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CHRONICLES OF LIVESTOCK IMPROVEMENT: EXCERPTS FROM THE MEMOIRS OF A GENETICIST

by

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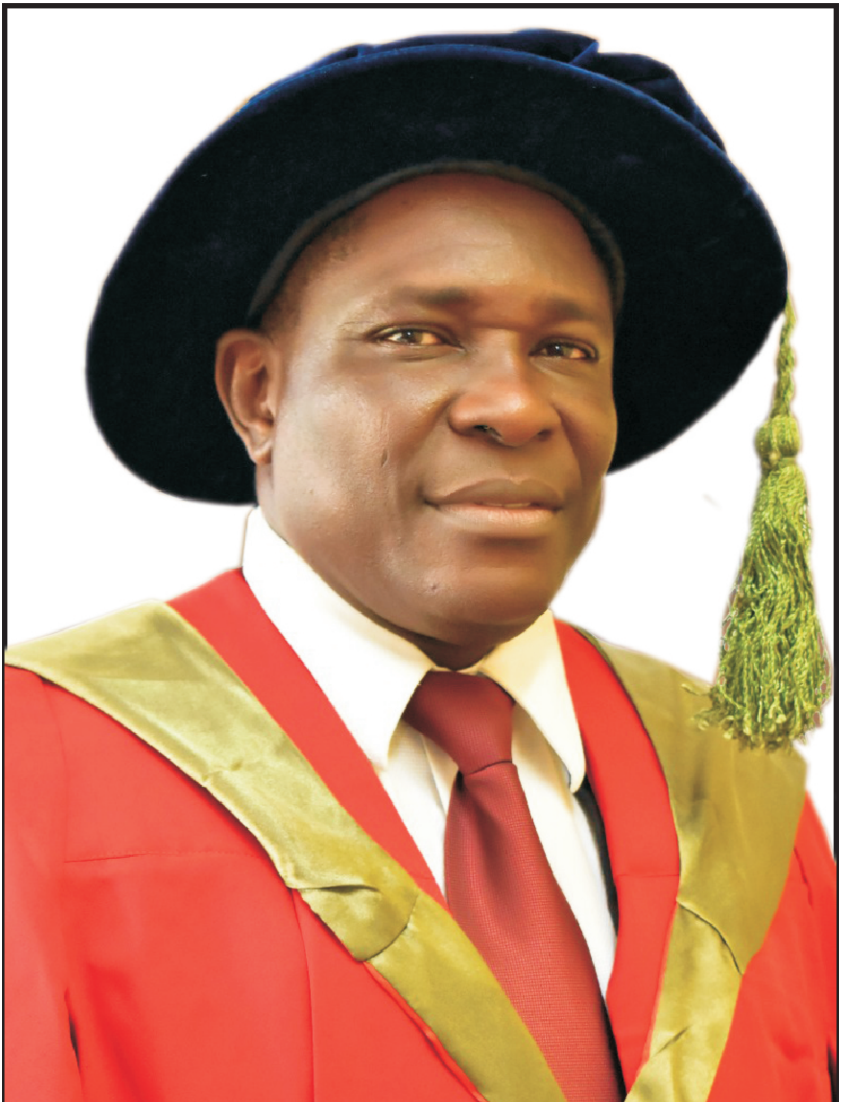

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The Vice-Chancellor;
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Distinguished members of the University Senate;
Distinguished Academic and Professional Colleagues in FUNAAB and from other Universities;
My Academic Mentors;
My Lord Spiritual and Temporal;
Members of my immediate and extended families;
Gentlemen of the Press;
Distinguished Ladies and Gentlemen;
Great FUNAABITES;

Preamble

The LORD is my strength and song and is become my salvation. The voice of rejoicing and salvation is in the tabernacles of the righteous: the right hand of the LORD doeth valiantly (Psalm 118:14-15 KJV of the Holy Bible).

With gratitude to God Almighty, the Creator of all things and the Giver of life, by whose mercy, I am whom I am, I stand before you this day to deliver the 58th in the series of Inaugural Lectures of this great University. Although, this lecture is coming up about twelve years after I had been promoted a professor, I am pleased to deliver it because as a professor, the delivery of an inaugural lecture is an occasion of significance in the career of an academic staff member in the University. I am therefore, grateful to the

Dean, College of Animal Science and Livestock Production for giving me this unique opportunity to deliver the 10th Inaugural Lecture from the College of Animal Science and Livestock Production and the 2nd from the Department of Animal Breeding and Genetics.

Inaugural lectures provide professors with the opportunity to inform colleagues, the campus community and the general public of their work, including current research. The first inaugural lecture from the Department of Animal Breeding and Geneticstitled 'Animal Breeds: A Nation's Heritage' was delivered by Prof. Olufunmilayo Adebambo in 2003, that's about fifteen years ago. She is already on her way out of the system and she is planning a valedictory lecture. I made up my mind and prayed to God that I would like to present my inaugural lecture before she delivers her valedictory lecture. I felt it would be odd that she presented inaugural and valedictory lectures before any other professor in the Department had the opportunity to deliver inaugural lecture. God surely answered my prayer and here I stand before you today to deliver the second inaugural lecture from the Department of Animal Breeding and Genetics. Therefore, Mr. Vice Chancellor sir, distinguished ladies and gentlemen, permit me to address you this afternoon on the subject matter I titled 'Chronicles of Livestock Improvement: Excerpts from the Memoirs of a Geneticist'.

1.0 Introduction

Livestock systems occupy about 30% of the planet's ice-free terrestrial surface area and this sector employs approximately 1.3 billion people globally and directly supports the livelihoods of about 600 million smallholding farmers in developing countries (Thornton, 2010). Livestock production is, therefore, a key component of the world's agriculture and it is of utmost importance as breeders' income and livelihood depend on it.

Underlying all animal breeding programmes is the fact that neither all animals nor breeds are equal. There are differences between and within breeds in fertility, size, stress, disease resistance, grazing and mothering behaviour, as well as in many other traits. Productivity is an average measure of efficiency of production and the major parameters that determine the productivity of a breeding herd are the reproductive performance of the breeding females, breeding values of the sires, mortality rate, growth rates from birth to maturity and milk production levels(de Leeuw *et al.,* 1991). Productivity is an important economic factor influencing biological and economic returns (Huettel *et al.,* 2011). Efficiency of production is of utmost importance for the sustainable improvement of animal productivity and it is a critical factor influencing the economic viability of livestock farmers. Low productivity is often identified as one of the primary constraints hindering the effectiveness of livestock production systems (Brumby and Trail, 1986).

Most livestock germplasm in sub-Sahara Africa display great adaptive potentials, but exhibit poor productive performance (Ozoje *et al.,* 2005 and Lamy *et al.,* 2012). African livestock, according to these reports, are late maturing, slow growing with reduced mature body weight and efficiency on overall performance is greatly depressed. Ferguson (1987) stated that the genetic improvement of indigenous breeds of livestock is very valuable because of their high adaptability to harsh environmental conditions. Although, adaptive traits are important components of overall productivity, increased adaptability is usually at the expense of production potentials. It is therefore necessary to compromise these attributes to optimize production. Productive adaptability is an excellent concept for utilizing environmental stresses (thermal and diseases) and productive response of an animal to accurately predict relative level of production potential in adversely hot and unfriendly climatic conditions. The interactions of these factors shape the productive performance of a given breed of livestock.

Genetic improvement in any production system can be achieved either through selection among purebred animals or through crossbreeding and gene complementarity with improved strains. However, these methods are not mutually exclusive. The classic definition of genetic improvement of animals consists of the application of biological, economic and mathematical principles with the aim of discovering optimum strategies to exploit the genetic variation existing within an animal species, particularly to maximize its merit. The ultimate objective in my research career therefore was to see how I can improve the productivity of the breeds of livestock adapted to our local environment with minimal compromise of their adaptive potentials.

2.0 Distribution of Nigerian Livestock Genetic Resources

There is a wide range of environments in Nigeria; ranging from the heavy rain forest in the South through the well-watered savannahs to the dry arid region in the North, and according to Lamy *et al.* (2012), climatic variation can affect any animal's ability to survive and be productive in many ways. Some areas, because of temperature extremes, topography or excessive lack of moisture, are totally unsuited for habitation either continuously or during particular seasons of the year. Other areas may support livestock during some seasons but not others. Other factors that may affect the distribution of livestock species include availability of breeding sites and territories for growth and protection of the young and food supply for survival (Rust and Rust, 2013). Abundant vegetation grows during the rainy season even in the semi-arid zones, but unfortunately, conditions are usually too wet to conserve any excess plant material during the active growing period. Thus, feed supply may exceed demand for a part of the year, but livestock are nutritionally deficient at other times. This has resulted in great diversity and localisation of livestock breed types across the country.

