Circular
Agricultural Systems

ARTICLE

Open Access

https://doi.org/10.48130/cas-0023-0012
Circular Agricultural Systems **2024**, 4: e001

Comparative analysis of cattle production systems in Nigeria grassland agroecology

Akeem B. Sikiru[1*], Bisong O. Otu[2], Olayinka J. Makinde[3], Saoban Saheed[2], Stephen S. A. Egena[2] and Ibrahim R. Muhammad[1]

[1] *Department of Animal Science, Federal University of Agriculture Zuru, Zuru 872252, Kebbi State, Nigeria*
[2] *Department of Animal Production, Federal University of Technology, Minna, 920101, Niger State, Nigeria*
[3] *Department of Animal Science, Federal University Gashua, 671105, Yobe State, Nigeria*
* Corresponding author, E-mail: akeembaba01@gmail.com

Abstract

This study explores herd production characteristics and phenotypic traits of indigenous dairy cattle in the grassland agroecology of Nigeria. The study highlighted the crucial role of agroecology as a modifier of cattle production operations and emphasized the need for further research to understand the genetic basis of variations in the production. Herd production data were collected through focus group meetings using FEAST software, while body measurements and phenotypic traits of lactating and breeding cattle were recorded in the agroecological zone within the grassland. The data obtained were subjected to descriptive statistics, and Moses Test of Extreme Reaction using SPSS v.20.0.0. The results indicate that the agroecology type significantly influenced various herd production characteristics ($p < 0.05$). Additionally, agroecology had a significant effect on body measurements and phenotypic trait expressions in the cattle, including live weight, body condition score, testis circumference, age at puberty, and age at first calving ($p < 0.05$). Furthermore, age differences were observed among cows based on the agroecological zones ($p = 0.008$), while no significant variation was found in the age of breeding bulls across both agroecology. This study concludes that within the Nigeria's grassland, agroecology plays a crucial role as a modifier of herd production characteristics and phenotypic trait expressions in smallholder dairy cattle operations. These cannot be unconnected with genetics, hence, there is a need for understanding the genetic basis of the variations.

Citation: Sikiru AB, Otu BO, Makinde OJ, Saheed S, Egena SSA, et al. 2024. Comparative analysis of cattle production systems in Nigeria grassland agroecology. *Circular Agricultural Systems* 4: e001 https://doi.org/10.48130/cas-0023-0012

Introduction

Dairy cattle production is a crucial agricultural activity that sustains the economic and livelihood needs of approximately 150 million households worldwide[1]. In Nigeria, dairy production has proven to be beneficial for numerous households, even among those engaged in low-input operations. It has significantly contributed to their well-being, household incomes, and overall living conditions. As such, it holds substantial importance within the livestock production sector. However, one of the major factors influencing the performance of dairy cattle is the agroecological context in which they are raised. Agroecology encompasses environmental variables such as temperature, relative humidity, and heat stress, which can modulate the genetic responses of cattle, ultimately impacting their productivity[2]. The fundamental objective of sustainable dairy animal production is to ensure the animals' capacity to thrive, reproduce, and maintain productivity under a wide range of environmental conditions[3]. Consequently, understanding the expression of phenotypic traits and production characteristics within a specific agroecological context becomes imperative for optimizing productivity. This need highlights the significance of investigating these factors under smallholder operations in the forest-savanna transition agroecology of Nigeria.

Agroecology are geographically defined areas characterized by similar climatic conditions that influence their suitability for rainfed agricultural practices. These zones are shaped by factors such as geoposition, elevation, temperature, rainfall patterns, and the distribution of rainfall during the wet season[4]. In Nigeria, there are six distinct agroecological zones, including the Mangrove Swamp, Rainforest, Derived Savanna, Guinea Savanna, Sudan Savanna, and Sahel Savanna, extending from south to north[5]. While livestock production is primarily concentrated in the northern regions of Nigeria, the Derived Savanna agroecological zone in the southern region also supports a significant population of livestock, particularly cattle. This is attributed to pastoralists migrating southward from the north in response to feed resource shortages resulting from climate impacts[6,7]. Additionally, the Southern Guinea Savanna agroecological zone, situated as the southernmost part of northern Nigeria, provides potential pasture plants and range forages for cattle consumption during the dry season when there is a scarcity of range plants in the sub-arid Sahelian regions of northern Nigeria and other West African countries[8,9].

