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Integrating traditional knowledge with modern breeding techniques: A case study of cattle production in Nigeria's southern guinea and derived savanna agroecological zones

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Abstract
Nomadic pastoralists and agropastoralists are the primary custodians of cattle production in Nigeria, they operate a low external input production system which is proving difficult to modernize especially in the areas of breeding and reproduction for genetic improvement. This study was carried out to gather historical, phenotypic, and perceived genetic information associated with cattle breeding and reproduction practices of the nomadic pastoralists and agropastoralists in the Nigeria Southern Guinea Savanna and Derived Savanna agroecological zones through interviewer-led focus group meetings. The study revealed that the respondents operate similar breeding practices which are native knowledge and practices preserved and transmitted over many generations. The practices are communal in nature and consider climate conditions as well as being comparably similar with the modern scientific standards, hence it was concluded that the respondents have the potential to easily adopt the modern approach of animal breeding and reproduction. These findings suggest a pathway for integrating traditional knowledge with contemporary breeding techniques to enhance cattle production. Future research should explore specific strategies to facilitate this integration and evaluate its impact on productivity and sustainability in the agro-ecological zones

Keywords: *Cattle Selection and Breeding; Artificial Insemination; Crossbreeding; Indigenous breeds; Genomic Selection; Agroecological Zones.*

Introduction

There are two major groups of nomads in Nigeria; the first group is pastoral nomads, while the second group composed of migrant fishermen and farmers. The pastoral nomads are the majority accounting for about 7 million out of the entire 9.4 million nomads in Nigeria; hence, the pastoral nomads are important stakeholders in the country (Abbo, 2011). These pastoral nomads are major custodians of cattle production in the country and are predominantly people of Fulani tribe. In addition, there is also another partially pastoral nomadic tribe known as Shuwa Arab found in the Lake Chad basin of Nigeria who are also custodians of cattle production (Černý *et al*, 2007). Meanwhile, apart from these pastoral groups, there are other custodians of cattle in Nigeria who are not nomads but practice livestock production in addition to crop production – as such they regarded as agropastoralists. While pastoral nomads are either Fulani or Shuwa Arabs, the agropastoralists are of many tribal origins including Fulani, Gbagyi, Berom, Hausa, Yoruba, Kamberi, Dakkarawa and Bariba

(Sikiru, 2020; Ducrotoy *et al*., 2020). The agropastoralists are not keeping livestock as their main economic activity; however, both the nomadic pastoralists and agropastoralists employ the use of low external input in their production which thrives on extensive grazing (Fernández-Rivera *et al*., 2004). The production system is basic animal husbandry which has been proving difficult to modernize in Nigeria – a situation requiring concerted efforts to increase food supply and economic growth in the country (Olukunle, 2013).

The pastoral nomads and agropastoralists engage in the extensive use of natural grassland for livestock production; although, the two groups differ but they engage in a single trade – livestock production (Dong, 2016). The pastoral nomads are purely livestock producers who do not engage in crop production but depend on the sales or exchange of their animals and the animal's products (milk and manure) for crops. They are predominantly migrants who follow pasture resources in an unpredicted pattern year-in-year-which is the most critical success factors for their production system. They have good knowledge of pasture, rainfall patterns, diseases of animals, political insecurity, local, state, national, and international boundaries, as well as access to markets on their routes which are features enabling them to sustain their production and livelihood (Nunow, 2011). In Nigeria, this group of pastoralists are found predominantly in the north; but they also navigate across the Savanna grassland and sub-humid regions of the country year-round in search of pasture.

The agropastoralists on the other hand are either settled Fulani with or without land rights, who engage in the cultivation of sufficient food crops for their families in addition to livestock production or non-Fulani people who engage in livestock production in addition to crop production or other businesses (Schmidt and Pearson, 2016). The agropastoralists practice either crop production or some off-farm businesses as their main sources of income while animal production serve as additional sources of income. Although, livestock is still a valued property of the agropastoralists, but their herd size is on average smaller compared with the herd size of the nomadic pastoralists. Also, unlike the nomadic pastoralists that invest less in housing and other permanent facilities such as borehole for water supply, the agropastoralists usually invest heavily in housing or other local infrastructure at their settled locations compared with the pastoral nomads who hardly built permanent homes. Some agropastoralists who are Fulani are the people who usually act as brokers between the nomadic pastoralists and their host communities in case of misunderstanding and conflicts. This is because, Fulani agropastoralists are usually ethnolinguistic similar with the pastoral nomads but socially integrated with life of their host communities who are usually not Fulani (Gray *et al*., 2003).