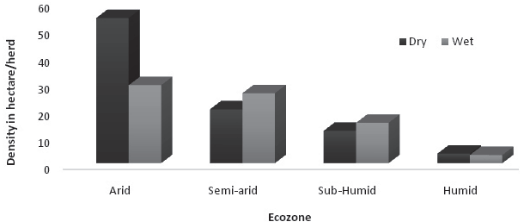
The major species of indigenous livestock found in Nigeria include cattle, sheep, goats and chicken, which can be classified broadly into two main groups:

1. The trypanotolerant species include the humpless breeds of N'Dama and Muturu cattle and the West African dwarf sheep and goats commonly confined to the tsetse-infested zones in the South. Trypanosomes transmitting tsetse fly occurs roughly in 50% of the Nigerian landmass. However, continuous deforestation and the transformation of vegetation and land use pattern have greatly reduced the natural habitats and wildlife hosts of the tsetse fly over much of the country (Bourns *et al.,* 1986). The presence of this arthropod renders large portions of Nigeria's land area unsuitable for habitation by domesticated mammals. Nevertheless, many indigenous livestock breeds develop resistance to this disease.

2. The trypanosome susceptible breeds of the humped zebu cattle, and the long-legged sheep and goats majorly found among the Fulani pastoralists.

The observed distributions of cattle during the wet and dry seasons vary greatly as a result of the movement of pastoralists in search of feed and water for their herds.

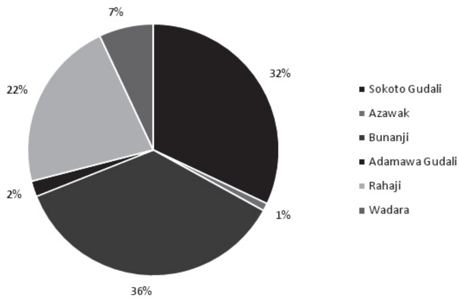
Number of cattle increase steadily with declining rainfall, so that much of the South has low cattle densities and most of the population is in the North (Blench, 1996). Figure 1 shows the densities by ecozone in both wet and dry seasons. The mean density of cattle is approximately 15/km^2, or 6.6 hectare/head.



Adapted from Blench, (1999)

Figure 1: Densities of cattle by ecozone

In Nigeria, the Zebu cattle are divided into six distinct resident breeds according to Blench (1999). They are Bunaji or White Fulani, Sokoto Gudali, Rahaji (Red Bororo), Wadara, Adamawa Gudali and Azawak. The Bunaji, Sokoto Gudali and Rahaji breeds constitutes 90% of the Zebu cattle found in Nigeria (Figure 2).



Adapted from Blench, (1999)

Figure 2: Contribution of Zebu Breeds to Nigeria National Herd

Sheep and goats on the other hand are important to the subsistence economy and social livelihood of most rural household in Nigeria and are therefore kept everywhere.

Ebozoje and Ikeobi (1995) and Ajayi (2010) reported that the Nigerian indigenous chicken population is widely distributed across the country and it is classified both by strains and ecotypes based on locations.

Maintaining the diversity and distribution of animal genetic resources in Nigeria is essential to satisfy the basic human needs for food and livelihoods. Genetic diversity ensures that different species and breeds can adapt to extreme conditions. It allows for the expression of advantageous traits influencing adaptability to harsh environments, productivity anddisease resistance. These indigenous livestock breeds express varying degrees of enhanced resistance within and between zones.

3.0 Productivity of Nigerian Livestock breeds

Productivity is the average measure of the efficiency of production, which can be expressed as the ratio of output to inputused in the production process. However, livestock productivity in the tropics is affected by several variable factors which include individual genetic potentials and the influences of environmental factors that include seasonal changes affecting feed availability and thermal stress. Seasonal extremes in all climatic zones present environmental limitations and such limitations are particularly important in the humid tropics (Lamy *et al.,* 2012). The interactions of these factors shape the productive performance of a given breed. Therefore, an individual's performance potential is the result of its true genetic ability and its specific ability to cope with environmental stresses. The concept of productive adaptability revolves around this basic principle. Most Nigerian livestock breeds possess wide margins for adaptation expressing good specific physiological properties that made acclimatization possible (Horst, 1988; Ozoje and Ikeobi, 1998; Ozoje, 2002). For example, the livestock breeds confined to the humid zones are small compared to the others. They are also hardy and trypanosome resistant with variable coat colour to enhance thermoregulation. To avoid increase in body temperature and maximize heat loss under high ambient temperatures, the amount of heat produced by the body must be equal to the amount dissipated to the surrounding environment. Livestock breeds rely on a combination of six strategies to accomplish this objective.

1. Increase surface area per unit of body weight;
2. Increase temperature gradient between animal and air;
3. Increasing conduction of heat from body core to skin;
4. Decreasing solar radiation reflection;
5. Increasing metabolic rate and feed intake and
6. Adjusting cellular mechanisms.

Most livestock species in the Southern and more humid areas of Nigeria are smaller and lighter than their counterparts in the North as they tend to have lower metabolic rates with proportionately smaller internal organs and larger body surface areas. They also have greater ability to produce sweat (Hansen, 2004; Berman, 2011 and Lamy *et al.,* 2012).

3.1 Nigerian Cattle Breeds

Cattle account for a significant percentage of livestock population in Nigeria and its significant contribution to the Nigerian agriculture system is well recognized. Despite its economic and social importance, its productivity has largely remained in the hands of transhuman pastoralists with traditional breeding systems that have little or no breeding strategies and performance improvement focus. Therefore, the average productivities of these animals have largely remained the same and poor over the years (Rege *et al.,* 1994). Nevertheless, these breeds of cattle are adapted to the tropical conditions in Nigeria and can withstand high thermal stress, high disease prevalence and poor nutrition conditions.

White Fulani (Bunaji): The White Fulani cattle breed is the most numerous and widely distributed cattle breed in Nigeria (Ahamefule *et al.,* 2007 and Kubkomawa, 2017). The White Fulani is a strain of the Bororo zebu cattle representing 37% of the national cattle herd (Alphonsus *et.al.,* 2012and Rege *et al.,* 1993).The Bororo zebu (White Fulani and RedBororo) are animals characteristic of the semi-arid zones particularly suited for long journeys (Pagot, 1992 and Kubkomawa, 2017). The White Fulani is a multiple purpose breed with average matured weight range of 425-665 kg for the bull and 250-380kg for the cow (Tawah and Rege, 1996, Ahamefule *et al.,* 2007 and Kubkomawa, 2017). It is described as a medium breed measuring about 130cm at withers (Oyedipe *et. Al.,* 1982, Tawah and Rege, 1996, and Kubkomawa, 2017). The average pre- and post-weaning performance of this cattle breed under station and Traditional management systems are surmarized in Tables 1 and 2.

Table 1: Pre-weaning weights (±standard error) of White Fulani cattle by location and management system

Location	Management System	Birth weight (kg)	3 months weight (kg)	6 months weight (kg)	9 months weight (kg)
Shika, Nigeria	Station	22.3±1.1	63.21±1.6	101.7±13.4	126.5±24.1
Kabomo, Nigeria	Station	23.0±4.6	81.5±11.7	130.2±23.2	-
Birnin Kudu, Nigeria	Station	21.7±4.3	64.7±13.2	130.8±24.6	-
Vom, Nigeria	Station	24.2	-	129.4	-
Bambui, Cameroon	Station	23.1±1.8	60.2±3.6	88.7±6.1	98.5±9.8
Idon, Nigeria	Ranching	198		76.3±15.2	99.3±11.2
Mando, Nigeria	Ranching	20.1	-	97.8±25.5	128.7±27.8
Adet, Nigeria	Village	20.2±8.3	-	61.6±14.3	76.9±23.4
Madaechi, Nigeria	Village	18.2±9.4	-	-	67.0±29.5

Sources: Faulkner and Epstein (1957), Oyenuga (1967), Wheat and Broadhorst (1968), Otchere (1983), Tawah and Mbah (1989), Rege *et al.,* (1993)

Table 2: Post-weaning weights (± standard errors) of White Fulani cattle by location and management system

Location	Management System	12 months weight (kg)	18 months weight (kg)	24 months weight (kg)	30 months weight (kg)	36 months weight (kg)
Shika, Nigeria	Station	145.1±0.4	188.8±0.9	226.8±1.5	267.0±2.2	302.4±2.2
Kabouro, Nigeria	Station	214.2±6.2	255.6±8.0	333.9±8.1	-	-
Abet, Nigeria	Village	92.5±1.9	113.4±1.6	-	-	-
Hirmin Kudu, Nigeria	Station	180.5±3.2	236.5±4.1	278.1±5.3	300.0±9.4	322.0±9.4
Abet, Nigeria	Village	92.5±1.9	113.4±1.6	-	-	-
Kurmin Biri, Nigeria	Village	96.5±2.2	114.3±1.6	-	-	-
Mando, Nigeria	Ranching	136.0±4.2	174.8±5.6	-	-	-

Sources: Wheat and Broadhorst (1968); Wheat *et al.,* (1972); Otchere (1983); Rege *et al.,* (1993)

Table 3: Reproductive characteristics and lactation performance (± standard deviations) of White Fulani females