Consequently, the Southern Guinea and Derived Savanna agroecological zones serve as vital hubs for livestock production in Nigeria, witnessing the annual migration of animals' southwards in search of pasture. This is because this agroecology are majorly the Nigeria's grassland where extensive graz-

ing is a common practice. While separate studies have reported smallholder livestock production in this agroecology[10,11], there is currently no comprehensive study that directly compares both areas in a single study as reported in this paper. Thus, this study aims to address this research gap by assessing livestock production characteristics and phenotypic traits of cattle under low-input production practices within the two agroecological zones. By conducting this comparative analysis, we can gain a comprehensive understanding of the unique challenges and opportunities associated with smallholder dairy cattle production in the forest-savanna transition agroecology of Nigeria.

Materials and methods

Study design

This study utilized focus group meetings with pastoralists and agropastoralists to collect data on herd production and record phenotypic traits, including body measurements, scrotal circumference, and body condition scores of indigenous dairy cattle. The focus group meetings and animal body measurements were conducted in the Southern Guinea Savanna and the Derived Savanna agroecology of Nigeria, as these regions are recognized as major hubs for cattle production in the country.

Participants and geographic locations

The participants in the study were household heads who actively engaged in focus group meetings. The meetings were conducted at six different study sites, with 12 household heads participating at each location, resulting in a total of 72 household heads engaged in the focus group meetings. The geographic coordinates of each study site were determined using Google Earth (https://earth.google.com/). In the Southern Guinea Savanna, the three study sites were referred to as location A (altitude: 545 m, Longitude: 9°19'50" N, Latitude: 7°26'21" E), location B (altitude: 516 m, Longitude: 9°19'01" N, Latitude: 7°15'11" E), and location C (altitude: 730 m, Longitude: 9°18'58" N, Latitude: 7°35'24" E). In the Derived Savanna, the three study sites were referred to as location D (altitude: 343 m, Longitude: 7°59'33" N, Latitude: 3°33'35" E), location E (altitude: 375 m, Longitude: 8°39'41" N, Latitude: 3°30'36" E), and location F (altitude: 312 m, Longitude: 7°58'00" N, Latitude: 3°34'05" E). These study sites are in Niger and Oyo states of Nigeria, respectively.

Questionnaire administration for collection of herd characteristics data

Structured questionnaires were administered during the focus group meetings at the selected locations. The questionnaires were designed to collect data on various aspects, including land holding capacity of the respondents, cultivation of food and fodder crops, purchased feed for livestock, animal diet and nutrition, milk and livestock prices, sources of income, and herd information such as population and categories of animals (lactating, non-lactating, heifers, male calves, female calves). The data collection followed the guidelines of focus group and individual farmers' interview procedures outlined in the Feed Assessment Tools (FEAST) software developed by the International Livestock Research Institute (ILRI).

Animal body measurements and computation of live weights

A total of 40 milk-producing cows and 40 breeding bulls were selected from each agroecological zone for a comparative assessment of body measurements and phenotypic traits. The recorded body measurements included body length, measured diagonally across the body of the cattle using a flexible measuring tape, and heart girth, measured as the circumference of the girth. Scrotal circumference was measured as the maximum point of dimension around the pendulous scrotum after pushing the testes firmly into the scrotal sac[12,13]. Body condition scores were determined using attributes specific to dual-purpose cattle. Live weight was computed using a general formula for evaluating animal live weight based on the recorded body measurements[13,14].

Statistical analysis

All collected data were subjected to descriptive statistical analyses. Additionally, the herd production characteristics data were subjected to Moses Test of Extreme Reaction (MTER) to determine the effect of agroecology differences on the herd production characteristics. The MTER is a statistical test that helps identify significant differences between groups. For the body measurements and phenotypic traits data, independent sample t-tests were conducted to assess the effect of agroecology and breed differences on the phenotypic traits of the cattle. The independent sample t-test is a statistical test used to compare the means of two independent groups. These statistical analyses were performed using SPSS v.20.0.0 software. The significance level for determining significant differences in means was set at $p < 0.05$, indicating a 5% probability threshold. The results obtained from the statistical analyses provided insights into the relationship between agroecology, herd production characteristics, and phenotypic traits of indigenous dairy cattle in the Southern Guinea Savanna and Derived Savanna agroecological zones of Nigeria.

Results

Effect of agroecology on herd production characteristics

The agroecology types also influenced herd production characteristics. Significant differences were observed in land and livestock ownership, land use for food and fodder crops production, cattle dry matter intakes by sources, metabolizable energy intake by sources, protein intake by sources, and the nutrition analysis of the cattle (Table 1).

