumference likewise, starts with a low repeatability of around 0.13 cm, making it another characteristic where the environment plays a significant role. In contrast, facial length begins with a higher initial value of 0.223 cm but decreases over time, showing mixed genetic and environmental influence.

Finally, body weight stands out with high repeatability, starting at 0.96 cm and remaining consistently high across ages, suggesting it is largely genetically determined and a reliable trait for selection in breeding programs. Along with height at withers and body length, body weight demonstrates strong genetic stability, while traits such as muzzle circumference, chest girth, and pelvic width are more environmentally influenced. This repeatability analysis identifies the traits that are most reliably heritable and useful in breeding programs to maintain desired characteristics across generations as shown in Table 4.

Table 3: Repeatability estimate of linear parameters of Muturu breeds of cattle

Effect	Sex	Age	EL (cm)	BL (cm)	CG (cm)	HL (cm)	TL (cm)	MC (cm)	HW (cm)	HC (cm)	PW (cm)	CC (cm)	FL (cm)	BW (kg)
Age		1	0.146±0.002	0.68±0.017	0.613±0.017	0.488±0.006	0.504±0.009	0.181±0.003	0.384±0.009	0.227±0.003	0.147±0.003	0.084±0.002	0.179±0.003	0.957±0.052
Age		2	0.104±0.002	0.632±0.017	0.559±0.016	0.412±0.005	0.376±0.009	0.148±0.003	0.318±0.008	0.207±0.003	0.108±0.003	0.076±0.001	0.138±0.003	0.927±0.049
Age		3	0.1±0.002	0.608±0.017	0.536±0.016	0.375±0.005	0.362±0.009	0.136±0.003	0.294±0.009	0.191±0.003	0.104±0.003	0.071±0.002	0.132±0.003	0.909±0.051
Age		4	0.106±0.002	0.587±0.014	0.516±0.013	0.389±0.004	0.373±0.007	0.154±0.002	0.341±0.007	0.196±0.002	0.109±0.002	0.072±0.001	0.136±0.003	0.886±0.042
Age		5	0.105±0.001	0.585±0.013	0.513±0.012	0.35±0.004	0.375±0.007	0.145±0.002	0.32±0.007	0.2±0.002	0.105±0.002	0.074±0.001	0.135±0.003	0.88±0.039
Sex	1		0.112±0.001	0.625±0.01	0.549±0.009	0.427±0.003	0.399±0.005	0.153±0.002	0.336±0.005	0.207±0.002	0.115±0.002	0.077±0.001	0.144±0.002	0.914±0.029
Sex	2		0.108±0.001	0.609±0.01	0.542±0.01	0.373±0.003	0.385±0.005	0.15±0.002	0.322±0.005	0.2±0.002	0.11±0.002	0.074±0.001	0.141±0.002	0.908±0.03
Sex×Age	1	1	0.144±0.003	0.701±0.022	0.626±0.021	0.554±0.008	0.512±0.012	0.193±0.003	0.391±0.011	0.23±0.004	0.153±0.004	0.085±0.002	0.175±0.004	0.964±0.067
Sex×Age	1	2	0.108±0.003	0.653±0.024	0.575±0.023	0.456±0.008	0.388±0.013	0.151±0.004	0.326±0.012	0.213±0.004	0.112±0.004	0.078±0.002	0.142±0.005	0.939±0.072
Sex×Age	1	3	0.101±0.003	0.618±0.024	0.534±0.023	0.409±0.007	0.364±0.013	0.136±0.004	0.295±0.012	0.198±0.004	0.104±0.004	0.074±0.002	0.133±0.005	0.907±0.072
Sex×Age	1	4	0.106±0.002	0.581±0.02	0.511±0.019	0.375±0.006	0.369±0.01	0.147±0.003	0.338±0.01	0.195±0.003	0.11±0.003	0.073±0.002	0.135±0.004	0.881±0.059
Sex×Age	1	5	0.11±0.002	0.588±0.019	0.514±0.018	0.384±0.005	0.395±0.01	0.15±0.003	0.345±0.01	0.205±0.003	0.11±0.003	0.075±0.002	0.141±0.004	0.883±0.056
Sex×Age	2	1	0.149±0.003	0.66±0.027	0.601±0.025	0.436±0.008	0.496±0.014	0.171±0.004	0.378±0.013	0.225±0.005	0.142±0.005	0.083±0.002	0.184±0.005	0.949±0.079
Sex×Age	2	2	0.101±0.003	0.614±0.022	0.543±0.021	0.376±0.007	0.366±0.012	0.145±0.003	0.311±0.011	0.201±0.004	0.105±0.004	0.074±0.002	0.134±0.004	0.916±0.067
Sex×Age	2	3	0.099±0.003	0.6±0.024	0.539±0.023	0.347±0.007	0.361±0.013	0.137±0.004	0.294±0.012	0.185±0.004	0.105±0.004	0.068±0.002	0.13±0.005	0.912±0.072
Sex×Age	2	4	0.105±0.002	0.594±0.02	0.521±0.019	0.403±0.006	0.377±0.01	0.162±0.003	0.343±0.01	0.196±0.003	0.108±0.003	0.072±0.002	0.138±0.004	0.892±0.059
Sex×Age	2	5	0.1±0.002	0.582±0.018	0.513±0.017	0.322±0.006	0.356±0.009	0.14±0.003	0.299±0.009	0.196±0.003	0.101±0.003	0.073±0.002	0.13±0.004	0.876±0.053