Traits	Mean ± SD	Source
Age at first service (months)	26.5±4.9	Aganga et al., (1986)
Length of oestrus cycle (days)	20.8±2.0	Johnson and Gambo (1979)
Duration of oestrus (hours)	8.3±4.6	Payne (1970)
Intensity of oestrus	4.12±0.03	Zakari *et al.,* (1981)
Interval from parturition to first oestrus (days)	74.0±51.3	Adayemo (1986), Dawudu et al (1987)
Interval from parturition to conception (days)	43.8±15.2	Adayemo (1986)
Interval from parturition to complete uterine involution	26.0±1.1	Eduvie (1985)
Interval postpartum to detection of first follicles (days)	44.9	Eduvie (1985)
Interval postpartum to first ovulation (days)	65.8	Eduvie (1985)
Number of ovulations	1.7±0.5	Adamu *et al.,* (1990)
Lactation yield (kg)	992.6±118.3	Aganga *et al.,* (1986)
	932.5±115.9	Hill (1956)
	536.5±114.3	Tawah and Mbah (1989)
Lactation length (days)	2495±9.2	Aganga *et al.,* (1986)
	244.7±10.0	Hill (1956)
	175.5±38.6	Tawah and Mbah (1989)

The average age at first calving of the White Fulani (Table 3) has been reported to vary between 42 and 45 months (Alphonsus *et al.,* 2012). Age at first service averaged 26.2 months, and length of productive life varies from 9 to 10 years according to Ngere, (1975). Average lactation length and lactation milk yield ranged from 173 to 365 days and 465 to 2950 kg per lactation respectively.

Red Bororo is specific to the Bororo Fulani people of Northeast Nigeria and constitute about 22 percent of the national cattle herd population in Nigeria (Kubkomawa, 2017; Meghan *et al.,* 1999).These cattle survive in conditions of low rainfall (3-5 five months of rain followed by the long dry season). The Red Bororo cattle is of average stature with highly develop horns. Apart from the difference in coat colour used for selection by the Bororo herdsmen, their productivity is not significantly different from that of the White Fulani cattle (Pagot, 1992; Kubkomawa, 2017).

Plate 1: Red Bororo
Photos provided by Larry W. Harms

Plate 2: White Fulani herd

Gudali cattle: Gudali cattle breed of Nigeria is grouped with the short-horned zebu of West and Central Africa. It constitutes 32% of Nigeria national cattle herd. There are about 5 strains of **Gudali,** namely: **Sokoto Gudali**, Adamawa **Gudali**, Banyo **Gudali**, Yola **Gudali** and Ngaundere **Gudali (Kubkukowa, 2017)**. The **Sokoto Gudali** is the strain found in North-west

Nigeria (Tawah and Rege, 1996). The Gudali cattle is primarily used for meat and milk (Domingo, 1976; Tawah and Rege, 1996). About 90 percent of the Gudali cattle are traditionally kept by the Fulani and Hausa pastoralists (Ngere, 1985). Cumulative mortality rate of the Sokoto Gudali at one year of age ranged from 6.2% to 24.6 percent (Ileoje, 1985; Tawah and Rege, 1996). The growth performance of the Gudali as summarized in Table 4 revealed that its average birth weight ranged from 23.7 kg to 24.5kg. At maturity, Sokoto Gudali bull weighs between 495 and 660 kg, while the cow weigh between 240-355 kg. The reproductive performance of Gudali cattle breed summarized in Table 5 showed that age at first calving and calving interval range from 38.6 to 49.5 months and 378 to 537 days respectively (Tawah and Rege, 1996). The latter is attributed to the ovarian inactivity in the postpartum period and to abortions and stillbirths, whose incidence rate vary from 4.7 to 5.9% (Eduvie, 1985).

Table 4: Means (kg) of pre-and post-weaning liveweights of Gudali cattle

Station	Strain	BW (kg)	6mth wt (kg)	12mth wt (kg)	18mth wt (kg)	24mth wt (kg)	36mth wt (kg)	Mature wt Kg)
Wakwa	NG	24.2	124.2	162.2	194.4	228.1	417.4	400-563
Bambui	Banyo	24.5	80.7	153.7	183.2	218.2	-	400-408
Dongodaji	SG	22.0	114.0	144.0	199.0	241.0	358.0	499-660
Shika	SG	23.7	87.4	120.5	-	-	-	

SG – Sokoto Gudali, NG - Ngaundere Gudali
Adapted from:Faulkner and Epstein, (1971); Tawal and Mbah, (1989); Tawah and Rege,(1996); Oni *et al.,* (1988); Domingo, (1976); Ngere, (1985).

Table 5: Mean reproductive parameters of Gudali cattle

Station	Strain	Age at 1st Calving (mths)	Calving Interval (days)	Calving Rate (%)	Lactation Yield (kg)	Lactation length (days)
Bambui	NG	48	511.5	54.0	619	221
Wakwa	NG	53.0	536.0	57	374	140
Bambui	Banyo	48	511.6	75	1249	-
Kofare	YG	-	431.0	-	884 – 1247	216-305
Bulassa	SG	43.4	496.0	-	-	-
Dogondaji	SG	40.8	439.0	74.2	-	-
Shika	SG	40.4	378.4	-	1101.3	244.8
Legon	SG	41.0	459.0	33	-	-

SG – Sokoto Gudali, NG - Ngaundere Gudali, YG – Yola Gudali
Adapted from: Gates (1952); Faulkner and Epstein, (1957); Domingo, (1976);Johnson *et.al.,* (1984, 1986); Tawah and Mbah (1989); Tawah and Rege,(1996)

Plate 3: Sokoto Gudal;

Azawak (Azaouak) is another cattle breed found in Nigeria. It is native to the Azawak valley of North-east and it is distributed along its North-west boarder. It is lightly built with medium length horn, drooping ears, and a loose hide. Azawak breed vary in coat colour, but the main colour is primarily red with some white patches. The average height at withers of the Azawak bull varies between 115.7 and 131.4cm and 123.3cm for the cows (Pagot, 1992, Maaouia *et al.,* 2017).Azawak cattle are exploited mainly for meat and milk. The average milk production rate of the Azawak cow vary between 445.5 and672.5 kg with an average lactation length of between 270 to 300 days (Kubkumawa, 2017). Average birth weight is 20.7 kg for males and 19.8 kg for females, while weight at six month stands at an average of 100.4 kg. At 24 months and at maturity respectively, Azawak bulls weigh about 204.8 kg and 393.8 kg, while the cows weigh about 195.1 kg and 292.3 kg (Pagot, 1992).

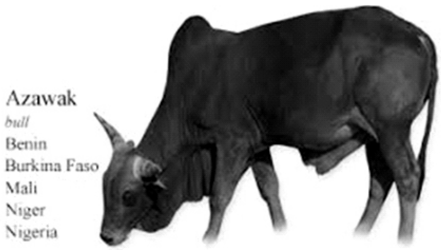


Plate 4: Azawak (Azaouak) bull
Source: Kranky kids education resources programme.

Kuri: The kuri is a large-bodied humpless, long-horn cattle found in the island region of Lake Chad. It inhabits a hot, humid semi-arid region of the Sahel Savannah with temperature range of 14^{0}C to 39^{0} C (Mpofu and Rege, 2002). The coat colour of the Kuri cattle is predominantly white with pigmented mucous membrane (Tawah *et al.,* 1997). It is reputed for tolerance to insect bites. The Kuri cattle are tall among African breeds with long back, shallow body and a large bony rump. Height at withers of the Kuri is about 180cm in the bulls. Heart girth in females is 172cm, whereas in males it ranges from 183 to 112cm. The body length ranges from 133.7 to 144cm in females and 152 to 165cm in males. Kuri have massive bulbous shaped horns with its length ranging from 70 to 150cm, the circumference of which may reach up to 100cm (Epstein 1971; Queval *et al.,* 1971). The females attains puberty early and are very fertile. Age at first calving ranges from 36 to 48 months. Calving intervals range from 15 to 18 months with about 75% of calving occurring between October and April. The bulls are sexually mature at 3 years of age.

The average weight at birth of Kuri calves ranges from 22kg to 25kg, 125 kg to 130kg at 12 months, and 225 kg and 200kg at two years of age for males and females respectively (Mpofu and Rege, 2002). Tawah*et al.,* (1997) indicated that the mature body weights of Kuri cattle ranges from 360 to 650kg with bulls weighing between 500 and 650kg and cows between 360 to 450kg. Average lactation milk yield of up to 2400kg per lactation have been reported (Tawah *et al.,* 1997).

Plate 5; Kuri cow (Mpofu and Rege, 2002)

N'Dama cattle breed is the most representative "Bos taurus" breed in West Africa. The origin of this breed is in the Fouta-Djallon highlands of Guinea. N'Dama are hardy breed of cattle and are well adapted to stressful humid and dry tropical climates. They are known for their tolerance to trypanosomoses, allowing them to be kept in tsetse fly-infested areas. They are also highly resistant to tick-borne infections(Mattioli *et al.,* 1995). The N'Dama cattle are small-sized animals with compact body. They are usually of fawn colour, but their colouration can vary from sand to black and sometimes spotted. Average height of the cows is about 100 cm at shoulder and about 120 cm for bulls (Ngamuna *et al.,* 1988; Claxton and Leperre, 1991; Dwinger, 1992 and Mattioli *et al.,* 1995).