Land ownership characteristics based on agroecology

The land ownership categorization included small, medium, and large land ownerships. The average land size per household for large land ownership was 12.17 ± 1.82 hectares, medium land ownership was 8.05 ± 1.06 hectares, and small land ownership was 4.37 ± 0.35 hectares. The percentages of household land ownership by categories were 40.00% ± 12.40%, 18.75% ± 3.24%, and 41.25% ± 12.52% for large, medium, and small landowners, respectively. The average land size for each category of ownership (large, medium, and small) was higher for households in the derived savanna agroecology compared to the households in the southern Guinea savanna. Additionally, while most households in the southern Guinea savanna fell under the category of small landowners, most households in the derived savanna fell under the category of large landowners, indicating that households in the derived savanna agroecology have access to more land compared to households in the southern Guinea savanna (Table 2).

Tropical Livestock Units (TLUs) of local and improved livestock

The Tropical Livestock Units (TLUs) of the local dairy cattle per household were higher in the southern Guinea savanna compared to the derived savanna. Conversely, the TLUs of improved dairy cattle per household were higher in the derived savanna compared to the southern Guinea savanna agroecological zone. Moreover, the TLUs of non-milk-producing animals, including dry cows, heifers, and young male or female calves, were lower for the derived savanna agroecology compared to the southern Guinea savanna agroecology (Table 3 & 4).

Table 1. Test of significant difference (Moses Test of Extreme Reaction) for the effect of agroecology type herd production characteristics of the respondent households.

Parameters	*p*-values
Land ownership	0.001
Local livestock holding	0.001
Improved livestock holding	0.001
Land use for food crops and fodder production	0.001
Dry matter intake by sources	0.001
Metabolizable energy intake by sources	0.001
Protein intake by sources	0.001
CP:ME ratio	0.001
Milk yield per ME intake	0.001

CP: crude protein; ME: metabolizable energy. The *p*-values represent the statistical significance levels corresponding to of each reported parameter; $p = 0.001$ indicates strong evidence against the null hypothesis, suggesting that there is a significant association between agroecology and the reported parameters. In other words, the p-value suggests that the observed effects are associated with agroecological factors.

Land use for fodder crops production

The land use for fodder crop production varied between the two agroecological zones. In the southern Guinea savanna, the mean total crop area per household was 4.93 ± 0.78 hectares, while in the derived savanna, it was slightly higher at 5.78 ± 1.02 hectares. Similarly, the total forage area per household was higher in the derived savanna (1.49 ± 0.75 hectares) compared to the southern Guinea savanna (1.02 ± 0.55 hectares). When considering specific yield measurements, it was found that the crop residue yield (kg DM/ha) in the derived savanna was higher (1,886.76 ± 415.63) than in the southern Guinea savanna (1,425.50 ± 317.43). Additionally, the forage yield (kg DM/ha) was significantly higher in the derived savanna (23,650.37 ± 9,516.69) compared to the southern Guinea savanna (16,874.43 ± 7,303.12). This indicates that the derived savanna agroecology has a higher capacity for fodder production. Moreover, the

Table 2. Land ownership and access characteristics of the respondents in the Southern Guinea savanna and derived savanna agroecology by land ownership size and ownership categories.

Land ownership parameters	Southern Guinea savannah	Derived savannah	Mean
Large land ownership (ha)	9.29 ± 0.43	15.00 ± 2.85	12.17 ± 1.82
Medium land ownership (ha)	6.10 ± 0.27	10.00 ± 1.48	8.05 ± 1.06
Small land ownership (ha)	3.75 ± 0.38	5.00 ± 0.00	4.37 ± 0.35
Large landowners (%)	15.00 ± 8.66	65 ± 8.65	40.00 ± 12.40
Medium landowners (%)	20.00 ± 5.70	17.50 ± 4.33	18.75 ± 3.24
Small landowners (%)	65.00 ± 14.46	17.50 ± 4.33	41.25 ± 12.52

ha: hectare.

Table 3. Per household Tropical Livestock Units (TLUs) of local livestock ownership of the respondents in the Southern and derived savanna agroecology.

Parameters	Southern Guinea savanna	Derived savanna	Mean
Local dairy cattle (TLUs/HH)	53.68 ± 2.85	51.82 ± 17.88	52.75 ± 8.07
Fattening and draught cattle (TLUs/ HH)	1.80 ± 0.55	12.30 ± 7.14	7.05 ± 3.92
Local dairy cows - lactating (TLUs/HH)	27.24 ± 1.55	26.97 ± 0.47	27.10 ± 0.79
Local dairy cows - non lactating (TLUs/HH)	11.00 ± 0.57	13.23 ± 0.30	12.11 ± 0.56
Local dairy heifers (6 months old - 1st calving) (TLUs/HH)	5.72 ± 0.09	27.51 ± 6.96	16.61 ± 5.71
Local dairy female calves (less than 6 months old) (TLUs/HH)	2.12 ± 0.26	11.62 ± 2.97	6.87 ± 2.50
Local dairy calf's male (less than 6 months old) (TLUs/HH)	0.33 ± 0.06	0.79 ± 0.13	0.56 ± 0.18
Local bulls less than 2 years (TLUs/HH)	1.75 ± 0.41	6.50 ± 3.78	4.12 ± 1.97
Local bulls older than 2 years (TLUs/HH)	0.61 ± 0.10	15.20 ± 8.72	7.90 ± 4.41

TLUs: tropical livestock units; HH: household.