In contrast to pastoral nomads, agropastoralists are everywhere in Nigeria, but they are predominantly found in the southern parts of the country. Despite operating in dissimilar ways considering their social lives, the nomadic pastoralists and agropastoralists shared some commonalities in the areas of livestock husbandry practices, such as the selection and breeding of animals as well as herd production management. However, while some of the breeding practices and objectives of nomadic pastoralists and agropastoralists in other places across Africa have been reported by researchers including Ilatsia *et al*. (2012), and Krätli (2008), reports on the breeding practices and

objectives of the nomadic pastoralists and agropastoralists in Nigeria are rarely reported. Therefore, this study was carried out to assess cattle breeding practices, cattle selection, and reproduction among nomadic pastoralists and agropastoralists operating at selected locations in the Nigeria's Southern Guinea and Derived Savanna agroecological zones to gather information that could be useful for improving cattle productivity in the country.

Methodology

The study was carried out implementing a participatory rural appraisal of the breeding and reproduction practices of nomadic pastoralists and agropastoralists operating in the Southern Guinea and Derived Savanna agroecological zones of Nigeria (Fig. 1). Three focus group meetings were held at each of the agroecological zones, and participants at each of the meetings were 15 household heads who were invited to participate in the focus group meeting, followed by random selection of 3 participants among each focus group who were further interviewed personally at their residences. The peculiarities of the WoDaBee cattle breeding system in Niger republic was adopted as the basis for discussion at the at the focus group meeting (Krätli, 2008). The discussion procedure followed raising questions about each of the key issues for discussion by interviewer, and then each group is allowed to give 3 responses per issue, followed by a voting of a consensus and most accurate response recorded as the groups' response on the issue. The key peculiarities and the questions asked per each of the issues are presented in Table 1.

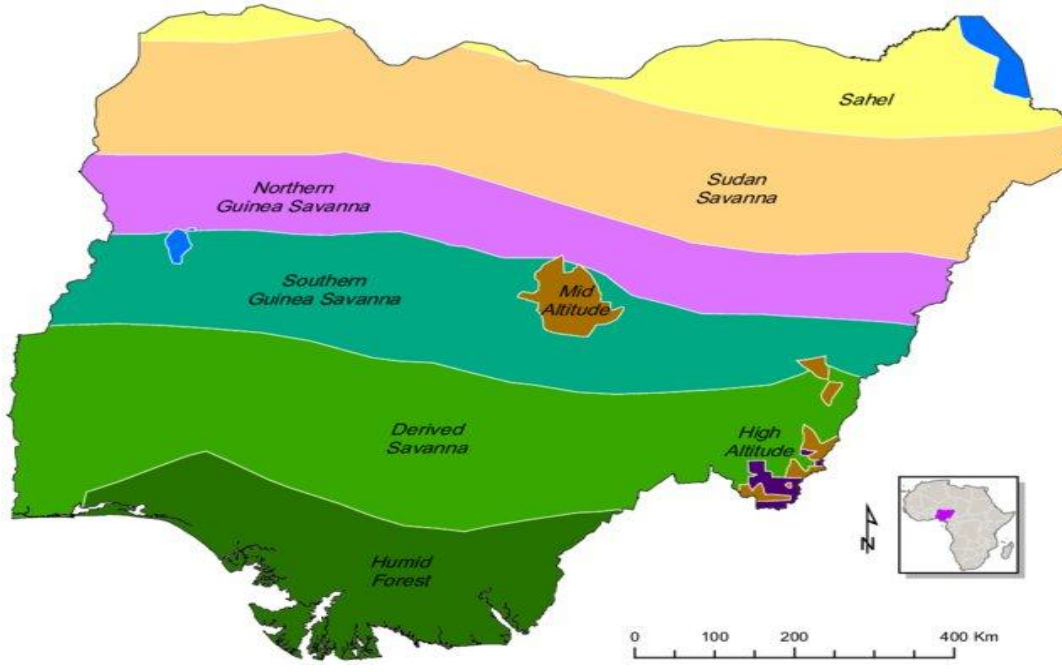

Fig. 1: Map of Nigeria showing different agroecological zones, the Southern Guinea Savanna and Derived Savanna agroecological zones where the focus group meetings were conducted (Source: Tarfa *et al*., 2017).