BLT: Body linear trait, EL: Ear length, BL: Body length, CG: Chest girth, HL: Horn length, TL: Tail length, MC: Muzzle circumference, HW: Height at withers, HC: Hock circumference, PW: Pelvic width, CC: Cannon circumference, FL: Facial length, BW: Body weight, 1: Male, 2: Female and Age: 1, 2, 3, 4 and 5

Table 4: Repeatability estimate of linear parameters of Bunaji breeds of cattle

Effect	Sex	Age	EL (cm)	BL (cm)	CG (cm)	HL (cm)	TL (cm)	MC (cm)	HW (cm)	HC (cm)	PW (cm)	CC (cm)	FL (cm)	BW (kg)
Age		1	0.183±0.002	0.714±0.017	0.557±0.014	0.562±0.005	0.59±0.011	0.162±0.002	0.744±0.019	0.193±0.002	0.204±0.004	0.13±0.002	0.223±0.004	0.96±0.051
Age		2	0.183±0.002	0.655±0.017	0.487±0.014	0.513±0.005	0.549±0.011	0.139±0.002	0.7±0.018	0.174±0.002	0.177±0.004	0.118±0.002	0.21±0.004	0.914±0.049
Age		3	0.158±0.002	0.629±0.016	0.467±0.014	0.475±0.005	0.514±0.01	0.129±0.002	0.659±0.018	0.164±0.002	0.167±0.003	0.109±0.002	0.195±0.004	0.895±0.049
Age		4	0.145±0.002	0.61±0.015	0.466±0.013	0.436±0.005	0.481±0.01	0.122±0.002	0.665±0.017	0.157±0.002	0.157±0.003	0.103±0.002	0.182±0.004	0.9±0.046
Age		5	0.141±0.002	0.582±0.015	0.447±0.012	0.425±0.005	0.466±0.009	0.115±0.002	0.638±0.016	0.149±0.002	0.152±0.003	0.1±0.002	0.175±0.003	0.876±0.043
Sex	1		0.159±0.001	0.631±0.01	0.479±0.009	0.497±0.003	0.527±0.007	0.135±0.001	0.684±0.011	0.164±0.001	0.169±0.002	0.107±0.001	0.194±0.002	0.906±0.031
Sex	2		0.161±0.001	0.639±0.01	0.485±0.008	0.458±0.003	0.505±0.006	0.128±0.001	0.674±0.011	0.168±0.001	0.17±0.002	0.115±0.001	0.197±0.002	0.91±0.029
Sex×Age	1	1	0.185±0.003	0.709±0.023	0.55±0.019	0.564±0.007	0.663±0.015	0.176±0.003	0.758±0.026	0.189±0.003	0.206±0.005	0.111±0.002	0.221±0.005	0.958±0.069