Average birth weight of 19 kg to 22 kg was reported by FAO (1987) in a high and zero trypanosomoses risk areas respectively. Average live body weight of the mature N'Dama cows vary between 250 and 330 kg and average body weight of the bulls between 320 and 360 kg (Payne 1970; Starkey 1982; 1984; Maule 1990; Porter 1991; Pagot, 1992; Mason, 1996; Rege and Tawah 1999). The average pre-weaning and post-weaning performance of the N'Dama calves under both station and traditional management systems are summarized in Table 6.

Plate 6: N'Dama Herd (Aderoju, 2017)

Table 6: Average Production Characteristics of N'Dama and Muturu cattle breeds

Growth Traits	N'Dama		Muturu	
	M	F	M	F
Birth Weight (kg)	17.7±1.0	16.7 ± 0.7	12.5 ± 0.3	12.0 ± 0.2
3 months Weight (kg)	55.1± 2.1	51.4 ± 2.2	36.5 ± 1.3	36.7 ± 1.0
6 months Weight (kg)	89.8 ± 2.4	84.3 ± 2.3	61.2 ± 2.2	61.7 ± 2.5
9 months Weight (kg)	114.8 ± 4.1	109.4 ± 3.9	81.6 ± 3.8	84.7 ± 4.6
Yearling Weight (kg)	129.7 ± 5.1	120.7 ± 6.1	92.8 ± 4.9	95.8 ± 4.8
24 months Weight (kg)	227.4 ± 7.2	190.9 ± 8.1	162.0 ± 6.7	145.8 ± 7.1
36 months Weight (kg)	311.2 ± 9.1	259.8 ± 8.1	162.0 ± 6.7	145.8 ± 7.1
Mature weight (kg)	330.8 ± 20.0	286.7 ± 8.3	-	-
Average lactation yield (kg)	-	588 ± 11.9	-	421 ± 11.0

Adapted from: Payne, (1970); Starkey, (1982); (1984); Maule, (1990); Porter, (1991); Pagot, (1992); Mason, (1996); Rege and Tawah, (1999)

The N'Dama is relatively a low milk producer. The full lactation yield is about 500-600kg (Payne 1970; Mason 1984; Portar 1991). Under the traditional system of management, age at first calving was reported as 48 months and the interval between calvings average 20 months. Under ranching conditions, however, the heifers calve from 35 to42 months (Starkey 1984; Maule 1990)

Muturu: The Muturu cattle breed is a variety of West African Shorthorn. Generally, two types of Muturu cattle have been identified in Nigeria: a larger savannah-type and a Dwarf-Forest type which appears to have evolved through adaptation to the humid forest environment. Most of the Muturu cattle of Nigeria belong to the savannah type, spread over the Benue plateau and smaller numbers are found further to the south-west (Epstein, 1971). DAGRIS (2005) classified the Muturu cattle breed into four separate cattle populations, namely: Ghana dwarf Muturu, Liberia dwarf Muturu, Nigerian forest Muturu and Nigerian savannah Muturu. Nigerian forest Muturu is found along the coastline of Nigeria, from the border with Benin to the Cameroon border.

The Muturu is found in areas heavily infested with tsetse, because this breed has adapted and are naturally selected to be tolerant to trypanosomosis, ticks and tick-borne diseases, although it is susceptible to rinderpest. The typical coat colour of forest Muturu is black and that of the savannah Muturu is black and white. Height at withers is 95cm for bulls and 88cm for cows (Maule 1990). It is the smallest cattle breed known. As a beef cattle breed, it performs well. The growth characteristics of the Muturu are summarized in Table 6. Age of first calving is 635 days and calving interval is 363 days (Roberts and Gray, 1973). However, Ferguson, (1967) reported average age at first calving of 26 months at Ado Ekiti Livestock Investigation Centre under unrestricted mating conditions. At Vom in Plateau State, which is a tsetse-free zone, the average age at first calving was 21 months with dry-season supplementation (Roberts and Gray, 1973). Calving intervals can be as short as 11 to 13 months under intensive ranching or research station conditions (Ferguson, 1967; Oyenuga, 1967; and Roberts and Gray,1973;Olutogun, 1976), but it generally varies from 18 to 24 months under village conditions. Calving occurs throughout the year. Mortality rate of only 2% is reported from research stations, and the mortality rate under village conditions is also very low. An average milk production of 421 kg was recorded over 216 days before 1969 at Ado Ekiti (Olaloku, 1976 andFricke,1979).

Plate 7:HerdedMuturuinvillage.
Source: Adebambo, 2001.

3.2 Sheep and Goat breeds

In Nigeria, sheep and goats are found in large numbers and they account for more than 75% of total ruminant species. They are widely distributed in rural, urban and peri-urban areas (Adu and Ngere,1979; Otchere *et al.,* 1985; Adu *et al.*, 1985).The ownership structure of sheep and goats in Nigeria differ significantly from that of cattle. Although, some seasonal movement of pastoral sheep does take place, the great majority of these animals are sedentary village livestock owned by rural farmers. Their patterns of distribution mirror those of human settlement (Bourn *et al.,* 1994).

Sheep: There are four major breeds of sheep recognised in Nigeria. They are the Yankasa, West African Dwarf (WAD), Uda and Balami. Each of these breeds is well adapted to their natural environment/vegetation ecozones. Management system is mainly extensive and it is similar in both sheep and goats (Epstein, 1971; Adu and Ngere, 1979; Ngere, 1983).

The WAD sheep are highly adaptable to a broad range of environments ranging from the heavily tsetse fly-infested forest zones to the middle belt zone. The Balami and Uda sheep are kept in the semi-arid regions while the Yankasa sheep are found all over the country (Bourns *et al.,*1994).

Generally, sheep mature early. Adu and Ngere (1979) stated that the age at first oestrus was between 5 and 8 months for the WAD breed, 7 and 9 months for Yankasa and about 9.5 months for Uda. First lambing among the WAD sheep sometimes occurs before one year of age (Rombaut and Van Vlaenderen, 1976). Studies carried out in different environments, however, reported that average age at first lambing among the WAD sheep ranged from 11.5 to 20.5months (Adu and Ngere, 1979;Ngere, 1983; Ngere, *et al.,* 1985a&b; Chukwuka *et al.,* 2010). Osuhor *et al*., (1997) reported age at first lambing of 533.1 days (17.8 months) for Yankasa sheep in Shika, while Otchere *et al.,* (1985) reported 19 months. Dumas, (1980) in a comprehensive study of the small ruminants of Sahel reported average age at first lambing of 17 months among the Sahel breeds of sheep which include Uda and Balami while Cardinale *et al.,* (1997) reported average age of 17.9months (Table 7).

Table 7 : Reproductive parameters of Nigerian Sheep breeds

Parameters	WAD	Yankasa	Uda	Balami
Age at First Lambing (mths)	16.27-20.3	16.5-19.9	16.2	16.9
Gestation Length (days)	145-148	150.9-151.9	150.3-153.3	150.3-153.3
Lambing Interval (days)	191-344	253-308	344.8	329.8
Average Litter size at birth	1.22	1.19	1.06	1.10
Fertility rate (%)	121.8	111-121	122.6	128.5
Annual Reproductive rate (%)	110-161	125.6	132.3	146.8

Adapted from: Dettmers and Loosi, 1974; Adu and Ngere, 1979;Ngere, 1983 ;Wilson, 1991 ;Yapi-gnaore *et al.,* 1997; Mbap and Ikechi, 1998; DAGRIS, 2005 ;Momoh *et al., 2013.*

Age at first lambing is influenced by the nutritional status of the animalaccording to Ngere, (1983). Among the WAD sheep, prolificacy varies from between 110 % under village condition and161% on station (Dettmers and Hill, 1974; Vallerand and Brankaert, 1975). Matthewman (1980) reported a lambing rate of 115% in his village survey near Ibadan, while Adu and Ngere (1979) reported 120%. Among the Sahel sheep breed, Adamu(2005) reported prolificacy rate of 146.8% for Balami, 132.3% for Uda and 125.6% for Yankasa. These values are substantially high compared to earlier work of Haumesser and Gerbaldis (1975)who reported lambing percentage of 107% forUda breed. These studies also reported twin lambing but very few triplets. Lambing pattern indicate that the prolificacy in the WAD sheep increases with age, reaching its peak at four years of age. Average lambing interval of eight months is generally reported among the WAD sheep (Adu and Ngere, 1979, Ngere, 1983 and Chukwuka *et al*., 2010). Lambing interval of 306, 344.8 and 329.8 days and lambing rates of 1.19, 1.06 and 1.10 for the

Yankasa, Uda and Balami respectively (Table 7) was reported by Mbap and Ikechi (1998).The shortest interval generally occurs in traditional systems where uncontrolled breeding is the norm (Adamu,2005). In the WAD sheep, annual overall fecundity rate can be as high as 206% according to Rombaut and Van Vlaenderen (1976). Fecundity is the number of offspring born per female of reproductive age per year. High fecundity reflects the performance of a female which exhibits relatively short parturition intervals and is prolific as well. Fecundity is a product of fertility and prolificacy. Mortality rate is generally reported to be high among the young. Rombaut and Van Vlaenderen (1976) point out that this high mortality rate among the young curbs numerical productivity considerably despite the very high fecundity rate among these sheep breeds.