Results

The respondents in the Southern Guinea Savanna are pastoral nomads while the respondents in the Derived Savanna agroecology are agropastoralists. Despite operating in different agroecological zones of Nigeria which are the Southern Guinea Savanna and Derived Savanna agroecological zones where the study was carried out, the breeding objectives and practices of the respondents are similar (Table 1). The respondents recognized contributions of the Miyetti Allah Cattle Breeders Association of Nigeria (MACBAN) as a major stakeholder and actor in cattle breeding activities. Furthermore, due to the advent of bulk milk collection by industrial processors of milk in Nigeria, the respondents in the Derived Savanna agroecological zone identified contributions of dairy cooperatives societies such as the FADOV Dairy Cooperative Society as a major stakeholder and actor in cattle breeding activities. In both agroecological zones, the average breeding herd population per household is 30 heads of cattle, the ratio of cows to breeding bull is 28 cows to 2 bulls in the Southern Guinea Savanna, while the ratio of cows to breeding bull in the Derived Savannah agroecology is 29 cows to 1 breeding bull. However, the breeding objectives of the nomads in the Southern Guinea Savanna consider climate impact on herd productivity, population and growth while the breeding objectives of the agropastoralists in the Derived Savanna agro-ecological zone focus on the productivity of the herd in terms of milk yield and number of calves reaching market weight within 24 months of calving (Table 1).

Table 1: Comparative analyses of breeding system among nomadic pastoralists and agropastoralists interviewed in the Nigeria's Southern Guinea and Derived Savanna Agroecological Zones

S/N	Parameters	The description within the context of low external input production	Responses of the Southern Guinea Savanna Agroecological zone	Responses of the Derived Savanna Agroecological zone
1	**Main actors in the breeding system**	Who are the main people involved in the activities of cattle breeding in the study areas; rural cattle breeders, commercial producers, and local breeding networks?	Families, community groups, and local breeding network	Community groups and local breeding networks, including Miyetti Allah Cattle Breeders Association (MACBAN), and FADOV Dairy Cooperative Society.
2	**The aim of breeding activities concerning climate impact on herd**	Whether the breeding aims for resilience to changing climate, continuity of cattle breeds or lineage, and maximising reliability?	Yes, the breeding target production of calves with the capacity to endure shortages of water and feed resources. Cattle whose progeny are well-known for their	Breeding for continuity of breeds or lineage only.

			ability to survive extreme conditions of water and feed resource shortages in terms of reduced forage availability for grazing are preferred for use as foundation stock in breeding.	
3	**The selection goals**	Do you normally consider maximizing herd population, feed resource utilization, tolerance to climate change, the social organization of people for livestock production, knowledge transmission, and animal-human interaction as your breeding objectives?	Continuity of cattle from a lineage with superior growth, adapt to feed shortage, climate change, and local disease conditions.	Maximizing the herd population for the achievement of at least one calving per year per cattle.
4	**The strategy of breeding bull selection**	Manipulation of inheritance, genetics, dam-sire matching, dissemination and circulation of lineages of cattle within kinsmen, the role of patrilineal and matrilineal inheritance in the selection of breeding bull?	Knowledge transmission and tolerance to climate conditions as well as circulation of a lineage of cattle with superior performance within kinsmen. Matrilineal inheritance of breeding selection with a specific focus on the selection of bulls of a cow whose progenies up to 3 generations are fast-growing, produce higher milk yield, long teat and adapted to difficulty in feed resources supply.	Manipulation of inheritance; selection of bulls with more pendulous scrotum and the use of dam-sire matching.
5	**The time scale of the selection and breeding programme**	Long or short-term selection and breeding programme, generations of progeny within the lifetime of a given bull, features genetically and extra-genetically transmitted	Long-term selection and breeding programme with a focus on the transmission of the desired traits.	Minimum of 3 generations of cattle.

