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QUALITATIVE TRAITS CHARACTERIZATION OF INDIGENOUS CATTLE BREEDS IN NASARAWA SOUTH AGRO-ECOLOGICAL ZONEOF NASARAWA STATE, NIGERIA

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Running title: *Morphological differentiation of Nigerian indigenous cattle*

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Abstract

The study aimed at characterizing the qualitative traits of three indigenous cattle breeds in Nasarawa South Agro-Ecological Zone of Nasarawa State, Nigeria. Sampling was carried out at Lafia, Doma, Obi, Keana and Awe Local Government Areas of Nasarawa State, Nigeria. A total of 179 adult cattle of both sexes (male; n= 88 and female; n= 91) of White Fulani (n=59), Sokoto Gudali (n= 62) and Red Bororo (n= 58) were sampled. Visual appraisal of the appearance (observation of qualitative traits) of the three cattle breeds was done and recorded, using a structured format for morphological description. The qualitative traits are vital for breed identification and selection, as they often correlate with genetic diversity and adaptability to environmental conditions. The following traits were considered: Coat colour pattern, muzzle pigmentation, eyelid pigmentation, coloured belly, hoof pigmentation, horn colour, cephalic profile, ear shape, dewlap size, hump position, backline, horn shape, udder size and testes size. All the fourteen qualitative morphological traits of White Fulani, Sokoto Gudali and Red Bororo were analyzed for descriptive statistics using frequency procedure and cross-tabulation. The non-parametric Kruskal-Wallis test option of the non- parametric followed by the Mann–Whitney U test for post Hoc separation was employed to test the effects of breed and sex on the proportion of each qualitative trait. CHAID algorithm was employed to assign the cattle into their appropriate breed based on the qualitative variables. There were variations (P< 0.01) in the colour traits based on breed. White Fulani was whiter in colour (60.9%) than the Sokoto Gudali (39.1%). The Red Bororo had more of red (92.3%) and brown (85.7%) colourations while the Sokoto Gudali was more mixed in colour (54.5%). However, based on sex, coloured belly was the only trait affected, and was more common (P<0.05) in females. There were significant (P<0.01) variations in the cephalic profile, ear shape, hump position, backline, and horn shape based on breed. The sexes also varied (P<0.01; P<0.05) in cephalic profile, dewlap size, hump position and horn shape. However, the cattle can be assigned to their original breed based on ear shape, coat colour and horn shape. The current information may be a step to further characterization of the Nigerian indigenous cattle breeds using a large population.

Keywords: Qualitative Traits, Characterization, Indigenous Cattle, Nigeria

Introduction

Cattle are the most common type of large domesticated animals, with about 90% of their population found in the northern part of Nigeria and predominantly under the care of resource-poor herders (WB, 2017). Together with sheep and goats, cattle contribute 30% to the National Agriculture gross domestic product (GDP) and 3.2% to Nigeria's overall GDP (Lakpini, 2018). Cattle are reared for meat (beef), milk, and other dairy products, and as draught animals (Yakubu *et al*., 2019).

The genetic makeup and dynamics of cattle populations are significantly influenced by the production systems and pastoralism practices in which they are raised. Cattle breeds and populations adapt genetically to the specific environmental conditions of their production systems and grazing areas (Malau-Aduli *et al.*, 2021). For example, cattle in tropical regions develop resistance to heat stress, parasites, and diseases endemic to those environments. Pastoralist systems in arid regions select for cattle that can thrive on sparse vegetation and tolerate water scarcity (Malau-Aduli *et al.*, 2021). The production goals and market demands of different systems drive selection for certain phenotypic and genetic traits. Beef cattle in extensive grazing systems are selected for traits like fertility, maternal ability, and adaptability, while feedlot cattle are selected more for growth rate and carcass quality. Dairy cattle in intensive systems are selected primarily for milk yield. Cattle rustling in North Central Nigeria has escalated into a severe security crisis, characterized by violent raids by armed groups that result in numerous deaths, the destruction of livelihoods, and heightened instability in affected communities (Abubakar, 2019). In Nigeria, there are several indigenous cattle breeds that overlap in their territories, including the White Fulani (Bunaji), Red Bororo, Sokoto Gudali, Wadara, N'dama, and Muturu, among others. These breeds are distributed across various ecological zones, particularly in the northern and central regions of the country, where they coexist and often compete for resources such as grazing land and water (Kubkomawa, 2017).