Table 4. Per household Tropical Livestock Units (TLUs) of improved livestock ownership of the respondents in the southern and derived savanna agroecology.

Parameters	Southern Guinea savannah	Derived savannah	Mean
Improved dairy cattle (TLUs/HH)	0.00 ± 0.00	22.73 ± 8.74	22.73 ± 8.74
Improved dairy cows - lactating (TLUs/HH)	0.00 ± 0.00	15.90 ± 9.17	15.90 ± 9.17
Improved dairy cows - non-lactating (TLUs/HH)	0.00 ± 0.00	3.08 ± 1.74	3.08 ± 1.74
Improved dairy heifers (6 months old - 1st calving) (TLUs/HH)	0.00 ± 0.00	3.60 ± 2.06	3.60 ± 2.06
Improved dairy female calves (less than 6 months old) (TLUs/HH)	0.00 ± 0.00	1.20 ± 0.69	1.20 ± 0.69
Improved dairy calf's male (less than 6 months old) (TLUs/HH)	0.00 ± 0.00	1.00 ± 0.55	1.00 ± 0.55
Improved bulls older than 2 years (TLUs/HH)	0.00 ± 0.00	3.00 ± 1.75	3.00 ± 1.75

TLUs: tropical livestock units; HH: household.

forage crop area as a percentage of the cropped area was higher in the derived savanna (21.20% ± 8.87%) compared to the southern Guinea savanna (17.29% ± 7.22%). This suggests that farmers in the derived savanna allocate a larger proportion of their cropped area specifically for fodder crop cultivation, highlighting the importance of fodder production in agroecology (Table 5).

Feeds, feeding management, and animal nutrition efficiency

Grazing was found to be the major source of dry matter intake in both agroecological zones, contributing to an average of 62.00% ± 13.90% of the total feed supply. However, there were notable differences between the two zones. In the southern Guinea savanna, grazing contributed a higher percentage (75.00% ± 0.00%) to the total feed supply compared to the derived savanna (49.00% ± 28.26%). This could be attributed to the availability of more grazing land and favorable climatic conditions for natural pasture growth in the southern Guinea savanna. Regarding metabolizable energy intake, grazing remained the primary source of feed in both zones. However, there was a significant difference in the contribution of cultivated fodder. In the derived savanna, the percentage supply of metabolizable energy from cultivated fodder was higher (31.00% ± 28.26%) compared to the southern Guinea savanna (15.00% ± 0.00%), indicating a greater emphasis on cultivated fodder production in the derived savanna agroecology (Table 6).

A similar pattern was observed for crude protein supply percentage. Grazing contributed the largest proportion of crude protein in both zones, but the percentage supply from cultivated fodder was higher in the derived savanna (26.00% ± 15.81%) compared to the southern Guinea savanna (9.00% ± 0.00%). This indicates that farmers in the derived savanna agroecology focus more on providing protein-rich fodder to their cattle. Furthermore, the metabolizable energy quantity supply in millijoules (MJ) per household was higher in the derived savanna agroecology compared to the southern Guinea savanna, reflecting the overall higher availability and quality of feed resources in the derived savanna. These findings suggest that while grazing remains a significant source of feed in both agroecological zones, the derived savanna shows a greater emphasis on cultivated fodder production, leading to higher nutritional efficiency and potential for improved animal productivity presented in Tables 7, 8 & 9.

Animal body measurements and expression of phenotypic traits

The agroecology types had a significant effect on the animals' measurements and phenotypic traits of the cattle. Significant differences were observed in body condition scores, testis circumference, live weight, age at puberty, and age at first calving between the two agroecological zones. There was a significant difference in the age of the cows under production in the agroecological zones ($p = 0.008$), but no significant difference in the age of the bulls (Table 10).

Discussion

This study aimed to assess the impact of agroecology differences on herd production characteristics and phenotypic traits of indigenous and improved cattle used for dairy production under low external input operations in Nigeria. The chosen agroecology, the Southern Guinea savanna and derived savanna, are significant regions for livestock production in the country. The results of this study indicate that the derived savanna agroecology is more favorable for dairy production in Nigeria compared to the southern Guinea savanna agroecology.