		from parents to offspring across kinship, and social relationships?		
6	**The expected final product/outcome of the breeding programme**	What is the breeding population, establishment of specialized communities of animals suitable for breeding and production?	30 cattle (28 cows; 2 bull studs)	30 cattle (29 cows; 1 bull stud)
7	**The economic goal of the selection and breeding programme**	What is the economic goal of the breeding programme?	The fast growth of the calves, milk production of the dam and progeny.	The fast growth of the calves, milk production of the dam and progeny.
8	**Dissemination of information about the selection and breeding programme**	What is the method of distribution of animals for selection and breeding; whether borrowing animals is a common practice?	Family sharing and bull borrowing; family sharing involves, the use and circulation of a superior bull within a family.	Bull borrowing and sharing within a community.
9	**Target ecological and environmental considerations in the breeding programme**	What is the strategic production approach, specific or unpredicted and whether for the harnessing of resource availability?	Unpredicted but production for deriving maximum benefits of feed resources availability.	The specific production is predictive of superior growth and milk yield.
10	**Target production environment**	What is target production performance in breeding with a focus on cow-calf operations?	Production of calf ready for sale at the market within 24 months.	Production of calf ready for sale at market weight or suitable for breeding within 24 months.
11	**Impact of selection of the breeding**	What is the impact of the breeding system with a focus on redundancy in traits and what is the breeding network nature (households, clans, clan-cluster, kinsmen, and human generational cycles?	Household, clans, clan-cluster, kinsmen, human-generational cycles.	Breeding association and dairy cooperative societies, human-generational cycles.

12	**Traits of importance in bull selection**	Which traits among the listed do you consider in a bull for breeding: milk yield of the daughter, the concentration of the solid in the daughter's milk, live weight of progeny after 12 months (age at slaughter), growth rates of the progenies, carcass quality of the progeny, and leanness of the meat?	Milk yield of the daughter, the concentration of the solid in the daughter's milk, live weight of progeny after 12 months (age at slaughter), growth rates of the progenies	Milk yield of the daughter, the concentration of the solid in the daughter's milk, live weight of progeny after 12 months (age at slaughter), growth rates of the progenies
13	**Diseases inheritance**	Do you consider a bull's health status, disease susceptibility and family inherited diseases in selection for breeding?	Yes, very important	Yes, very important
14	**Physical appearance**	Do you consider any of the following physical appearance in selecting a bull for breeding: body colour, shape, structural traits, and body condition score?	No, not important	Yes, specific focus on body colour and excellent body condition score
15	**Reproduction traits**	Which of the listed reproduction traits do you consider for the selection of a bull for breeding: daughter's age at first mating, daughter's age at first calving, daughter's calving interval?	All	All

Discussion

The outcomes of the assessment carried out in this study at both agroecological zones showed that community breeding is the common practice by both the pastoral nomads and agropastoralists operating in the study areas. Meanwhile, there is a paucity of information about this breeding practice among the livestock stakeholders in Nigeria, hence, this present study suggests advancing of community-based breeding practice among these stakeholders. This is because, breeding of cattle is being carried out by the respondents in groups which come together to improve and share genetic resources of cattle. The groups are in families, friends, trade-partners, and communities which is like the breeding practices reported from

other areas in West and East Africa whereby people with similar interests of livestock production come together to share animal genetic resources (Krätli, 2008; Mueller *et al*., 2015). This form of community breeding interests could have a critical impact on adoption of modern developments in animal breeding and reproduction practices to increase herd productivity in the study areas.

The findings also indicated that controlled inbreeding and stabilising of optimal performance of cattle with selection focus relatively on centralised marketable performance traits, such as milk yield and growth rates are potential animal breeding objective that could be used for improving the production system of the respondents. This is necessary because, the traditional systems of cattle improvement in the study and other parts of Africa cannot run away from the incidence of inbreeding since there is no systematic and organized selection programme involving animals' record-keeping for the genetic improvement (Halilu and Abate, 2016). Furthermore, natural mating is the common practices in the study areas whereby one or a few bulls are used for many cows. Meanwhile, this is a common practice reported from other parts of Africa where extensive low external input operations are in practice (Beriso *et al*., 2015). Although, this has the propensity to limit the genetic transfer of economically important traits relating to milk, and beef production, however, it is meeting up with the breeding objectives of the pastoralists who select breeding bulls based on their body size, physical appearance, and dam performance (Gudeto *et al*., 2021).