Lack of appropriate breeding and conservation programmes has been identified as the most common threat to sustainable livestock production in Nigeria (Yakubu *et al*., 2010). There is therefore, the need to map out result-oriented strategies towards genetic improvement and conservation of the local stock, which are more adaptable to the prevailing environmental conditions for sustainable production and empowerment. Characterization of cattle breed is the first approach to a sustainable use of their animal genetic resources. The FAO global strategy involves the identification and understanding of a unique genetic resource in a particular region and to develop the proper use of the associated diversity (Rahal *et al*., 2017; Getachew *et al*., 2021; Lomillos and Alonso, 2020; Polak *et al*., 2022). One of such efforts involves the phenotypic (including external qualitative traits) characterization of the cattle populations, which will guide appropriate interventions towards improving the local stock. Qualitative variation among cattle breeds indicates a genetic diversity that may be worth conserving for future uses while better understanding of the external features helps to facilitate the implementation of conservation policies aimed to ensure local resources survival (Anya *et al*., 2018; Houessou *et al*., 2019; Sztandarski *et al*., 2021; Adoligbe *et al*., 2022).

In terms of morphology, few works are available in literature with respect to cattle breeds in Nasarawa State, north central Nigeria. The objective of this study, therefore, was to evaluate the qualitative traits of indigenous cattle based on breed and sex in Nasarawa South agro-ecological zone of Nasarawa State, Nigeria.

Materials and methods

Sampling areas

Sampling was carried out at Lafia, Doma, Obi, Keana and Awe Local Government Areas (LGAs) of Nasarawa State, Nigeria. The five LGAs fall within Nasarawa South agro-ecological zone, Nasarawa State, Nigeria (Fig. 1).

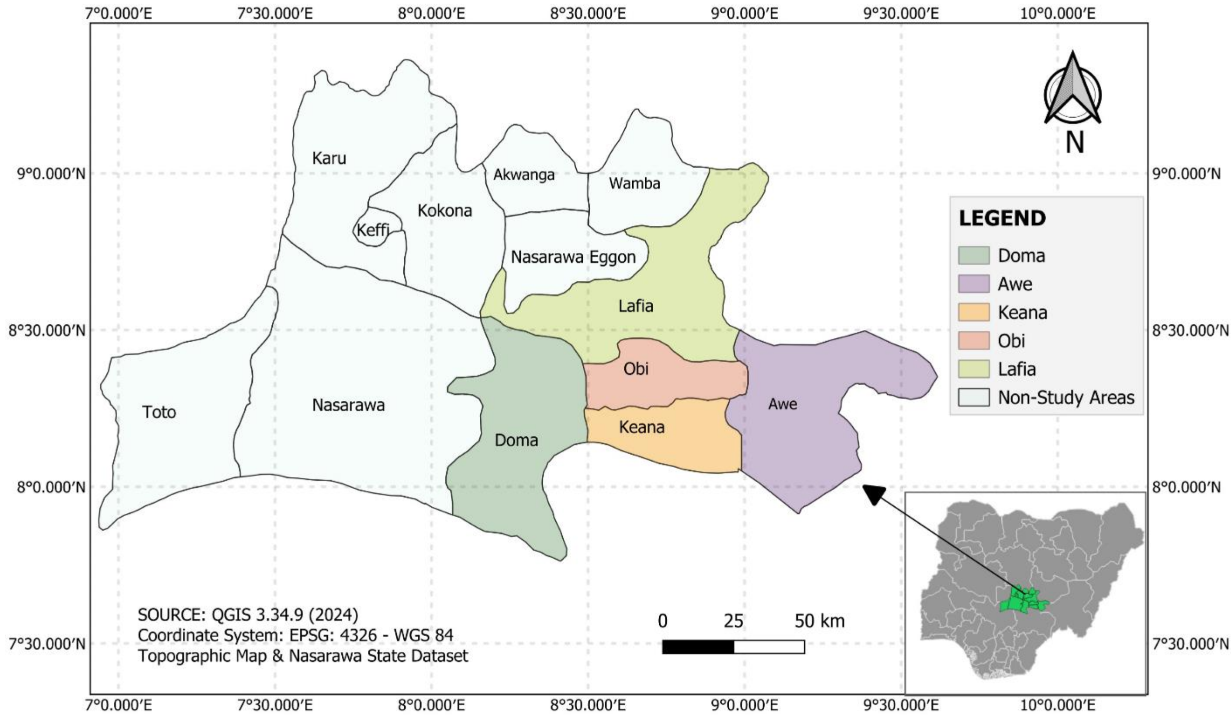

Figure 1: Map of Nasarawa State showing the study local government areas

Sampling procedure

A total of 179 adult cattle of both sexes (male; n= 88 and female; n= 91) of White Fulani (n=59) (Fig. 2), Sokoto Gudali (n= 62) (Fig. 3) and Red Bororo (n= 58) (Fig. 4) were sampled. Apparently healthy animals that were >2 years as indicated by dentition were randomly sampled. Sampling took place in villages and designated markets in the five LGAs of Nasarawa South agro-ecological zone.