Table 6. Per household sources of dry matter intake of cattle from different sources of the feed supply in the Southern Guinea savanna and derived savanna agroecology.

Parameters	Southern Guinea savanna	Derived savanna	Mean
Purchase feed (%)	5.33 ± 0.82	16.50 ± 9.58	10.97 ± 4.91
Grazing (%)	75.00 ± 0.00	49.00 ± 28.26	62.00 ± 13.90
Collected fodder (%)	2.66 ± 0.67	0.00 ± 0.00	2.66 ± 0.67
Crop residue (%)	7.66 ± 0.67	6.00 ± 2.30	6.83 ± 1.14
Cultivated fodder (%)	9.00 ± 0.00	28.50 ± 16.48	18.75 ± 8.51

Table 7. Per household sources of metabolizable energy intake of cattle from different sources of the feed supply in the Southern Guinea savanna and derived savanna agroecology.

Parameters	Southern Guinea savanna	Derived savanna	Mean
Purchase feed (%)	8.00 ± 1.10	11.50 ± 6.08	9.75 ± 2.85
Grazing (%)	74.33 ± 0.67	48.50 ± 28.09	61.47 ± 13.77
Collected fodder (%)	2.00 ± 0.00	0.00 ± 0.00	2.00 ± 0.00
Crop residue (%)	9.00 ± 1.00	4.00 ± 1.10	6.50 ± 1.32
Cultivated fodder (%)	6.67 ± 2.09	36.00 ± 20.71	21.33 ± 11.47

Table 8. Per household sources of crude protein intake of cattle from different sources of the feed supply in the Southern Guinea savanna and derived savanna agroecology.

Parameters	Southern Guinea savanna	Derived savanna	Mean
Purchase feed (%)	9.67 ± 1.47	12.50 ± 6.63	11.03 ± 3.18
Grazing (%)	73.33 ± 1.67	48.50 ± 28.19	60.97 ± 13.75
Collected fodder (%)	2.00 ± 0.00	0.00 ± 0.00	2.00 ± 0.00
Crop residue (%)	7.33 ± 1.33	5.50 ± 2.03	6.47 ± 1.10
Cultivated fodder (%)	7.66 ± 2.33	33.50 ± 19.33	20.53 ± 10.40

Table 5. Per household total crop area, crop residue yield and percentage of fodder crop area in the southern and derived savanna agroecology.

Parameters	Southern Guinea savanna	Derived savanna	Mean
Total crop area per household (ha/HH)	4.04 ± 0.02	5.83 ± 1.48	4.93 ± 0.78
Total forage area per household (ha/HH)	0.50 ± 0.14	2.47 ± 1.49	1.49 ± 0.75
Crop residue yield (kg DM/ha)	986.89 ± 5.63	2,786.62 ± 232.63	1,886.76 ± 415.63
Forage yield (kg DM/ha)	40,960.00 ± 11,824.13	6,340.74 ± 3,660.83	23,650.37 ± 9,516.69
Forage crop area as percentage of cropped area (%)	12.41 ± 3.63	30.00 ± 17.31	21.20 ± 8.87

ha: hectare; HH: household; Kg: kilogramme; DM: dry matter.

Table 9. Analysis of nutrients intakes of the cattle kept by each household with respect to milk production per cattle in each household.

Parameters	Southern Guinea savanna	Derived savanna	Mean
Dry matter quantity (kg/HH)	64,511.25 ± 5,664.02	504,597.04 ± 227,307.56	284,554.15 ± 141,505.96
ME quantity (MJ/HH)	583,470.06 ± 51,226.91	4,836,953.98 ± 1,882,599.73	2,710,212.02 ± 1,270,420.18
CP quantity (kg/HH)	5,191.85 ± 455.84	40,726.10 ± 17,989.44	22,958.98 ± 11,309.27
CP:ME ratio (g CP/MJ)	8.9 ± 0.00	7.79 ± 0.87	8.34 ± 0.48
Milk yield per ME (Ltr/MJ)	0.01 ± 0.00	0.03 ± 0.00	0.017 ± 0.07

Kg: kilogramme; HH: household; ME: metabolizable energy; CP: crude protein; MJ: milojoules; Ltr: Litre.

Table 10. The descriptive statistics of the animal body measurements and expression of the phenotypic traits of the cows and bulls under low external input operations in the selected agroecology.