Therefore, the use of a bull for many cows by the respondents would have prepared them for easy adoption of artificial insemination as a reproductive technique as a modern reproduction technique in the study areas. Also, the respondents' knowledge of using physical appearance for the selection of breeding bulls indicated that they understand body conditions in selection of breeding bull. Although, they use body size as a trait for the selection of bulls to produce calves that will produce higher milk, used as draft power, fast growth rate, commanding of higher market price, and superior reproductive performances at maturity (Bayou *et al*., 2014). Furthermore, one of the breeding objectives common to the respondents is breeding for herd continuity; this understanding could be employed in modern breeding practice for improving their productivity and reduction of inbreeding to its barest minimum. This could also be used to encourage the respondents to adopt the use of artificial insemination, or the use of distant relatives' bulls or studs which have been suggested by researchers (Misganaw *et al*., 2014).

Furthermore, the pastoralists and agropastoralists interviewed in this present study seem to be aware of the impact of climate change on the productivity of their animals; therefore, they should be encouraged to breed animals with more compact bodies and animals likely to survive on low-feed resources. These criteria were also suggested for use by cattle farmers in Ethiopia, where farmers prefer cattle with more compact bodies as they have identified that large-sized animals have lower resistance to surviving in prolonged drought seasons than cows of small body size (Gudeto *et al*., 2021). The outcomes of this study also revealed the need to involve commercial breeders, agribusinesses, research institutes, and breeding societies in the breeding and reproduction activities of cattle in Nigeria in a collaborative manner for the promotion of breeding for improved productivity of cattle. This is because; input from these stakeholders for breeding activities could be channelled towards

practices for genetic gains of cattle which are currently lacking in Nigeria. Even though some of these stakeholders are usually listed to be involved in some breeding programmes to improve indigenous cattle breeds for whatever trait of interest, not much has been contributed by these stakeholders (Sikiru *et al*., 2022).

Although, this might be due to lots of factors amongst which are: poor government policy, inadequate investment on the part of commercial operators, improper funding of research institutions and many others. Meanwhile, it was reported by Leroy *et al*. (2022) that these stakeholders' involvement in breeding activities could differ, but is highly desirable because, through stakeholders, feasible and adaptable breeding objectives could be formulated. For example, the research organizations could be more interested in setting breeding goals, and conducting genetic evaluations, while other associated services such as the provision of incentives for keeping breeds at risk, and extension of breeding research outcomes to end users are almost exclusive responsibilities of the public sector. Besides, Nigeria has not overcome the colonial policy of trying to improve cattle breeds by practising crossbreeding with so-called imported exotic breeds which are usually poorly adapted to the prevailing climate conditions (Ogbimi and Oyewale, 2000). This is an underlying threat to cattle breeding and as it is, there is no serious cattle breeding programme involving stakeholders such as pastoralists, agropastoralists, research organizations, and commercial operators, breeders' associations as posited above. Meanwhile, the pastoralists have been resilient by building a quasi-organized communal breeding system in response to non-inclusion into some of the organized breeding programmes in the country. This has assisted them in using their breeding approaches tailored toward achieving goals that are important for their production targets.

The focus group discussion carried out showed that the pastoralists and agropastoralists have breeding bulls selected and improved over time to meet their set objectives of producing animals with good conformity for beef and milk production, survivability and continuity of the herd. However, the lack of well-organized breeding programmes and convergence between breeding goals of pastoralists and other stakeholders such as breeders' associations, research organizations, and commercial breeders is a major hindrance to the success of breeding activities in Nigeria. Therefore, going forward, there is a need to have a robust breeding programme for both beef and dairy production involving all the stakeholders. The pastoralists must be engaged to serve as the front runners as their expertise and knowledge will be required even if commercial breeders are to step in to provide a major boost. The importation of exotic genetic pools either in the form of semen for artificial insemination, or live animals for crossbreeding alone will not suffice as the real forms of breeding for genetic improvement in Nigeria. This is because experience has shown that this is not tenable due to the inability of the crossbred progenies to survive and do well to adapt properly to the climatic niche prevalent in the country (Ogbimi and Oyewale, 2000).