Data collection

Visual appraisal of the appearance (observation of qualitative traits) of the three cattle breeds was done and recorded, using a structured format for morphological description, following standard descriptors of FAO (2012) (Table 1).

Table 1: Characteristic features of qualitative traits of cattle

Qualitative trait	Description
Coat colour pattern	Solid White; Grey; Black; Red; Brown; Roan; Mixed colours
Cephalic profile	Concave; Convex; Straight
Ear shape	Erect; Horizontal; Drooping
Muzzle pigmentation	Pigmented; Not pigmented
Eyelid pigmentation	Pigmented; Not pigmented
Hoof pigmentation	Pigmented; Not pigmented
Horn colour	Black; Brown; Grey, Mixed colours
Dewlap size	Well developed; Medium; Small
Hump position	Absence; Cervico-thoracic; Thoracic
Backline	Straight; Concave; Convex
Horn shape	Polled; Lyre; Crescent; Backward; Spiral
Coloured belly	Absent; Present
Udder size	Well developed, Medium, Small
Testes size	Well developed, Medium, Small

Figure 2: White Fulani

Figure 3: Sokoto Gudali

Figure 4: Red Bororo

Statistical analysis

All the fourteen qualitative morphological traits of White Fulani, Sokoto Gudali and Red Bororo were analyzed for descriptive statistics using frequency procedure and cross-tabulation of IBM-SPSS (2020). The non-parametric Kruskal-Wallis test option of the non-parametric followed by the Mann–Whitney U test for post hoc separation were employed to test the effects of breed and sex on the proportion of each qualitative trait. CHAID algorithm was employed to assign the cattle into their appropriate breed based on the qualitative variables using IBM-SPSS (2020).

Results

The proportions of colour traits in Nigerian indigenous cattle breeds are indicated in Table 2. There were significant ($P<0.01$) variations in the coat colour, muzzle pigmentation and hoof pigmentation of the three cattle breeds. White Fulani was whiter in colour (60.9%) than the Sokoto Gudali (39.1%). The Red Bororo had more of red (92.3%) and brown (85.7%) colourations while the Sokoto Gudali was more mixed in colour (54.5%). The White Fulani was more pigmented in the muzzle (39.0%) than their Sokoto Gudali (30.1%) and Red Bororo (30.8%) counterparts. Also, the White Fulani had more pigments in the hoof (38.4%) than their Sokoto Gudali (31.5%) and Red Bororo (30.1%) counterparts. The breeds did not significantly ($P>0.05$) differ in terms of coloured belly.

Table 2: Frequency (%) of colour traits of Nigerian indigenous cattle based on breed

		Breed				
Traits	Class	White Fulani n = 59	Sokoto Gudali n = 62	Red Bororo n = 58	Chi-square	Cramer's V
Coat colour	Solid White	35 (60.9)[a]	29 (39.1)[b]	0 (0.0)[c]	1367.90**	0.62**
	Grey	0 (0.0)[b]	2 (100.0)[a]	0 (0.0)[b]		
	Red	1 (2.6)[b]	2 (5.1)[b]	36 (92.3)[a]		
	Brown	1 (7.1)[b]	1 (7.1)[b]	12 (85.7)[a]		
	Roan	0 (0.0)[b]	2 (40.0)[a]	3 (60.0)[a]		
	Mixed colour	18 (32.7)[b]	30 (54.5)[a]	7 (12.7)[c]		
Muzzle pigmentation	Pigmented	57 (39.0)[a]	44 (30.1)[b]	45 (30.8)[b]	14.12**	0.28**
	Not pigmented	2 (6.1)[b]	18 (54.5)[a]	13 (39.4)[a]		
Hoof pigmentation	Pigmented	56 (38.4)[a]	46 (31.5)[b]	44 (30.1)[b]	10.49**	0.24**
	Not pigmented	3 (9.1)[b]	16 (48.5)[a]	14 (42.4)[a]		
Coloured belly	Absent	56 (32.6)[a]	59 (34.3)[a]	57 (33.1)[a]	1.017[ns]	0.08[ns]
	Present	3 (50.0)[a]	2 (33.3)[a]	1 (16.7)[a]		

*n = No. of cattle observed; *, **Significant at P<0.05 and P<0.01, respectively; [ns] = Not significant Means within rows having different superscripts are significantly different.*

The proportions of colour traits in Nigerian indigenous cattle breeds based on sex are indicated in Table 3. The sexes did not significantly (P>0.05) differ in coat colour, muzzle pigmentation and hoof pigmentation. However, coloured belly was present (P<0.05) in six female cows.