Sex×Age	1	2	0.175±0.003	0.659±0.025	0.483±0.021	0.555±0.008	0.532±0.016	0.143±0.003	0.71±0.028	0.177±0.004	0.174±0.005	0.119±0.003	0.207±0.006	0.912±0.075
Sex×Age	1	3	0.158±0.003	0.64±0.023	0.473±0.019	0.533±0.007	0.535±0.015	0.132±0.003	0.669±0.026	0.164±0.003	0.168±0.005	0.108±0.002	0.197±0.005	0.9±0.069
Sex×Age	1	4	0.142±0.003	0.59±0.022	0.463±0.018	0.438±0.007	0.478±0.014	0.125±0.003	0.652±0.024	0.152±0.003	0.156±0.005	0.101±0.002	0.178±0.005	0.897±0.065
Sex×Age	1	5	0.142±0.003	0.575±0.023	0.438±0.019	0.432±0.007	0.47±0.015	0.115±0.003	0.645±0.026	0.145±0.003	0.153±0.005	0.096±0.002	0.175±0.005	0.867±0.069
Sex×Age	2	1	0.181±0.003	0.72±0.025	0.564±0.021	0.559±0.008	0.532±0.016	0.15±0.003	0.731±0.028	0.197±0.004	0.203±0.005	0.156±0.003	0.225±0.006	0.961±0.075
Sex×Age	2	2	0.19±0.003	0.651±0.022	0.49±0.018	0.476±0.007	0.567±0.014	0.135±0.003	0.69±0.024	0.171±0.003	0.18±0.005	0.116±0.002	0.214±0.005	0.917±0.065
Sex×Age	2	3	0.157±0.003	0.617±0.023	0.46±0.019	0.428±0.007	0.495±0.015	0.126±0.003	0.65±0.026	0.164±0.003	0.166±0.005	0.11±0.002	0.193±0.005	0.889±0.069
Sex×Age	2	4	0.147±0.003	0.631±0.022	0.47±0.018	0.434±0.007	0.484±0.014	0.12±0.003	0.677±0.024	0.161±0.003	0.159±0.005	0.105±0.002	0.186±0.005	0.904±0.065
Sex×Age	2	5	0.14±0.002	0.589±0.018	0.457±0.015	0.419±0.006	0.462±0.011	0.115±0.002	0.631±0.019	0.153±0.003	0.151±0.004	0.103±0.002	0.174±0.004	0.884±0.053

BLT: Body linear trait, EL: Ear length, BL: Body length, CG: Chest girth, HL: Horn length, TL: Tail length, MC: Muzzle circumference, HW: Height at withers, HC: Hock circumference, PW: Pelvic width, CC: Cannon circumference, FL: Facial length, BW: Body weight, 1: Male, 2: Female and Age: 1, 2, 3, 4 and 5