Also, the cattle breeding goals of the interviewed respondents in this study suggested that breeding objectives targeted at improving the indigenous cattle population in the study areas could focus on the ability of cattle to continue surviving in a climate that is ever-changing because of anthropogenic activities. This is because, the gene pool of the indigenous breeds is already flowing around for several years of natural

and artificial selection, particularly for their ability to survive in an otherwise challenging environment with sparse feed resources. This calls for the exploitation of the naturally selected trait of the indigenous breeds to complement the higher milk production trait of the exotic breed to develop a breed with improved adaptation and milk production capacity. In this regard, the recent intervention by Friesland-Campina in the southwest, and Niger State, are welcomed developments as indicated by some of the respondents interviewed in this study. However, for these interventions to be successful as envisaged, emphasis must be placed on the conservation of the indigenous traits of the cattle in addition to selection and improvement in reproductive capacity and increased milk production.

Maximising specific, discrete traits such as productivity, phenotypical, morphological, physiological and behavioural features pertinent to productivity could be another area of focus for breeding and genetic improvement of Nigeria's indigenous cattle. This is because cattle having these specific traits could increase the productivity of meat and milk as revealed through this present study. However, these traits need to be characterised phenotypically first and then genotypically confirmed so that their maximum potential could be tapped. This study showed that the pastoralists interviewed had a specific focus on the productivity, phenotypic, morphological, physiological and behavioural traits in the selection of cattle for breeding especially the bulls. This could be linked with the sustenance of the cattle populations of the respondents over years against a myriad of challenges bothering on health, climate change, management regimes and scarce feed resources. In specific, the nomadic pastoralists interviewed stated that they select bulls with longer legs, compact bodies, and the ability to survive a shortage of water and feeds as climate change adaptation scenarios. These traits are considered important for an animal's ability to survive harsh climate conditions, and maintenance of thermoneutrality which could impact positively on their productivity, and physiological and behavioural patterns. Meanwhile, animals selected based on such traits could be better in dissipation of excess body heat to the environment through the effective negation of heat load (Haidary *et al*., 2012). Since, heat dissipation depends on physiological responses such as increased respiratory rate, changes in rectal temperature, pulse rate, sweating rate, and skin temperature (Sharma *et al*., 2013).

The selection of cattle based on skin colour could also be vital for maintaining thermoneutrality following account of the pastoralists which prefer white coloured animals against darker colours as they believe heat maintenance is better in the white animals. Even though the rate and efficacy of evaporative cooling from the skin surface are not limited to skin colour alone, and other factors such as fur or hair coat, physical and optical properties, density and thickness of hair coat, and hair length are also important. Meanwhile, Hillman *et al*. (2001) and Gebremedhin et al. (2008), reported that black dairy cows had a higher sweating rate (800 W/m^2) than white cows (500 W/m^2). Similarly, Silva *et al*. (2019) established that light hair coats exhibited higher reflectivity than dark hair coats having a wavelength range of 300 to 850 nm. Meanwhile, Hillman *et al*. (2005) reported that heifers show an increase in sensible heat flux under sunlight in the order of 26 % (dark- red), 22 % (black), 5% (tan), and 4 % (white coat colour), respectively. This means that heat gain is higher in darker-coloured cattle compared with their lighter-coloured peers. Hence, the rule of thumb, therefore,

could be to encourage pastoralists to keep selecting white colour which is their preference to ensure the survival of their animals as a strategy of adapting to changing climatic conditions, particularly temperature increases inducing heat stress. Another rule of thumb is to consider all traits that would make the animals more robust which could be the selection of animals to increase livability and productivity. These traits may include rumen physiology, the ability to walk and reach scarce feed resources, intake of water and ability to rehydrate, ability to compensate for low feed quality by selecting high-quality diets from different plant components or species or to respond with increased night-time grazing to high afternoon temperatures, or even genetic aspects of diet selection (Hall, 2008). These could all play critical roles in adaptation to climate change.