	Southern Guinea savanna	Derived savanna	Mean	*p*-values
Live weight of the bulls (kg)	205.24 ± 16.30	309.62 ± 27.88	257.43 ± 22.09	0.010
BCS of the bulls	5.79 ± 0.90	6.90 ± 0.59	6.35 ± 0.75	0.010
Testis circumference of the bulls	28.42 ± 0.58	35.20 ± 2.17	31.81 ± 1.38	0.040
Age of the bulls (years)	3.00 ± 0.25	2.70 ± 0.24	2.87 ± 0.25	0.430
Live weight of the cows (kg)	157.33 ± 6.15	313.84 ± 22.73	235.58 ± 14.44	0.006
BCS of the cows	3.50 ± 0.22	6.71 ± 0.33	5.10 ± 0.28	0.001
Age of the cows (years)	3.90 ± 0.37	6.14 ± 0.38	5.02 ± 0.37	0.008
Age of the cows at puberty (years)	2.00 ± 0.00	2.40 ± 0.15	2.20 ± 0.05	0.018
Age of the cows at first calving (years)	2.75 ± 0.00	3.15 ± 0.15	2.95 ± 0.08	0.016

BCS: body condition scores; kg: kilogram.

The southern Guinea savanna, like other savanna regions in Africa, is characterized as a rainfed grassland with a relatively shorter and less intense dry season compared to the Sahelian agroecology. This makes it a relatively suitable agroecology for livestock production in the northern parts of Nigeria compared to other areas in the region[15,16]. On the other hand, the derived savanna agroecology is more suitable for dairy cattle production due to its abundance of feed resources and less dense forest cover compared to the tropical rainforest agroecology.

The derived savanna is a transitional zone between the lowland rainforest and Guinea savanna agroecological zones, resulting from human-induced forest degradation and subsequent regrowth into savanna-type grasses[17]. This conversion of forests into savanna landscapes is often associated with deforestation, which is a growing concern due to the loss of biodiversity[18]. In Nigeria, forest conversion in the derived savanna agroecology has primarily been driven by crop food production and urban development, but more recently, it has also been attributed to cattle ranching, particularly in the southwestern parts of the country where laws have been enacted to restrict extensive cattle production on natural grasslands. The derived savanna agroecology is characterized by a forest-savanna transition terrain, making it suitable for both crop and livestock production[19]. As a result, it has become a major hub for dairy cattle production, attracting pastoralists from the northern regions in search of greener pastures as well as investment-driven smallholder dairy farms[20,21].

In line with previous studies conducted in the derived savanna agroecology, which indicated a higher number of cows than bulls in the herd composition, suggesting a prevalent dairy farming practice among smallholders in the area, this study observed an improvement in the herd composition[22]. While the indigenous Bunaji breed still represents a significant portion of the herd (80%), there is now a substantial number of crossbred cattle used for milk production. This shift can be attributed to the growth of the dairy industry development being promoted by both the government and the private sector, as recommended in a previous study conducted in the area[23].

Furthermore, the husbandry practices in the derived savanna agroecology appear to be more advanced compared to those in the southern Guinea savanna. For instance, feeding and animal nutrition management in the derived savanna heavily rely on cultivated fodders, industrial compounded feeds, and crop residues. This improved feeding strategy is reflected in the significantly higher nutrient intake per cattle kept for milk production in the derived savanna compared to the southern Guinea savanna, indicating better efficiency in nutrient utilization among cattle in the derived savanna agroecology. Overall, the findings of this study highlight the importance of considering agroecology differences in dairy cattle production. The derived savanna agroecology in Nigeria offers better conditions for dairy farming due to its favorable climate, availability of feed resources, and improved husbandry practices[24]. Therefore, an understanding of these agroecological variations can contribute to the development of targeted interventions and policies aimed at promoting sustainable and efficient dairy production in specific regions.

The results of this study shed light on the significant impact of agroecology as a modifier of cattle herd production characteristics and phenotypic traits in the context of dairy production under low external input operations. The investigation focused on two key agroecology in Nigeria, namely the southern Guinea savanna and derived savanna, which are crucial regions for livestock production in the country. By examining the differences between these agroecology, the study aimed to address a notable knowledge gap in understanding the specific factors contributing to variations in cattle performance. The background of the study emphasized the importance of considering agroecology differences in dairy cattle production. While the southern Guinea savanna agroecology is known for its suitability for livestock production in the northern parts of Nigeria, the derived Savanna agroecology offers more

favorable conditions for dairy farming due to its feed resources and less dense forest cover. This distinction is particularly significant considering the ongoing climate change and its potential impact on agroecological zones, including the transition from rainforests to savanna landscapes. Therefore, exploring the relationships between agroecology, climate change, and cattle performance becomes crucial for sustainable and efficient dairy production.