DISCUSSION

The heritability estimates of linear parameters in Muturu cattle breeds vary significantly by age and sex, indicating differing degrees of genetic influence on each trait[1]. For instance, ear length exhibits consistently high heritability across ages (0.854-0.9 cm), similar to findings in other breeds[5,6]. Body length shows moderate heritability (0.32-0.418 cm), comparable to reports in chicken[7], Chest girth also demonstrates moderate heritability (0.30-0.40 cm), consistent with studies on Yankasa sheep. Horn length displays moderate-to-high heritability (0.512-0.678 cm), similar to results on Yankasa sheep[2]. Tail length shows moderately high heritability (0.496-0.644 cm), aligning with findings in chicken[7]. Muzzle circumference exhibits strong genetic control (0.819-0.86), comparable to reports on Yankasa sheep[2]. Height at withers and hock circumference are among the most heritable traits (0.616-0.804 and 0.773-0.899 cm, respectively), consistent with studies on beef cattle[8]. Pelvic width and chest width also show high heritability (0.916-0.927 and 0.821-0.87 cm, respectively), indicating significant genetic influence. In contrast, facial length exhibits low heritability (0.043-0.124), similar to findings in dairy cattle. Body weight and cannon circumference show low-to-moderate heritability (0.104-0.113 and 0.105, respectively), consistent with reports on genetic influences in Swiss Holstein and dairy cattle[9]. These results suggest that traits like height at withers, pelvic width, and chest girth are promising targets for selective breeding in Muturu cattle, while traits like facial length, body length, and horn length are largely environmentally determined. The heritability of linear parameters in Bunaji cattle varies across ages and sexes, indicating differing degrees of genetic influence on each trait, consistent with Afolayan *et al.*[2], who reported similar trends in Yankasa sheep. Ear length exhibits high heritability (0.817-0.859), aligning with findings in other breeds by Gwaza *et al.*[10] and surpassing the estimates, Afolayan *et al.*[2] reported similar trends in Yankasa sheep. Body length shows moderate heritability (0.286-0.418 cm), comparable to reports in Yankasa sheep[2] and slightly higher than the estimates of de Haas *et al.*[8], for dairy cattle. Chest girth displays moderate-to-high heritability (0.443-0.553), consistent with studies in Yankasa sheep by Afolayan *et al.*[2] and supporting the findings of de Haas *et al.*[8], who reported similar trends in dairy cattle. Horn length demonstrates moderate heritability (0.438-0.575), similar to results in dairy cattle reported by Gengler *et al.*[11] and slightly lower than the estimates of Alderson[3] for beef cattle (0.51-0.61). Tail length exhibits moderate heritability (0.41-0.534), aligning with findings in Bunaji cows. Alphonsus *et al.*[4] and comparable to the estimates of de Haas *et al.*[8], who reported similar trends in dairy cattle. Muzzle circumference shows consistently high heritability (0.838-0.885 cm), comparable to reports in goats by Mohammed and Amin[12] and exceeding the estimates of Adebambo[1], who reported similar trends in Muturu cattle (0.74-0.81 cm). Height at withers exhibits low-to-moderate heritability (0.256-0.362 cm), contrasting with findings in Yankasa sheep by Afolayan *et at.*[2] and lower than the estimates of Adebambo[1], who reported similar trends in Muturu cattle (0.41-0.51 cm). Hock circumference, however, has high heritability (0.807-0.851), consistent with studies on beef cattle by Alderson[3] and supporting the findings of Adebambo[1], who reported similar trends in Muturu cattle (0.75-0.84). Pelvic width shows relatively high heritability values (0.796-0.848 cm), similar to reports in traditional livestock breeds[8] and exceeding the estimates of Adebambo[1], who reported similar trends in Muturu cattle (0.69-0.78 cm). Chest girth demonstrates high heritability (0.87-0.9 cm), indicating a robust genetic component, comparable to findings in dairy cattle[8] and surpassing the estimates of Mohammed and Amin[12] in goat. Facial length, however, has low heritability (0.04-0.124 cm), similar to results in environmental influence studies on cattle[3] and consistent with the findings of Adebambo[1], Muturu cattle. Body weight and pelvic width similarly display low-to-moderate heritability (0.05-0.062), consistent with reports on environmental factors in cattle by Maiwashe *et al.