The findings from this study also indicate the need for manipulation of genetic inheritance of indigenous animals through the genetics of selection, artificial insemination, and focus on patrilineal inheritance patterns; because these are capable to enhance the genetic merit of the herd. Hence, to improve the genetic merit of cattle breeds reared by pastoralists and agropastoralists engaged in this study, it will be essential to manipulate the principles of genetic inheritance, apply artificial insemination, and take advantage of the passage of inheritance patrilineal. In the past, the genetic improvement of indigenous cattle largely involved the introduction of exotic or improved genes through the upgrading of available indigenous breeds or the complete replacement of the indigenous stock with the imported improved breeds. However, there are negative results of that approach such as the loss of unique genes associated with the local adaptation and difficulty to survive under challenging tropical climates. Confirmation of these was reported which showed that the imported improved exotic breeds could not perform to their true genetic potential in Nigeria and in some other Tropical African environments which differed from the sanitized environments and temperate climates where they were originally developed (Adebambo, 2003). This kind of introduction also has implications regarding the possible worst-case scenario of extinction of valuable indigenous breeds of livestock and loss of valuable genes in local breeds which is genetic insurance for immediate use and future food security.

Particularly in the face of global climate change, conservation of local gene pool diversity is a matter of great priority when planning genetic improvement of livestock breeds. The best-case scenario is to see how the indigenous bulls and cows could be selected (naturally or artificially) for traits of importance to the pastoralists and consumers, then improved upon over some generations. The long-held misleading notion of the low productivity of indigenous cattle breeds is largely because unlike their peers in Europe and North America, they have not been genetically manipulated for the specific production of meat and milk (Awobajo *et al*., 2015). Some of the indigenous breeds could have a genetic structure compared to their exotic counterparts, but most of these traits have not been documented (Okpeku *et al*., 2016). This study, therefore posited that with proper selection and provision of the right environmental conditions, rich nutritional regimes, and proper disease and pest control, the indigenous breeds could be more suitable to local agricultural systems because of their high adaptability. So, it is important to select them for production traits (e.g., milk yield and composition) and functions such as fertility, disease resistance, feed intake and

body weight. Meanwhile, the use of molecular genetics techniques in conjunction with conventional animal breeding techniques could be used to optimize such selection and breeding programmes, for higher yields in terms of greater genetic gains within an ample reasonable period, as it is possible to determine the potential of an animal, even before the trait is expressed phenotypically (Kiplagat *et al*., 2012).

Artificial insemination is another approach through which cattle breeding can be scaled up since it is possible to carry out many inseminations per bull for genetic improvement within or among breeds. The semen of an improved bull can be used in the artificial insemination of a cow to improve the milk and meat production potential. This improved semen could be easily and widely used at the farm level to produce future generations of cattle. Although, for this to be successful, there will be a need for the provision of associated tools and equipment adapted to the local environment. This is where governmental input will be highly appreciated and move cattle production, from basic pastoralism to more settled commercial concerns. It is of utmost importance to improve the breed of the indigenous cattle before consideration of crossbreeding, because the fallback of crossbreeding using the gene pool from imported sires with proven ability for beef and milk production alone may not translate to desirable and expected performance improvements. For this to be successful, inputs from the pastoralists should also be sought, and conditions put in place to ensure the adaptation, survival and productivity of hybrids produced. These have been reported from successful crossbreeding programmes involving indigenous and exotic breeds that exist in developing and tropical parts of the world such as Nigeria.

For example, Wakchaure *et al*. (2015) reported that replacing nondescript animals in India, Holstein-Friesian and Jersey inheritance with nondescript animals at around 50-62.5 % exotic inheritance level leads to better production performance. Also, Singh (2016) observed that up to 50 % exotic blood level inheritance is ideal for growth, reproduction and milk production when improving indigenous cattle of India. The crossbreeding cattle improved milk production and per capita milk availability, lactation length and growth rate were observed to be generally higher than those of local cows (Tadesse and Dessie, 2003). Furthermore, Demeke *et al*. (2000) in their study of Holstein-Friesian x Ethiopian Boran cattle at the Holetta Research Center in Ethiopia, observed that in an average lactation, the purebred Holstein Friesian cattle produced 4.5 times more milk than the Boran, and nearly 1000kg more ($p<0.01$) milk than the best-producing F2 (3/4H1/4HB) crossbred cattle. All the crossbred groups produced at least three times more ($p<0.01$) milk per lactation than the indigenous Boran. Therefore, crossbreeding of the indigenous cattle of Nigeria with exotic high performing breeds holds some promise as a means of improving the indigenous cattle breeds performance when properly done and necessary provision is made in terms of health care, environmental control and adequate nutrition.