T**able 3: Frequency (%) of colour traits of Nigerian indigenous cattle based on sex**

		Sex			
Traits	Class	Male n= 152	Female n= 148	Chi-square	Cramer's V
Coat colour	Solid White	32 (50.0)[a]	32 (50.0)[a]	7.62[ns]	0.21[ns]
	Grey	2 (100.0)[a]	0 (0.0)[a]		
	Red	16 (41.0)[a]	23 (59.0)[a]		
	Brown	5 (35.7)[a]	9 (64.3)[a]		
	Roan	1 (20.0)[a]	4 (80.0)[a]		
	Mixed colour	32 (58.2)[a]	23 (41.8)[a]		
Muzzle pigmentation	Pigmented	73 (50.0)[a]	73 (50.0)[a]	0.22[ns]	0.04[ns]
	Not pigmented	15 (45.5)[a]	18 (54.5)[a]		
Hoof pigmentation	Pigmented	71 (48.6)[a]	75 (51.4)[a]	0.09[ns]	0.02[ns]
	Not pigmented	17 (51.5)[a]	16 (48.5)[a]		
Coloured belly	Absent	87 (50.6)	85 (49.4)	5.94*	0.18*
	Present	0 (0.0)	6 (100.0)		

*n = No. of cattle observed; * Significant at P<0.05; ns= Not significant, Means within rows having different superscripts are significantly different.*

The proportions of structural traits in Nigerian indigenous cattle breeds are indicated in Table 4. There were significant (P<0.01) variations in the cephalic profile, ear shape, hump position, backline, and horn shape. The White Fulani was more concave (53.3%) while the Sokoto Gudali had more convex profile (67.7%). The ear shape of White Fulani was erect (75.7%), while that of Red Bororo and Sokoto Gudali were horizontal and drooping. Dewlap was well developed in all the three breeds of cattle. The Red Bororo cattle were more Cervico-thoracic as regards hump position whiles both White Fulani and Sokoto Gudali was more thoracic. However, breed had no significant (P>0.05) effect on udder size and testis size.

Table 4: Frequency (%) of structural traits of Nigerian indigenous cattle based on breed

Traits	Class	Breed White Fulani n = 59	Sokoto Gudali n = 62	Red Bororo n = 58	Chi-square	Cramer's V
Cephalic profile	Concave	48 (53.3)^{a}	16 (17.8)^{c}	26 (28.9)^{b}	45.80**	0.36**
	Convex	0 (0.0)^{c}	21 (67.7)^{a}	10 (32.3)^{b}		
	Straight	11 (19.0)^{b}	25 (43.1)^{a}	22 (37.9)^{a}		
Ear shape	Erect	53 (75.7)^{a}	2 (2.9)^{c}	15 (21.4)^{b}	174.38**	0.70**
	Horizontal	5 (15.2)^{b}	0 (0.0)^{c}	28 (84.8)^{a}		
	Drooping	1 (1.3)^{c}	60 (78.9)^{a}	15 (19.7)^{b}		
Dewlap size	Well developed	29 (26.1)^{a}	43 (38.7)^{a}	39 (35.1)^{a}	8.92^{ns}	0.16^{ns}
	Medium	27 (46.6)^{a}	17 (29.3)^{a}	14 (24.1)^{a}		
	Small	3 (30.0)^{a}	2 (20.0)^{a}	5 (50.0)^{a}		
Hump position	Not classified	11 (34.4)^{a}	13 (40.6)^{a}	8 (25.0)^{a}	13.64**	0.20**
	Cervico-thoracic	12 (22.2)^{b}	14 (25.9)^{b}	28 (51.9)^{a}		
	Thoracic	36 (38.7)^{a}	35 (37.6)^{a}	22 (23.7)^{b}		
Backline	Straight	47 (51.1)^{a}	20 (21.7)^{b}	25 (27.2)^{b}	42.17**	0.34**
	Concave	11 (13.9)^{c}	42 (53.2)^{a}	26 (32.9)^{b}		
	Convex	1 (12.5)^{b}	0 (0.0)^{c}	7 (87.5)^{a}		
Horn shape	Polled	4 (9.3)^{b}	36 (83.7)^{a}	3 (7.0)^{b}	90.71**	0.51**
	Lyre	46 (52.9)^{a}	9 (10.3)^{c}	32 (36.8)^{b}		
	Crescent	5 (19.2)^{b}	13 (50.0)^{a}	8 (30.8)^{ab}		
	Backward	2 (11.8)^{b}	2 (11.8)^{b}	13 (76.5)^{a}		
	Spiral	2 (40.0)^{a}	1 (20.0)^{a}	2 (40.0)^{a}		
Udder size	Well developed	7 (17.9)^{a}	18 (46.2)^{a}	14 (35.9)^{a}	7.21^{ns}	0.20^{ns}
	Medium	18 (43.9)^{a}	11 (26.8)^{a}	12 (29.3)^{a}		
	Small	4 (44.4)^{a}	3 (33.3)^{a}	2 (22.2)^{a}		
Testis size	Well developed	21 (30.9)^{a}	26 (38.2)^{a}	21 (30.9)^{a}	4.33^{ns}	0.16^{ns}
	Medium	7 (43.8)^{a}	3 (18.8)^{a}	6 (37.5)^{a}		
	Small	0 (0.0)^{a}	0 (0.0)^{a}	1 (100.0)^{a}		