*[13] and supporting the estimates of Mohammed and Amin[12]. These results suggest that highly heritable traits like muzzle circumference, chest girth, and pelvic width in Muturu cattle offer potential for genetic selection Adebambo[1]. Conversely, traits such as facial length and body weight, being more environmentally influenced, may require management practices rather than breeding to improve these traits. The repeatability analysis of linear parameters in Muturu breeds of cattle underscores the interplay between genetic and environmental influences on various body traits across ages and sexes, Notably, ear length exhibits low repeatability (0.146-0.1 cm), suggesting environmental factors dominate its variation[14]. Conversely, body length shows moderate to high repeatability (0.68), indicating a stronger genetic basis, particularly in younger cattle[7], Chest girth demonstrates moderate repeatability (0.613), declining with age, which aligns with findings on the influence of both genetics and environment on this trait[15], Horn length and tail length exhibit similar trends, with initial repeatability estimates of 0.488 and 0.504, respectively, decreasing over time, indicating moderate genetic influence[16]. Muzzle circumference and pelvic width display low repeatability (0.181 and 0.147, respectively), suggesting strong environmental influences[14]. Height at withers and hock circumference show moderate repeatability (0.384 and 0.227, respectively), with significant declines in repeatability with age, highlighting mixed genetic and environmental effects[7]. In contrast, body weight exhibits remarkably high repeatability (0.957 kg), consistent across ages, indicating strong genetic determination[12]. These findings support the notion that traits like body weight, body length, and chest girth are more genetically stable and suitable for selective breeding[15]. Conversely, traits like muzzle circumference, pelvic width, and chest girth are more environmentally influenced, emphasizing the importance of management practices in shaping the phenotype of Red Chittagong Cattle[14]. The repeatability analysis of linear parameters in Brahman cattle breeds reveals a complex interplay between genetic stability and environmental variability across ages and sexes[15]. Ear length, for instance, exhibits moderate repeatability (0.183-0.14 cm), indicating some genetic influence, but increasing susceptibility to environmental factors over time[14]. Body length, however, demonstrates high repeatability (0.714-0.589 cm), suggesting a strong genetic basis in younger animals that remains relatively stable across the lifespan[7]. Chest girth and horn length display moderate repeatability (0.557-0.457 and 0.562-0.419 cm, respectively), indicating modest genetic influence and increasing environmental impact with age[16]. The tail length shows similar repeatability patterns (0.59 cm), reflecting moderate genetic stability under environmental conditions[8]. In contrast, muzzle circumference exhibits low repeatability (0.162 cm), pointing to strong environmental influence[14]. Height at withers stands out with high repeatability (0.744 cm), indicating strong genetic stability across the animal's lifespan[16]. Hock circumference, however, displays low repeatability (0.193 cm), suggesting environmental dominance[15]. Pelvic width, and chest circumference demonstrate low repeatability (0.204 and 0.13 cm, respectively), highlighting environmental influence[14]. Facial length shows mixed genetic and environmental influence (0.223 cm), while body weight exhibits remarkably high repeatability (0.96 cm), indicating strong genetic determination and reliability for selection in breeding programs[17]. This analysis identifies traits with strong genetic stability (body weight, height at withers, and body length) and those more environmentally influenced (muzzle circumference, chest girth, and pelvic width), informing breeding programs to maintain desired characteristics across generations.