It could also be inferred from this present study that the indigenous cattle breeds of the respondents in this study could be improved upon by giving cognizance to the genetic merit of the indigenous breeds such as their possession of stable and transferable traits for high production, and ability to adapt and survive the local ecosystem. This is because the local breed to have survived so far is indicative of possessing traits important for cattle

producers in the study areas. These traits such as the ability to withstand extremes of weather survive on the low input production system; coping with prevalent diseases, and tolerance to pest infestation, which has ensured their survival albeit with low productivity occasioned mainly by myriads of reasons could serve as critical useful genetic merits. These are genetic assets that could be transmitted to the next generation, especially when breeding objectives and breed/species choices are being made to harvest indigenous genetic resources for improved productivity. It is of utmost importance, therefore, that livestock improvement and climate change adaptation policies support the existing adaptive capacities of the livestock-keeping communities using relevant technical and financial support where necessary form the backbone of selection and breeding objectives (Raziq *et al*., 2011). Effecting the transmission of these heritable traits in local-climate adapted breeds will involve the use of both classical breeding techniques, and the use of modern methods such as estimated breeding values (EBVs), and genomic selection (GS), in combination with assisted reproductive technologies (Demeke et al., 2000). This will enable a more accurate selection and strong utilization of genetically superior parents for the next generation to accelerate the rates of genetic gain within the indigenous breeds. These could lead to increased rates of genetic gain which can improve livestock production efficiency and ultimately, the sustainability of indigenous cattle breeds reared by the pastoralists in Nigeria.

While findings in this study suggested that Nigerian pastoralists could be highly receptive to acceptance of modern livestock breeding and genetic improvement, required government interventions are lacking. Meanwhile, these are necessary because Nigeria's population is the highest and fastest growing in sub-Saharan Africa which is an indication that efforts geared towards breeding and genetic improvement of livestock could be contributing to the fight against food security. Apart from the food supply, it could also be resulting in a gain for the Nigerian state in form of savings from external spending, because currently, for example, the milk and dairy industry is import driven in the country. Meanwhile, the country has robust agricultural policies to address these challenges, however for the country to achieve self-sufficiency in basic food supply and attainment of food security, increased production of agricultural raw materials for industries, eradication of poverty and development of the rural economy are necessary. Unfortunately, poor implementation of the policy with a focus on animal breeding and genetic improvement is a common challenge in Nigeria like most other countries in sub-Saharan Africa (Opoola et al, 2019).

To overcome the problem of poor breeding and genetic policy implementation in Nigeria, there is a need for effective legislation that can contribute to livestock development, such as legislation in support of ranching and grazing reserves. This is because legislation focusing on animal breeding and genetic improvement concerning cattle ranching and grazing reserves in Nigeria has the potential for better productivity as a result of improved genetics which could serve as a major factor for compliance of the smallholders to ranching and grazing regulations in the country and potential of this compliance could amount to peaceful co-existence between herders and crop farmers in the country as well as safety of lives and properties. While in some other countries in sub-Saharan Africa, livestock are continually been improved upon, Nigeria's indigenous

livestock remained static over the years; and in agreement with this, Nigeria's Department of Animal Husbandry admitted there is a need to promote livestock breeding and improvement for animal production sector to contribute significantly to the country's agro-economy and contributes to the qualitative nutrition of the Nigeria citizenry as well as contribute to the overall food security status of the country. Therefore, the paramount roles of governance in the sustainable implementation of cattle breeding strategies and programmes are necessary for Nigeria.

Conclusion and Recommendation

The pastoral nomads and agropastoralists engaged in the study have a critical understanding of cattle selection and breeding which are historical, phenotypic, and perceived genetic information associated with breeding practices using their native knowledge transferred to them over generations. Therefore, their adoption of modern animal breeding and reproduction practices are ways of increasing their herd productivity and ensuring national food security.

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