The growth rates of WAD sheep breed have been recorded at various stations. Average weight at birth varies between 1.70 and 2.12 kg and between 11 kg and 12 kg at six months of age for both sexes. At 12 months, weight average of 16 kg for females and 19 kg to 19.2 kg for males has been reported. At two and three years of age respectively, body weight average of 24 kg for both females and males and 24 kg for females and 31 kg for males has been reported (Mark 1983; Oyenuga, 1967; Ademosum 1992).

Table 8: Growth characteristics of Nigeria Sheep breeds

Growth parameters	WAD	Yankasa	Ouda	Balami
Birth weight (kg)	1.7-212	1.6 -3.2	2.95-3.8	2.60-3.80
3 months weight (kg)	7.4-11	11.0	13.05	13.89
6 months weight (kg)	11-12	17.6	19.51	20.95
12 months weight (kg)	16-19.2	19.3-22	29.68	34.50
24 months weight (kg)	24-26	-	-	-
Mature weight (kg)	26-31	30-35	35-55	40-60

Adapted from: Adu and Ngere,(1979; Adu and Buvanendra (1982),), Osinowo *et al.,* (1992); Mbap and Ikechi, (1998); DAGRIS((2005), Momoh *et al.,* (213) Among the Yankasa sheep, Adu and Ngere, (1979) reported average mature weight of 35 kg for the ewes and 21 kg as the weight at first oestrus at 8 months. However, preliminary results from ILCA's work in the sub-humid zone in 1982 indicated slightly lower weights: about 20 kg at 12 months of age and 30 kg at mature weight after 4 years of age. Adu *et al.,* (1985) and Otchere, *et al.,* (1985) reported weight values of 1.6 kg at birth, 11kg at 3 months, 17.6 kg at 6 months and 19.3 to 22 kg at 12 months of age. Mbap and Ikechi, (1998); Momoh *et al.,*(2013) and Bratte, (2015) recorded average birth weight range of 2.39-3.2, 2.95-3.5 and 2.60-3.8 kg for the Yankasa, Ouda and Balami sheep respectively in northern Nigeria.

Plate 8: Flock of Yankasa sheep

Plate 9: Ouda sheep

Plate 10: Balami Ram

Plate 11:West African Dwarf Ram

Goats: In Nigeria, Mason, (1951), Epstein, (1971) and Matthewman, (1977) identified three breeds of goats: the West African dwarf (WAD), Red Sokoto (RS) and Sahel goats. Each of these breeds is well adapted to their natural ecozones. WAD goats are renowned for their hardiness and adaptability and they can survive in most environments. They are spread across the forest and savannah zones of the country. The Red Sokoto goats, on the other hand, are kept throughout the North, mostly in the old Sokoto province spreading east- and southwards through the savannah belt, while the Sahel goats are restricted to a strip along the frontier with Niger and Chad. Although, pastoral Sahel goats are found in the northern semi-arid zone, most of these goats are kept in villages. WAD goats measure about 40 to 50 cm at withers and are stocky with short legs. The head is short and wide, the ears are medium sized and carried horizontally or erect, and the horns are short, wide at the base in males and slenderer in females(Ebozoje *et al.,* 1995, and Chukwuka *et al.,*2010).

The WAD goats are the most prolific of all the domesticated small ruminants under tropical and subtropical conditions and good reproductive performance is a prerequisite for any successful livestock production programme. In small ruminants, reproductive efficiency can be measured by fertility, prolificacy, fecundity and survival. These four parameters together with age at first parturition and parturition interval also measure the reproductive performance (ILCA, 1982). Where breeding bucks are available in the flocks, age at first parturition is a good indicator of early sexual maturity in does.

Age at first kidding of 13 to 14 months on stations and 14 to 18 months under village conditions have been largely reported in WAD does (Adu *et al.*, 1979a&b; Mosi, *et al.,* 1982; Ngere,1983; Sumberg and Mack, 1985; Chukwuka*et al.*, 2010). Fertility and prolificacy among the WAD goats can be as high as 35% for single, 47% for twin, 17% for triplet and 1% for quadruplet births according to Buadu (1972). However, Matthewman (1977) reported 27% to 34% single, 62 to 67% twin, and 5 to 6% triplet births. According to Matthewman, (1977), prolificacy increases considerably with the number of kiddings, averaging 100 to 110% at first kidding, 150 to 170% at second and third kiddings and 200% at fourth, fifth and sixth kidding. The kidding interval averages about eight months (Table 9).

Table 9 : Reproductive parameters of Nigerian goat breeds

Parameters	WAD	Red Sokoto	Sahel
Age at First Lambing (mths)	13 -18	14.5 -15.2	15.26
Gestation Length (days)	145-148	145-155	147-166
Kidding Interval (days)	8 (240 -254)	331-333	258-328
Average Litter size at birth	1.6	1.45	1.08
Fertility rate (%)	124-155	114-124	123.8-124.5
Prolificacy rate	150-184	135-156	119-126.2
Annual Reproductive rate (%)	2.3	1.9	1.4

Adapted from: Dettmers and Loosi, 1974; Adu and Ngere, 1979; Adu *et al.,* 1979; Ngere, 1983; Wilson, 1988 Djibrillou Oumara, (1989);Yapi - gnaore *et al.,* 1997 ; Mbap and Ikechi, 1998; DAGRIS, 2005, Momoh *et al., 2013*

An analysis of the reproductive performance of RS goat of Nigeria from the records of 140 kidding from 96 does, Adu *et al.,* (1979) reported age at first kidding of 435 ± 18·9 days (14.5 months). The mean litter size at first kidding was 1.45. Prolificacy increased with parity, the kidding percentages from first to third paritywas 141, 186 and 200 respectively. However, Haumesser(1975a&b) and Wilson and Wageneer, (1982) under different conditions reported age at first kidding of 457.8 and 426.7 days respectively for the Sahel goats. Fecundity rate among these breeds of goats ranged between 157.1 and 181.5 days and twining rate ranged from 13.5 to 18 percent (Gerbaldi, 1978; Wilson and Wageneer, 1982; Wilson and Traore, 1982). Kidding intervals are generally found to be similar to lambing intervals. Otchere and Nimo (1976) reported kidding interval of 254 days under research station conditions among WAD goats, while Matthewman, (1980) and Putt *et al.,* (1980) reported an average of

8 months interval in WAD goats in Nigeria. Kidding interval among the Red Sokoto and Sahel goats varied between 331-333 days and 258 and 328 days respectively (Haumesser, 1975b; Gerbaldi, 1978; Wilson, 1982, 1984).

Growth and survival are important aspects of overall of productivity according to Sulieman, *et al.,*(1990). Average mortality rate of WAD goats is 15% under village conditions, according to Matthewman (1977). On stations, the mortality rate is sometimes very high, due mainly to *Peste des Petits Ruminants* (PPR) and gastrointestinal parasites. Upton (1987), and Ngere (1983) reported pre-weaning mortality rate 33% and 28.6% respectively. Otchere *et al.,*(1987) and Djibrillou Oumara, (1986) reported pre-weaning mortality rate of between 26.2 and 38% in Red Sokoto goats. The growth rate for dwarf goats is slow according to Wilson (1984), and Sumberg and Mack (1985). An analysis of the growth characteristics of Nigerian goat breeds is summarized in Table 10 below.