*n = No. of cattle observed; **Significant at P<0.01; ns = Not significant, Means within rows having different superscripts are significantly different.*

The proportions of structural traits in Nigerian indigenous cattle breeds based on sex are indicated in Table 5. There were significant (P<0.01; P<0.05) variations in the cephalic profile, dewlap, hump position and horn shape. Sex had no significant (P>0.05) effect on ear shape and backline.

The assignment of the breeds based on qualitative traits is shown in Figure 6. Here, it can be seen that the cattle can be assigned to their original breed based on ear shape, coat colour and horn shape. There are six terminal nodes which include 3, 4, 5, 6, 7 and 8. The root node (Node 0) indicated the descriptive statistics of the cattle breed. The Chi-squared base branch and the node distribution showed that ear shape was the variable of the utmost importance in assigning the cattle into their respective breed category followed by coat colours and then horn shape. The ear shape only was significantly (P<0.01) sufficient to discriminate between cattle breeds of White Fulani, Sokoto Gudali and Red Bororo. The dropping, horizontal and erect ears were mostly of Sokoto Gudali, White Fulani and Red Bororo, respectively. For coat colour, the mixed colours, solid white and red/brown/roan were mostly in White Fulani, White Fulani and Red Bororo, respectively.The Resubstitution estimate was 0.128 while the standard error was 0.03. Based on this, 86.4, 80.6 and 94.8% of the cattle were classified as White Fulani, Sokoto Gudali and Red Bororo (Table 6).The CHAID model recursively partitions a population into distinct groups defined by a set of independent predictor variables. The goal is to minimize the variance of the dependent target variable within the groups, while maximizing the variance across the groups

Table 5: Frequency (%) of structural traits of Nigerian indigenous cattle based on sex

		Sex			
Traits	Class	Male n= 152	Female n= 148	Chi-square	Cramer's V
Cephalic profile	Concave	53 (58.9)[a]	37 (41.1)[b]	13.89**	0.28**
	Convex	18 (58.1)[a]	13 (41.9)[a]		
	Straight	17 (29.3)[b]	41 (70.7)[a]		
Ear shape	Horizontal	34 (48.6)[a]	36 (51.4)[a]	4.99[ns]	0.17[ns]
	Erect	11 (33.3)[a]	22 (66.7)[a]		
	Dropping	43 (56.6)[a]	33 (43.4)[a]		
Dewlap size	Well developed	72 (64.9)[a]	39 (35.1)[b]	28.89**	0.40**
	Medium	14 (24.1)[b]	44 (75.9)[a]		
	Small	2 (20.0)[a]	8 (80.0)[a]		
Hump position	Absent	5 (15.6)[b]	27 (84.4)[a]	19.90**	0.33**
	Cervico-thoracic	26 (48.1)[a]	28 (51.9)[a]		
	Thoracic	57 (61.3)[a]	36 (38.7)[b]		
Backline	Straight	50 (54.3)[a]	42 (45.7)[a]	2.18[ns]	0.11[ns]
	Concave	34 (43.0)[a]	45 (57.0)[a]		
	Convex	4 (50.0)[a]	4 (50.0)[a]		
Horn shape	Polled	12 (27.9)[b]	31 (52.1)[a]	10.12*	0.24*
	Lyre	48 (55.2)[a]	39 (44.8)[a]		
	Crescent	15 (57.7)[a]	11 (42.3)[a]		
	Backward	9 (52.9)[a]	8 (47.1)[a]		
	Spiral	3 (60.0)[a]	2 (40.0)[a]		

Table 6: The classification matrix of cattle based on breed using CHAID model

	Predicted			
Observed	White Fulani	Sokoto Gudali	Red Bororo	Percent Correct
White Fulani	51	0	8	86.4
Sokoto Gudali	2	50	10	80.6
Red Bororo	2	1	55	94.8
Overall Percentage	30.7	28.5	40.8	87.2