This study addressed this knowledge gap by comparing herd production characteristics and phenotypic traits between the two agroecology. The results revealed substantial differences, highlighting the superior performance of cattle in the derived savanna agroecology compared to the southern Guinea savanna. Key findings included higher tropical livestock units (TLUs) of crossbred cattle used for milk production in the derived savanna, indicating the growth and adoption of improved dairy breeds. Moreover, the husbandry practices in the derived savanna, such as the reliance on cultivated fodders, compounded feeds, and crop residues, contributed to higher nutrient intake and efficiency compared to the southern Guinea savanna. These findings underscore the influence of agroecology on cattle performance and emphasize the need for tailored interventions and policies to support specific regions. Further research is warranted to delve into the specific factors driving the observed differences between the agroecology investigated. Exploring the relationships between climate change, agroecology, and cattle performance would provide valuable insights into the adaptability and resilience of dairy systems in the face of changing environmental conditions.

Climate change poses challenges to agricultural systems worldwide and understanding its implications for livestock production is crucial. Investigating how climate change influences agroecological zones and subsequently affects cattle performance can inform strategies to mitigate its adverse effects[25]. Factors such as temperature, precipitation patterns, and forage availability are likely to play significant roles in shaping the productivity and resilience of dairy cattle in different agroecological contexts[26]. By considering the interactions between climate change and agroecology, future research can contribute to the development of climate-smart practices and adaptation strategies in dairy production.

Conclusions

This study provides valuable insights into the role of agroecology as a modifier of cattle herd production characteristics and phenotypic traits in dairy systems. The results highlight the superiority of the derived savanna agroecology in Nigeria for dairy production, attributed to its favorable climate, abundant feed resources, and improved husbandry practices. The study bridges an important knowledge gap and emphasizes the need for further research to unravel the specific factors underlying the observed differences between agroecology. Understanding the complex relationships between climate change, agroecology, and cattle performance will contribute to the development of sustainable and resilient dairy systems in the face of evolving environmental conditions.

Author contributions

The authors confirm contribution to the paper as follows: study conception and design: Sikiru AB, Egena SSA; data collection, analysis and interpretation of results: Sikiru AB, Saheed S, Otu BO, Makinde OJ; draft manuscript preparation: Sikiru AB. All authors reviewed the results and approved the final version of the manuscript.

Data availability

All data generated or analyzed during this study are included in the manuscript.

Acknowledgments

The authors are thankful to the Fulani Cattle Breeders in Tafa Local Government Area and Bosso Local Government Areas of Niger State, Jere in Kagarko Local Government Area of Kaduna State, Iseyin Local Government Area, and Shaki West Local Government Area, of Oyo State, Nigeria for their cooperation for execution of the study. Special thanks to management and staff of Genius Farms, Iseyin, Oyo State, Nigeria. Our profound gratitude to Mr. Yusuf Adeyemo and Mr. Abdulrazak for providing us with free accommodation while carrying out the fieldwork.

Conflict of interest

The authors declare that they have no conflict of interest.

Dates

Received 2 October 2023; Accepted 28 November 2023; Published online 9 January 2024

References

1. Sejian V, Shashank CG, Silpa MV, Madhusoodan AP, Devaraj C, et al. 2022. Non-invasive methods of quantifying heat stress response in farm animals with special reference to dairy cattle. *Atmosphere* 13(10):1642
2. Algers B, Bertoni G, Broom D, Hartung J, Lidfors L, et al. 2009. Scientific report on the effects of farming systems on dairy cow welfare and disease. *EFSA Journal* 7(7):1143r
3. Brito LF, Bedere N, Douhard F, Oliveira HR, Arnal M, et al. 2021. Review: Genetic selection of high-yielding dairy cattle toward sustainable farming systems in a rapidly changing world. *Animal* 15:100292
4. Sebastian K. 2014. *Atlas of African agriculture research and development: Revealing agriculture's place in Africa*. Washington, D.C.: International Food Policy Research Institute. http://dx.doi.org/10.2499/9780896298460
5. Oyewale RO, Salaudeen MT, Bamaiyi LJ, Bello YL. 2020. Ecology and distribution of stem borers in Nigeria. *Sustainability in Food and Agriculture* 1(1):27–36
6. Obioha EE. 2017. Climate variability, environment change and food security nexus in Nigeria. *Journal of Human Ecology* 26(2):107–21
7. Gefu JO, Kolawole A. 2002. Conflict in common property resource use: Experiences from an irrigation project. *9th Biennial Conference of the International Association for the Study of Common Property (IASCP), Victoria Falls, Zimbabwe, June, 2002*. US: International Association for the Study of the Commons.
8. Sikiru A. 2016. Assessment of feed resources utilization for livestock production by agro-pastoralists in Tafa Local Government Area of Nigeria. *Journal of Rangeland Science* 6(1):43–52
9. Ellison J, Brinkmann K, Diogo RVC, Buerkert A. 2022. Land cover transitions and effects of transhumance on available forage