Table 10: Growth characteristics of Nigeria goat breeds

Growth parameters	WAD	Red Sokoto	Sahel
Birth weight (kg)	1.16-1.7	1.4-2.05	2.0-2.8
3 months weight (kg)	4.1-7.56	7.56-9.15	5.62-10.88
6 months weight (kg)	7.11	10.3-11.1	13.32-16.58
12months weight (kg)	10.17-10.22	15-17	19.82-22.10
Mature weight (kg)	20-30	27-35	25-50
Lactation milk yield (L)	-	24.5	23.3
Lactation Length (Months)	-	3-4	3-4

Adu *et al.,* (1979) a&b Ngere, (1983), Ehoche amd Buvernendran, (1983), Djibrillou Oumara, (1986), Ebozoje, (1993), Maina *et al.,* (2006), Makun *et al.,* 2008, Youssouf et al, (2014), Birteeb *et al.,* 2015, , Okafor *et al., 2016*

The weight of an animal at birth acts as a guide to postnatal development influencing growth rate and size of the adult animal (Sempho, 1985). The heavier the kid, the higher its rate of growth. Weight at birth varies between breeds mainly because of genetic differences. The average body weight of WAD goats at birth varies from 1.16 to 1.70 kg (Monstma *et al.,* 1981; ILCA, 1982; Sumberg and Mack, 1985; Ebozoje *et al.,* 1995), while that of the Red Sokoto ranged from 1.4 to 2.05kg (Adu *et al.,* 1979a, Ngere, 1983, Ehoche amd Buvernendran, 1983, Djibrillou Oumara, 1986). Average birth weight of the Sahel goats variesfrom 2.0-2.8kg (Akinwole *et al.,*1999, Youssouf *et al.,* 2014). Weight at 90 days according to Fitzhugh *et al.,* (1975) and Ebozoje (1993) is a composite character which provides a better indication of early postnatal development and an indicator of individual growth potential, doe maternal value and the genetic value of the sire. At 90 days, body weight of the WAD goats ranged from 4.1 to 7.56kg (Ehoche and Buvanendran 1983;Sumberg and Mack, 1985), while that of the Red Sokoto and Sahel goats ranged from 7.56 – 9.15 and 5.62 to10.88 kg respectively (Ehoche and Buvernendran, 1983; Djibrillou Oumara, 1986; Maina *et al.,* 2006; Youssouf *et al*., 2014). At maturity the adult WAD goat, on average weight between 20 and 30 kg, while the Red Sokoto goats weigh between 27 and 35kg (Ngere, 1983 and Osuhur *et al.,* 2002).

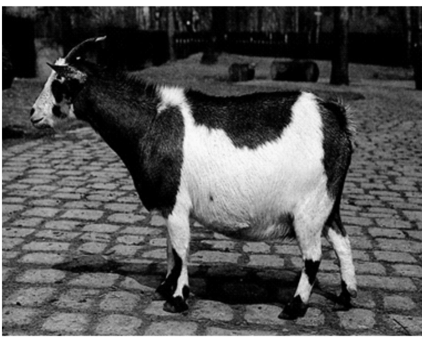


Plate 12: WAD doe

Plate 13: Sahel doe

Plate 14: Flock of Red Sokoto goats

3.3 Nigerian Local Chickens

The Nigerian local chicken constitutes between 80 and 90 percent of the chicken population in Nigeria, the bulk of which are kept by rural dwellers who are mainly crop farmers and largely managed them under extensive production system in small numbers. Reports on local chicken indicated a national average of four per household. (RIM, 1992, Ebozoje and Ikeobi, 1995, Ajayi, 2010,). Under the extensive management system, these birds are exposed to extreme weather conditions which partly account for their low productivity and heavy annual loss (Oluyemi, 1990). Nigerian local chickens are self-reliant and hardy birds with the capacity to withstand harsh weather conditions and adapt to adverse environment partially expressed in disease resistance (Nwosu, 1979; Oluyemi, 1990; Ebozoje and Ikeobi, 1995; Ajayi, 2010).

Several varieties/ecotypes of the Nigerian local chicken have been described mainly on the basis of location. Nwosu *et al.,* (1985) identified three varieties in Eastern Nigeria and classified them as Nsukka, Awgu and Owerri strains while Sonaiya *et al.,*(1995) described five varieties based on performance at Obafemi Awolowo University, Ile Ife, Osun State, Nigeria. They

are the Nsukka, Kaduna, Sagamu, Ilorin and Makurdi varieties. However, Olori, (1994) classified these chicken varieties into three ecotypes (Forest and Savannah or Yoruba and Fulani) based on genetic population. Variations between these populations arise from the adaptation of these chickens to different micro-environmental conditions and management practices (Ebozoje and Ikeobi, 1995). Nwosu*et al.,*(1985) did not report any significant differences in performance between chicken strains studied. However, at OAU, Ife, Sonaiya *et al.,*(1995) reported differences in age at first egg between the strains studied, with the Ilorin strain dropping first egg at 150 days of age followed by the Kaduna strain at 162 days of age. They also reported difference between these strains in other productive traits and disease resistance. Olori, (1994) reported differences in performance between the forest and savannah strains in growth rate, body weight and total feed consumed.
The Nigerian local chicken has also been classified along certain lines determined by the presence and actions of certain genes referred to as major genes. Sonaiya and Olori (1992)reported the identification and operation of feather distribution genes, feather structure genes and sex-linked dwarf gene in the Nigerian local chicken. These genes according to Horst (1989) are tropically relevant, directly influence productivity and quantitative trait loci. The frequency distribution of these genes among Nigerian local chicken varieties have been subsequently reported Peters, (2005); Peters *et al.,*(2007); Ajayi and Agaviezor, (2009).

The Nigerian local chicken is characterized by poor growth and small body size which are not desirable for competitive economic situations (Ibe, 1990; Ebangi and Ibe, 1994). In studies carried out by Akinokun (1975) and Akinokun, (1990), body weight of the Nigerian local chicken was significantly lighter than that of the exotic chicken light breeds. The body weight of the Nigerian local chicken pre-selection at 4, 12, and 20 weeks of age were 129.5g, 628.3g and 968 g for the hen respectively. According to Olori (1994), the body weight of the Forest and Savannah populations varied from 25g to 85g with a mean of

46.1g at 14 days and from 170g-570g at 70 days of age under intensive management system. At point of lay, the body weight of pullets and cocks varied from 0.95 kg to 1.46kg and from 1.48 kg to 1.98kg respectively. The overall mean body weight at point of lay for village-hatched but deep litter raised was 1.14kg. The ranges and coefficient of variations (13-17.9) indicated that selections for higher pullet weight would yield positive results (Omeje and Nwosu, 1984; Essiett and Okere, 1990). The growth rate of these chickens from day old to point of inflection is rapid and did not differ from that of the imported strains (Peters et al, 2007). They possess the potential to grow fast at early stages of life and are therefore fit to be used as parents in broiler chicken development (Akinokun, 1990; Adebambo, 2005).

Plate 15: Nigerian local chicken strain

Table 11 : Some productive characteristics of the Nigerian local chicken

parameters	mean performance	production system	sources
Live weight	1.285kg	Intensive	Ebozoje and Ikeobi, (1995), Ajayi, (2010)
Plucked weight	1.123kg	Intensive	Nwosu (1979)
Carcass weight	0.634 kg	Intensive	Nwosu (1979)
Bone weight	0.212kg	Intensive	Nwosu(1979)
Weight at day old	33.17g	Intensive	Adeleke et al (2010)
Weight at 4 weeks	158.52g	Intensive	Peters(2000) Gunn(2008)
Weight at 8 weeks	571.00g	Intensive	Ajayi(2010) Adeleke et al (2010)
Weight at 12 weeks	844.30g	Intensive	Peters(2004) Adeleke *et al.,* (2010)
Weight at 20 weeks	1.04kg	Intensive	Adeleke *et al.,* (2010)
Egg/hen/year	60-80	Extensive	Nwosu(1979)
	100	Semi-intensive	Nwosu(1979)
	124	Battery cage	Nwosu(1979)
	128	Deep litter	Nwosu,(1979)
% hen day	23.2	Semi-intensive	Nwosu(1979)
	34.1	Battery cage	Nwosu(1979)
	34.5	Deep litter	Nwosu(1979)
Age at point of lay	35weeks	Extensive	Eshiet *et al.,* (1989)
Length of laying period	12 days	Extensive	Eshiet *et al.,* (1989)
No of egg/Clutch	9 eggs	Extensive	Eshiet *et al.,* (1989)
Average number of clutches/year	2.9	Extensive	Sonaiya and Olori, (1990)
Average clutch size	10.4	Extensive	Otchere et.al. (1989)
Rearing period	2.75 months	Extensive	Eshiet *et al.,* (1989
Reproductive cycle	126 days	Extensive	Eshiet *et al.,* (1989
Production life	2.3 years	Extensive	Eshiet *et al.,* (1989

3.3.1 Egg production traits of the Nigerian local chicken

The productivity of the Nigerian local chicken is strongly dependent on management system (Sonaiya and Olori, 1990). Under extensive system, they reported that egg production occurred in clutches with the number of eggs per clutch ranging from 4 to 14 and an average of 9 eggs. Similarly, Eshiet and Okere (1990) reported average of 9 eggs per clutch of 12 days laying period (Table 11). The large variation in eggs per clutch may be due to lack of uniformity in nutrition. The Nigerian local chicken lays throughout the year in an average of 2.9 clutches(Otchere *et al.,* 1990). Average clutch size was 10.4 with a reproductive cycle of 126 days. Omeje and Nwosu (1984) reported average age at first lay of 157 days (22.5 weeks) while Sonaiya and Olori (1990) reported 24 weeks under intensive management system. However, Eshiet and Okere (1990) reported 35 weeks under extensive management system. Under village condition, the Nigerian local chicken produce 60-80 eggs per year (Akinokun, 1975, Sonaiya *et al.,*(1995). However, Nwosu, (1979) observed that the local chicken produced 100 eggs per annum under extensive system and 124-128 eggs per annum under intensive management system. Omeje and Nwosu (1984) reported egg weight at first lay as 25.97g and 40.36g at 52 weeks of age contrary to the claim of Akinokun (1975) who reported egg weight of 36g at 52 weeks of age. Average egg hatch ability was put at 77% with a range of 52-100 % by Akpa (1987).