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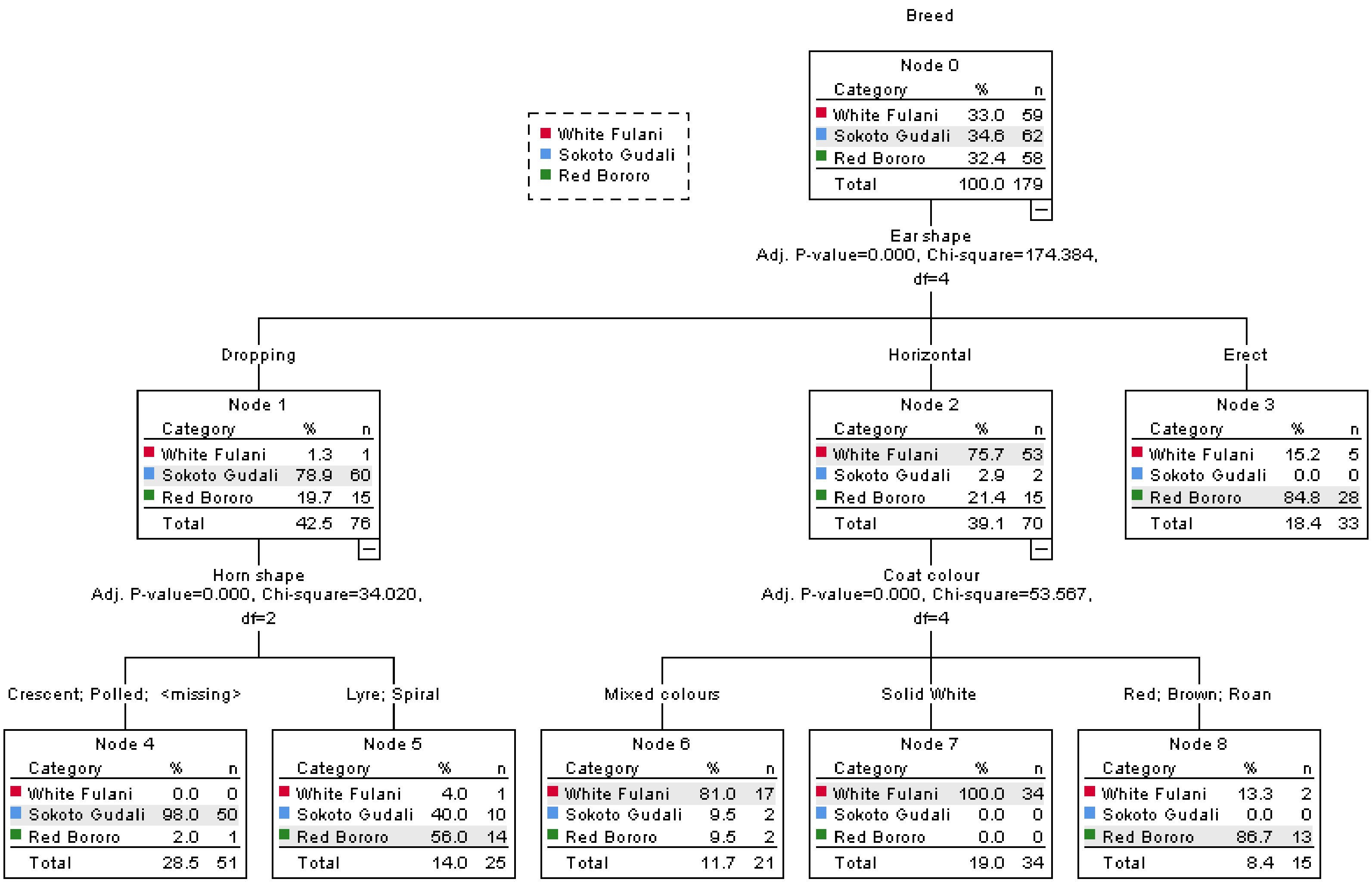

Figure 6: Assignment of animals into breed based on qualitative traits using the CHAID model