biomass of rangelands in Benin. *Environment, Development and Sustainability*12276–310
10. Olafadehan OA, Adewumi MK. 2009. Productive and reproductive performance of strategically supplemented free grazing prepartum Bunaji cows in the agropastoral farming system. *Tropical Animal Health and Production* 41(7):1275–81
11. Yakubu A, Dahloum L, Gimba EG. 2019. Smallholder cattle farmers' breeding practices and trait preferences in a tropical Guinea savanna agro-ecological zone. *Tropical Animal Health and Production* 51:1497–506
12. Song X, Bokkers EAM, van der Tol PPJ, Groot Koerkamp PWG, van Mourik S. 2018. Automated body weight prediction of dairy cows using 3-dimensional vision. *Journal of Dairy Science* 101(5):4448–59
13. Vanvanhossou SFU, Diogo RVC, Dossa LH. 2018. Estimation of live bodyweight from linear body measurements and body condition score in the West African Savannah Shorthorn cattle in North-West Benin. *Cogent Food & Agriculture* 4(1):1549767
14. Sun Y, Huo P, Wang Y, Cui Z, Li Y, et al. 2019. Automatic monitoring system for individual dairy cows based on a deep learning framework that provides identification via body parts and estimation of body condition score. *Journal of Dairy Science* 102(11):10140–51
15. Mailafiya DM. 2015. Agrobiodiversity for biological pest control in Sub-Saharan Africa. In *Sustainable Agriculture Reviews. Sustainable Agriculture Reviews*, ed. Lichtfouse E. vol 18. Cham: Springer. pp. 107–43. https://doi.org/10.1007/978-3-319-21629-4_4
16. Bello SK, Shobayo AB, Ibrahim MM, Alasinrin SY, Aliyu IA, et al. 2021. Biological nitrogen fixation contributes to soil productivity in tropical agroecologies. *Nigerian Journal of Soil Science* 31(1):1–14
17. Federal Department of Forestry (FDF). 2019. *National Forest Reference Emission Level (FREL) for the Federal Republic of Nigeria*. Federal Department of Forestry (FDF), Nigeria.
18. Tran HT, Mannava P, Murray JCS, Nguyen PTT, Tuyen LTM, et al. 2018. Early essential newborn care is associated with reduced adverse neonatal outcomes in a Tertiary Hospital in Da Nang, Viet Nam: A Pre- Post- intervention study. *EClinicalMedicine* 6:51–58
19. Olorunfemi IE, Olufayo AA, Fasinmirin JT, Komolafe AA. 2022. Dynamics of land use land cover and its impact on carbon stocks in Sub-Saharan Africa: an overview. *Environment, Development and Sustainability* 24(1):40–76
20. Olafadehan OA, Adewumi MK. 2010. Livestock management and production system of agropastoralists in the derived savanna of South-west Nigeria. *Tropical and Subtropical Agroecosystems* 12(3):685–91
21. Laoye JA, Ogunsua BO, Kareem SO. 2021. Links between the complexities in atmospheric-soil energy exchange and temperature dynamics in tropical regions. *Journal of Atmospheric and Solar-Terrestrial Physics* 219:105651
22. Daodu MO, Babayemi OJ, Iyayi EA. 2009. Herd composition and management practices of cattle production by pastoralists in Oyo area of Southwest Nigeria. *Livestock Research for Rural Development* 21(5):66
23. Sikiru AB, Otu BO, Makinde OJ, Saheed S, Egena SSA. 2022. Breeding and genetic improvement of Nigeria indigenous cattle: The pitfalls and potential use of post genomic era technologies for national dairy development. *Outlook on Agriculture* 51:404–13
24. Fadairo O, Olajuyigbe S, Adelakun O, Osayomi T. 2023. Drivers of vulnerability to climate change and adaptive responses of forest-edge farming households in major agro-ecological zones of Nigeria. *GeoJournal* 88(2):2153–70
25. Sikiru AB, Velayyudhan SM, Nair MRR, Veerasamy S, Makinde JO. 2022. Sustaining livestock production under the changing climate: Africa scenario for Nigeria resilience and adaptation actions. In: *Climate Change Impacts on Nigeria*, eds. Egbueri JC, Ighalo JO, Pande CB. Cham: Springer. pp. 233–59. https://doi.org/10.1007/978-3-031-21007-5_13
26. Nwosu CC, Ogbu CC. 2011. Climate change and livestock production in Nigeria: Issues and concerns. *Agro-Science: Journal of Tropical Agriculture, Food, Environment and Extension* 10(1):41–60