4.0 Genetics and Livestock Improvement

Animal improvement is a complex process which involves modification of the genotype and the environment in a harmonious fashion. Successes have generally involved either improvement in relatively simple traits like meat and milk yield or weight gain per unit feed consumed, or improvement of a complex of characters by breed substitution. Quantitative genetics is the basic tool of animal improvement. Although animal breeding was practiced long before the science of genetics and the relevant discipline of quantitative genetics were known (Hill, 2014), breeding programs thrive based on sound quantitative genetics principles developed and expounded by J.L. Lush, and formalized in Fisher's infinitesimal model(Mayo, 1989 and Hill, 2014). Quantitative genetics is described as a mature technology that works where a trait with reasonable heritability can readily be increased by simple truncation selection; linear genetic selection indexes can modify sets of traits in predictable ways and crossing schemes perform approximately as expected.

With recent development access to genomic data has created a revolution in which molecular information is being used to enhance response with "genomic selection". The predictions of breeding value utilize multiple loci throughout the genome and, indeed, are largely compatible with additive and specifically infinitesimal model assumptions.

4.1 Application of Quantitative Genetics Principles in Livestock Improvement

Following the rediscovery of the Mendelian theory, attempts were made to accommodate within the particulate Mendelian framework the continuous nature of many traits. A polygenic Mendelian model was first proposed by Yule in 1902 (Provine, 1971; Hill, 1984) and its first full exposition in modern terms was by Ronald A. Fisher (1918) whose analysis of variance partitioned the genotypic variance into additive, dominance and epistatic components. Sewall Wright by then developed the path coefficient method and subsequently showed how to compute inbreeding and relationship coefficients and their consequent effects on genetic variation of additive traits (Provine, 1971). From these basic findings, the science of animal breeding was largely developed (Hill, 2014).

Lush (1896-1982) was the first to adopt heritability in the narrow quantitative genetics sense as the ratio of additive genetic variance to phenotypic variation and to use "accuracy" of a predictor of breeding value to compare alternative selection schemes. Crucially, Lush developed what has become known as the "breeder's equation" for predicting response in terms of selection differential, $R = h^2S$. All breeders appreciated that Lush's breeder's equation $R = h^2S$ applied only to the trait on which selection is practiced.

4.1.1 Breeding Value Predictions

To utilize additive effects, genetic improvement requires identifying the animals with the highest breeding value and selecting them, then replacing them as better ones come along. A major intellectual insight into prediction of breeding value came from C. R. Henderson, a student of Lush and Hazel. He recognized that there were "fixed" effects such as herd and season which had to be included but not estimated, and other, "random" effects, which are samples from a distribution. In the standard index theory of Hazel and Lush, it was assumed that environmental effects were properly corrected for and straightforward to achieve when all animals are reared together but not for bulls with daughters obtained by artificial insemination and distributed unequally around many herds. The breeder's aim is not to estimate the current mean, but to predict the performance of future daughters. This methodology was formalized as BLUP (best linear unbiased prediction) by Henderson (1984). Henderson proposed the mixed model equations, which look like least-squares equations but include the critical shrinkage term for the random effects. They yield best linear unbiased estimates (BLUE) of fixed effects and predictors (BLUP) of random effects (breeding value).

The first widely used BLUP models were in terms of sire genetic effects and within sire deviations, which fulfilled the primary need for dairy sire evaluation and were computationally feasible. But the complete analysis requires the "animal model" in which the breeding value of each individual is defined in terms of effects and the covariance among breeding values of different individuals.

BLUP predictions allow comparisons among individuals in the population that differ in age and amounts of phenotypic information on them and their relatives and incorporate multiple traits. Thus, for example, genetic trends over years and generations can be estimated free of environmental changes.

Henderson (1953) also developed methods for estimation of variance components, *e.g.*, additive genetic variance, in designs with an unbalanced structure typical in livestock breeding; these methods were standard for many years until restricted (aka residual) maximum likelihood (REML, which incorporates BLUP) was developed (Patterson and Thompson, 1971) and computing power became adequate to use it for large data sets. REML is standard in quantitative genetic analysis and beyond. Bayesian methods for mixed models in quantitative genetics has also been stimulated particularly by Gianola and Fernando (1986) and following the development of Markov chain Monte Carlo (MCMC) techniques to facilitate computation, Bayesian methods are increasingly adopted.

4.1.2 Genomic Information in Animal Improvement

The use of genomic information (sequences or DNA marker polymorphisms) for the genetic improvement and selection of animals requires the knowledge of the effect of physically mapped genes with effects on economically important traits or quantitative trait loci (QTL). In Marker Assisted Selection(MAS), the genomic information is combined with the classical performance records and genealogical information to increase selection accuracy, performing selection earlier in life and reducing costs (Boichard *et al.,* 1998; Elsen, 2003). The first markers, blood groups, became available in the 1950s, and methods for linkage analysis were soon developed.

The development of single nucleotide polymorphisms (SNPs) technology and availability of thousands of molecular markers enables Linkage Disequilibrum (LD) association mapping rather than linkage mapping and so higher precision in QTL detection and location can be achieved (Meuwissen and Goddard, 2000). The understanding and training in population genetics stimulated by linkage and LD mapping and the dearth of useful QTL obtained, however, stimulated a more sophisticated view of genetic architecture and of how to utilize the knowledge in improving polygenic quantitative genetic traits. This has led to what is already becoming a major revolution in livestock improvement practice: genomic prediction.

4.1.3 Genomic Prediction and Selection

As dense SNP markers were becoming available and affordable, the landmark article by Meuwissen *et al.,* (2001) showed how whole-genome marker data could be incorporated effectively in a breeding program for a polygenic trait. Subsequent modelling showed how large an impact on genetic progress such a scheme might have (Schaeffer, 2006) and the ideas were rapidly brought into commercial practice (Hayes *et al.,* 2009). This opportunity stimulated more intense interest and activity in both development of statistical inference and methodology and its integration with quantitative genetics in the breeding context.

In conventional methodology, breeding value prediction for animals without records must be made from pedigree, but its accuracy is limited because the Mendelian sampling variation which comprises half the additive genetic variance for unselected parents, cannot be utilized. The genomic information on young animals and the genomic and production data on their older relatives enable prediction both within and across families of breeding values for animals without phenotypes. Benefits are likely to be greatest for traits that are sex limited, such as milk yield and egg production, or not recorded till late in life or post mortem such as longevity or meat content, but increases in accuracy can also be achieved for animals that do have records. Thus, greater rates of progress, up to double, can be made and the costs of genotyping can be at least partly offset by reducing or eliminating progeny testing (Montaldo, 2005; Hill, 2014).

The procedure in which the pedigree relationship matrix in BLUP is replaced by the genomic relationship matrix in BLUP is commonly known as GBLUP and the analysis can proceed otherwise essentially as in traditional BLUP (VanRaden, 2008).

Although, computation is much heavier since the Genomics Relationship Matrix (GRM) does not have a simple inverse but is generally feasible. Basically, the method, as indeed is BLUP, is a form of ridge regression statistical analysis with shrinkage of the least-squares equations according to the degree of genomic relationship. Use of GBLUP is equivalent to assuming that the distribution of marker-associated effects on the trait is the same for all markers fitted across the genome and each is sampled from a normal distribution with the same variance.

5.0 My Voyage in the Beautiful World of Quantitative Genetics and Livestock Improvement

Mr. Vice chancellor Sir, my journey into the beautiful world of applications of the principles of quantitative and statistical genetics to livestock improvement was purely accidental and it started in 1989 during my Ph.D degree programme in Animal Science at the University of Ibadan. On one bright Monday morning in the month of September, I walked into the office of my supervisor and my attention was drawn to a manual on his table written by C.R Henderson and titled 'Application of Best Linear Unbiased Prediction Methods in Livestock Improvement'. A revised and enhanced version of which was published in 1984 when Henderson was retiring from Cornell University, Ithaca, New York, United States of America. As fate would have it, my supervisor, Professor L. O. Ngere, was a Ph. D. student of C.R. Henderson at Cornell University, Ithaca. I took up this manual, flipped through and borrowed it for some days. By the time I was returning it to my supervisor, my mind was made up on the direction and focus of my research. My decision was further enhanced by my interest in statistics. I contacted a number of Statisticians and Programmers at that time who taught me the applications of some basic statistical principles and the use of programmes that help to make valid conclusions. It was not very easy because at the time most of the computer programmes were DOS-based and for some of them, one had to write some aspects of the programmes before it could work successfully. I had to attend short courses in statistics and statistical programming, paying for them from my little stipends and the salaries I received in the early days of my career. The sacrifices I made at that time had paid off beautifully for me today and had launched me into prominence in the field of quantitative and statistical genetics.