Discussion

Information on morphological characteristics is a prerequisite to sustainable breed improvement, utilization, and conservation. The precise identification of animal types and breeds, and an improved understanding of their values or adaptive traits are thus necessary but depend on the availability of accurate and comprehensive information on their characteristics as well as their production and marketing environments (Houessou *et al*., 2019; Bila *et al*., 2023). There were no clear-cut patterns in the distribution of the qualitative traits as observed in the current study. White Fulani with higher white coat colour is thought to aid in reflecting sunlight, helping them stay cooler in tropical environments. Also, the white colour may make them less susceptible to sunburn, which can be a concern in regions with intense sunlight. The higher grey colour in Sokoto Gudali can reflect some sunlight, although not as efficiently as the white colour (Raji *et al*., 2022). However, it may also absorb less heat compared to darker colours. The higher red coat colour in Red Bororo cattle might have implications related to heat tolerance. Red cattle, like grey ones, may absorb less heat compared to darker colours but more than white. This balance could be advantageous in environments with moderate to hot temperatures. Varying coat colours have also been reported in Bali cattle of Indonesia (Suhendro *et al*., 2024). Such heterogeneity in the coat colour revealed the presence of several ecotypes within the breed, which need advanced research at a molecular level (Gelaye *et al*., 2022). In a related study, Nigenda-Morales *et al*. (2018) reported that the overall fitness of individuals in their environments may be affected by colour while Gong *et al*. (2021) considered colour variation as an environmental indicator, which provides clues for the study of population genetics and biogeography. Also, coat colour has been associated with tick infestations (Okwuonu *et al*., 2021). The non-significant differences between male and female cattle in terms of coat colour can be relevant in animal husbandry, veterinary care, or breed standardization. The non-significant difference in colour belly is in agreement with the report of Olaniyi *et al*. (2020). This suggests that regardless of the breed, cattle tend to display similar characteristics or features related to their belly colouring and understanding such similarities or lack of differences among breeds can be important for various purposes, such as selecting breeding stock or managing herds for desired characteristics.

The higher presence of pigmented muzzle in White Fulani cattle, as observed in the study, can provide protection against harsh environmental conditions, particularly intense sunlight and UV radiation. The pigmentation acts as a natural defense mechanism against sunburn caused by excessive exposure to sunlight (Gelay *et al*., 2022) and the highest frequency of pigmented areas in the muzzle observed in White Fulani over other breeds indicated that the breed reflects the adaptation of these indigenous breed to their local environment over generations. These traits can be indicative of the breed's resilience and ability to thrive in the specific agro-ecological conditions of Nigeria (Gelay *et al*., 2022). The non-significant differences in the current study with respect to muzzle pigmentation and hoof pigmentation are contrary to report of Baye *et al.* (2022) who reported that the male cattle population has a higher percentage of pigmented muzzle (88.3%) compared to females (74.3%). Contrary to the findings of this work, Lorato *et al*. (2017) indicated that the muzzle of most female cattle was pigmented, followed by non-pigmented in both locations, which was noted in both sexes in cattle from Gamo Gofa Zone South West Ethiopia. The differences between the current study and the earlier ones could be attributed to genetics, number of animals sampled, location and age of the animals. The male and female cattle populations' dominant ear orientation and shape was the lateral orientation with 98.3% and 97.5%, respectively. This is in consonance with those of Yimamu and Kebede (2014) for Arsi-Bale cattle, Getaneh *et al*. (2019) for Malle cattle, and Woldeyohannes *et al.* (2019) for local animals in the Hadiya zone.

The cephalic profile in White Fulani and Red Bororo is similar to the findings of Gelaye *et al.* (2022) who reported 88.4% concave in males and slightly concave (11.6%) in females. The present results are consistent with the submission of Getaneh *et al*. (2019) for Malle cattle. Conversely, Gebru *et al*. (2017) observed that convex facial shape dominated the facial profiles of Begait cattle. Horned cattle are visually attractive and may protect themselves and other groups of animals from attackers (Kugonza *et al*., 2012). The higher horn shapes in the current study were Lyre and Crescent. Contrastingly, Woldeyohannes (2020) reported 45.5%) curved horn while Gelaye *et al.* (2022) reported 45% U-shaped horn in male and female cattle populations. The horn orientation of cows in the Debub Bench was 42.6% front, 41.6% upward, and 15% lateral, whereas in the Giddy Bench district, it was 45.3% forward, 44.3% upward, and 9.3% lateral. In contrast to the current findings, Getaneh *et al*. (2019) and Gebru *et al*. (2017) observed curved horn orientation on Malle and Begait cattle, respectively. The higher erect ear observed in White Fulani could mean that it can help in heat dissipation. In hotter climates like Nigeria, where temperatures can be high, cattle with erect ears may have an advantage in regulating their body temperature (Oke *et al*., 2022). This adaptation helps them stay cooler by increasing airflow around the ears, which aids in cooling blood circulating through the ears. Erect ears are associated with desirable traits such as heat tolerance and disease resistance, therefore, they may preferentially breed cattle with this characteristic to improve the resilience of their herds (Raji *et al*., 2022). The highest dropping ear shape in Sokoto Gudali observed in this study agrees with the report of Alphonsus *et al*. (2012) who reported that Sokoto Gudali breed had more dropping ears than White Fulani in Zaria, Kaduna State, Nigeria. Dropping ears can potentially offer some advantages in warm climates. Large drooping ears can aid in heat dissipation by increasing the surface area for cooling through evaporation. This can help cattle regulate their body temperature more effectively in hot environments, reducing the risk of heat stress. However, in a related study, the Red Bororo cattle breed was reported to have more drooping ears than their Sokoto Gudali counterparts (Moussa *et al.,* 2017). This could be as a result of genetic admixture with other indigenous cattle breeds or breeds from neighbouring West African countries occasioned by transmobility of cattle herders. Similarly, very high within-breed variation of qualitative traits due to local preferences of the stock keepers has been reported (Desta *et al*., 2011; Moussa *et al*., 2017).