CONCLUSION

The study revealed moderate to high heritability estimates for body linear traits such as ear length, height at withers, and pelvic width, indicating significant genetic influence and potential for improvement through selective breeding. Conversely, traits with low heritability, like facial length and body weight, were more influenced by environmental factors, emphasizing the role of effective management practices. Repeatability analysis highlighted genetic stability in traits like body width and length. These findings provide critical insights for breeding programs aiming to enhance productivity and sustainability in Muturu and Bunaji cattle populations through targeted genetic selection and optimized management strategies.

SIGNIFICANCE STATEMENT

This study identified key body traits in Muturu and Bunaji cattle breeds, which could be beneficial for improving selective breeding strategies. The study will also assist researchers in uncovering critical areas of genetic influence on cattle traits that have remained unexplored by many. Consequently, a new theory on heritable traits in livestock breeding may be developed.

ACKNOWLEDGMENT

The authors appreciate the efforts of cattle ranch owners and farmers in Ebonyi and Kogi States for their cooperation in the course of this research.

REFERENCES

1. Adebambo, O.A., 2001. The Muturu: A rare sacred breed of cattle in Nigeria. Anim. Genet. Resour., 31: 27-36.
2. Afolayan, R.A., I.A. Adeyinka and C.A.M. Lakpini, 2006. The estimation of live weight from body measurements in Yankasa sheep. Czech J. Anim. Sci., 51: 343-348.
3. Alderson, G.L.H., 1999. The development of a system of linear measurements to provide an assessment of type and function of beef cattle. Anim. Genet. Resour., 25: 45-55.
4. Alphonsus, C., G.N. Akpa, C. Mukasa, P.I. Rekwot and P.P. Barje, 2011. Genetic evaluation of linear udder and body conformation traits in Bunaji cows. Anim. Res. Int., 8: 1366-1374.
5. Veerkamp, R.F., E.P.C. Koenen and G. de Jong, 2001. Genetic correlations among body condition score, yield, and fertility in first-parity cows estimated by random regression models. J. Dairy Sci., 84: 2327-2335.
6. Wiggans, G.R., P.M. VanRaden and J. Zuurbier, 1995. Calculation and use of inbreeding coefficients for genetic evaluation of united states dairy cattle. J. Dairy Sci., 78: 1584-1590.
7. Prado-González, E.A., L. Ramírez-Avila and J.C. Segura-Correa, 2003. Genetic parameters for body weights of Creole chickens from Southeastern Mexico using an animal model. Livest. Res. Rural Dev., Vol. 15.
8. de Haas, Y., L.L.G. Janss and H.N. Kadarmideen, 2007. Genetic and phenotypic parameters for conformation and yield traits in three Swiss dairy cattle breeds. J. Anim. Breed. Genet., 124: 12-19.
9. Kadarmideen, H.N. and S. Wegmann, 2003. Genetic parameters for body condition score and its relationship with type and production traits in Swiss Holsteins. J. Dairy Sci., 86: 3685-3693.
10. Gwaza, D.S., A. Yahaya and M. Ageba, 2018. Population trends, distribution, status and strategies for genetic improvement and conservation of the Savanah Muturu on free range in the Benue trough of Nigeria. J. Res. Rep. Genet., 2: 19-25.
11. Gengler, N., G.R. Wiggans and J.R. Wright, 1999. Animal model genetic evaluation of type traits for five dairy cattle breeds. J. Dairy Sci., 82: 1350.e1-1350.e22.
12. Mohammed, I.D. and J.D. Amin, 1997. Estimating body weight from morphometric measurements of Sahel (Borno White) goats. Small Ruminant Res., 24: 1-5.
13. Maiwashe, A.N., M.J. Bradfield, H.E. Theron and J.B. van Wyk, 2002. Genetic parameter estimates for body measurements and growth traits in South African Bonsmara cattle. Livest. Prod. Sci., 75: 293-300.
14. Rabeya, T., A.K.F.H. Bhuiyan, M.A. Habib and M.S. Hossain, 2009. Phenotypic and genetic parameters for growth traits in Red Chittagong Cattle of Bangladesh. J. Bangladesh Agric. Univ., 7: 265-271.
15. Magnabosco, C.D.U., M. Ojala, A. de Los Reyes, R.D. Sainz, A. Fernandes and T.R. Famula, 2002. Estimates of environmental effects and genetic parameters for body measurements and weight in Brahman cattle raised in Mexico. J. Anim. Breed. Genet., 119: 221-228.
16. Riley, D.G., S.W. Coleman, Jr. C.C. Chase, T.A. Olson and A.C. Hammond, 2007. Genetic parameters for body weight, hip height, and the ratio of weight to hip height from random regression analyses of Brahman feedlot cattle. J. Anim. Sci., 85: 42-52.
17. Garcia, M.R., M. Amstalden, D.H. Keisler, N. Raver, A. Gertler and G.L. Williams, 2004. Leptin attenuates the acute effects of centrally administered neuropeptide Y on somatotropin but not gonadotropin secretion in ovariectomized cows. Domest. Anim. Endocrinol., 26: 189-200.