Different regions of Nigeria have varying climates, ranging from humid to arid. Hump position, backline, and horn shape among other structural traits variations may be adaptations to these climates (CCCD, 2022). For instance, larger dewlaps and humps are often associated with breeds adapted to hot, arid environments as they aid in thermoregulation by providing insulation and heat dissipation and knowledge in these structural differences will help in breed selection for the uniqueness of the environment and physical traits, such as dewlap size and hump position, may be associated with disease resistance or tolerance to parasites (Gelaye *et al*., 2022). Breeds with larger dewlaps or humps may have developed these traits as a defense mechanism against common diseases or pests in their environment.

The highest concave cephalic profile of male compared to female is similar to the report of Gelaye *et al*. (2022) where male cattle ranged from flat (88.4 %) to slightly concave (11.6 %) and female cattle, on the other hand, ranged from flat (86.4 %) to slightly concave (13.6 %). The present results are also consistent with those of Getaneh *et al.* (2019) for Malle cattle. Conversely, Gebru *et al*. (2017) observed that convex facial shapes dominated the cephalic profiles of Begait cattle. The variation in horns shapes in this study is in disagreement with the report of Getaneh *et al.* (2019) who reported familiar for male (100%) and female (100%) cattle populations' samples by the authors. This may be linked to a breed's character, as well as having an aesthetic appeal for the breed's owners. Horned cattle are visually attractive and may protect themselves and other groups of animals from attackers (Kugonza *et al.,* 2012). The results of higher concave horn shapes in male over female is consistent with the report of Woldeyohannes (2020), who reported that male and female cattle populations were curved (45.5%) and U-shaped (45%). Meanwhile, Getaneh *et al*. (2019) reported dominantly upward horn orientation in male cattle, which contradicts our findings. The horn orientation of male cattle in the Debub Bench district was lateral (U-shaped) (47.6%), curved (41.6%), whereas, in the Giddy Bench district (43.3%), lateral (U-shaped) and (49%) curved according to the present evaluation. The higher dropping ears observed in male may help in preventing fly infestations, as they can provide a physical barrier against flies and other pests. Flies are attracted to moisture and warmth, and the folds of pendulous ears may deter them from settling on the animal (Steagall *et al*., 2021). The higher dewlap size in male suggests that the dewlap can store fat reserves, especially in well-fed animals and fat stores can serve as an energy reserve during periods of nutritional scarcity or high metabolic demand, providing the animal with a source of energy to maintain body condition and meet its physiological needs (Putman *et al*., 2019). In eland antelopes, large dewlap size was associated with higher incidence of claw-marks, suggesting a potential role in thermoregulation rather than sexual selection or predator deterrence (Bro-Jørgensen, 2016).

The prominent hump position for male cattle was thoracic followed by cervico-thoracic. The current observation for hump position was similar to those of Ftiwi and Tamir (2015) for Begait cattle. The hump contains a network of blood vessels and acts as a heat sink, helping to dissipate excess body heat. This adaptation is particularly advantageous in hot climates, as it aids in thermoregulation and helps the animal cope with high temperatures. Bulls with humps are well-structured and often moderate in size, while most cows have smaller humps (Getaneh *et al*., 2019). This is because bulls with medium-sized and thoracic humps can withstand the pressure of the yolk from the ploughs, allowing them to draw more efficiently with less damage to the bulls' hides.

Conclusion

The current study revealed variations in the qualitative traits of White Fulani, Sokoto Gudali and Red Bororo, although these variations did not follow a definite pattern. This likely admixture could be due to the fact that cross-border seasonal livestock movements in West Africa bring into close contact several cattle breeds based on the evidence in this study. The significant differences in traits between locations suggest that targeted breeding programs could enhance the productivity and resilience of these cattle breeds, ultimately contributing to the livelihoods of local farmers and the sustainability of the livestock sector in Nigeria. Therefore, the current information may be a step to further characterization of the Nigerian indigenous cattle breeds using a large population. This should be carried out at the morphometric and genomic levels to ascertain breed purity and guide future management, conservation and breeding decisions.

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