6.0 My Research Thrust and Contributions to knowledge

Mr. Vice Chancellor Sir, my research career started under the supervision of Professor Livinus Ngere, one of the first and foremost Nigerian quantitative and statistical geneticists, who was trained by the renowned C.R. Henderson of Cornell University, Ithaca, U.S.A, the proponent of biometrical/statistical genetics, a student and a contemporary of J.L. Lush, who developed and expounded the basic science of animal breeding. Mr. Vice Chancellor sir, I have an enviable pedigree desired by many but only attained by a few. I see myself as second-generation Henderson and because Socrates, the great Greek philosopher once said, "the greatest way to live with honour in this world is to be what we pretend to be", I walked my way up the ladder to become a prominent statistical geneticist.

My research focused primarily on the use of quantitative and statistical genetics principles to develop breeding criteria for livestock improvement and modelling of the performance of pure and cross breeds of livestock over time. However, with the onset of genomic revolution, my research expanded to encompass the application of genomics principles. For this lecture, I will give a brief summary of some of my research findings under the following headings.

6.1 Genetic Evaluation and Adaptive Productivity of Livestock breeds

Mr Vice Chancellor sir, I started my research career evaluating the genetic potentials of the West African Dwarf (WAD) goats and exploiting the productive advantage of the Red Sokoto (RS) goats (a larger, faster growing and early maturing breed) to improve and determine improvement criteria for the WAD goats because previous attempts at improving tropical livestock using temperate breeds had not been very successful and suggestions had been made concerning the existence of possible genetic potentials in the different breeds of goats in West Africa that can be exploited to improve productivity (Amegee, 1984; Timon and Baber, 1987; Cunninghan and Syrstard, 1987).

Our first trial was to compare the performance of WAD X RS crossbred goats to their purebred counterparts, taking into consideration their growth potentials, pre-weaning survival, gene complementarities and combing abilities. We observed and reported that survival rate among these goat genotypes can be substantially increased by utilizing the complementarities of genes effects in addition to improving management systems (Table 12). In addition, we noted that growth was significantly improved among the crossbred genotypes because of general combing abilities among crossbred kids (Ebozoje and Ngere, 1995a&b and Ebozoje *et al.,* 1995).

Table 12: Least Square Means (± S.E) for weights (kg) at birth, 90 and 150 days

	Birth weight		90 day weight		150 day weight	
Variables	No	Means	No	Means	No	Means
Overall Mean	76	1.36±0.02	61	5.37±0.05	58	6.37±0.04
Breed						
WAD	45	1.31±0.01^{a}	35	4.87±0.04^{a}	33	5.88±0.04^{a}
WAD X RS	31	1.44±0.01^{b}	26	6.06±0.05^{b}	25	7.02±0.04^{b}
Sex						
Male	38	1.40±0.01^{a}	34	5.46±0.05^{a}	22	6.46±0.04^{a}
Female	38	1.30±0.01^{b}	27	5.28±0.05^{b}	25	6.26±0.04^{b}
Season						
Dry	55	1.37±0.02^{a}	43	5.66±0.07^{a}	41	6.38±0.06^{a}
Rainy	21	1.33±0.01^{a}	18	5.46±0.06^{a}	17	6.45±0.05^{a}
Type of Birth						
Single	34	1.04±0.01^{a}	32	5.51±0.05^{a}	32	6.49±0.04^{a}
Multiple	42	1.23±0.01^{b}	29	5.23±0.05^{a}	26	6.23±0.04^{a}

Columns with the same superscripts are not significantly different (P>0.05), , S.E Standard error Source: Ebozoje *et al.,* (1995b)

A measure of the heritability and genetic correlation analysis between the traits studied revealed a positive relationship between the various body traits examined as selection criteria for improvement. Increasingly, it was discovered that improvement in one will lead to improvement in many other traits.These results indicated that improvement in productivity can be obtained in the crossbred progenies using a larger breed within the West African region without compromising the productive adaptability of the West African Dwarf goats (Ebozoje and Ngere 1995b, Ozoje, 1997 and Ozoje and Ngere, 2002). This was a major contribution to sustainable development of indigenous animal genetic resources.

These principles were also applied in the study of the efficiency of reproduction and productive performance overtime in pure and crossbred cattle genotypes. Results obtained confirmed marked differences in breed performance and showed that crossbreeding improved the reproductive performance of crossbred genotypes, when the percentage of the exotic genes is not more than 50% (Table 13).

Table 13: Least square means of a ge at first calving (AFC) in months, c alving interval (CI) in days and calving rate(CR) in percentages by genotype of calves by subclass

Genotypes	AFC	CI	CR
BS	40.12±3.60a	475±22.0a	41.35±9.21b
F1	34.45±6.81abc	379±71.40ab	60.50±9.11a
F2	36.46±3.96ab	384.39±25.80ab	63.90±11.02a
F1-ND	42.05±6.22a	360.33±35.91b	46.30±7.04b
F1-BS	31.23±7.01b	477.33±83.86a	52.00±6.74ab
5/8 BS-ND	26.75±5.34c	342.30±68.57b	49.00±7.54ab
ND	43.65±4.23a	479.16±41.38a	29.71±6.50c
Individual heterosis (%)	19.11	22.05	47.80
Maternal heterosis (%)	8.10	12.05	24.00
Overall Average	36.38±3.31	414.07±40.03	47.88±7.11

Vales within a column with the same letter are not significantly different (P>0.05) BS- Brown Swiss, ND – N'Dama

Adapted from Ozoje *et al.,* (2001)

Age at first calving, calving interval and calving rate where significantly reduced among the crossbred genotypes. This is a contribution associated with non-additive genetic effects and gene interactions with the environment supporting the view that improvement in the performance of indigenous cattle breeds can be obtained using exotic breeds in a rotational crossbreeding system up to a maximum of 50% gene combination (Ngere and Cameron, 1972; Rege, *et al.,* 1994 and Ozoje *et al.,* 2001).

An evaluation of the productive life of some genotypes of N'Dama and Brown Swiss crossbred cows revealed that the crossbred stayed longer in the herd and were more productive. Performance increased with increase in adaptation potential measured by the proportion of N'Dama genes they carried. The F_2s and F_1-ND crossbreds appeared to be relatively more adapted than the Brown Swiss and F1-BS (Ozoje *et al.,* 2004). The major reason for cow disposal was reproductive failure and it accounted for about 40% of the total number of cows disposed. The scale parameter (λ) generated from the survival curve (Table 14) and based on Weibull distribution (Figure 3) were generally higher among the purebreds.

Table 14:: Estimates of scale and shape of the fitted Weibull distribution curve along with model and residual means squares

Items	BS	ND	F_1	F_2	F_1-BS	F_1-ND
Scale, λ	0.142	0.122	0.101	0.067	0.075	0.061
Shape, λ	2.09	1.66	2.02	1.86	3.82	1.80
Mean squares						
Model	2.39	2.59	3.21	4.49	4.71	4.73
Residual	0.0072	0.0037	0.0026	0.0034	0.023	0.0021

BS - Brown Swiss, ND - N’Dama.
Adapted from Ozoje *et al., (*2004)

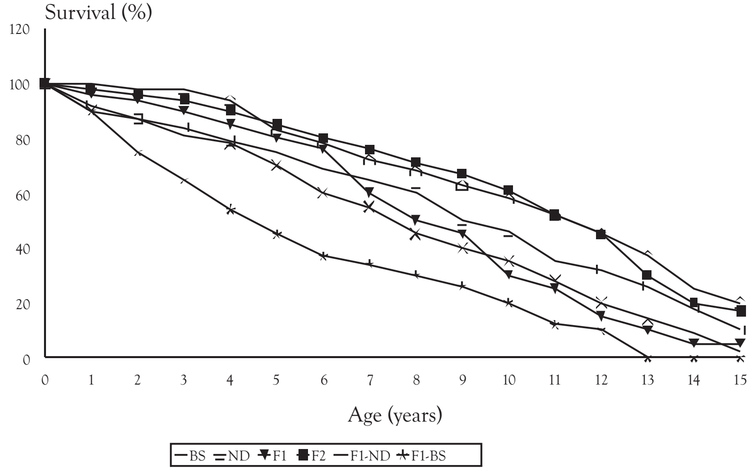


Fig 3: Survival curve for the six genotype groups represented in the herd

Genotype differences were also observed for general death loss, calving and calf survival problems and unsoundness. The ND and crossbred cows with high proportion of N'Dama genes were more structurally sound.

Evaluating the growth performance of the crossbred progenies of these cows in a paper are published in 2005. We observed that genotype significantly affected growth rates and body weight changes over time. The weight advantage of the F1 and BS calves were consistently maintained till 365 days of age (Table 15). However, mortality rate was higher among the genotypes with higher percentage of Brown Swiss genes as showed in Figures 5 and 6 (Ozoje *et al*., 2005). This was not surprising because according to Fisch and Vercoe (1984), increased adaptability is usually at the expense of productive potentials. It is necessary to compromise this attribute to optimize production. Most cattle germplasm in sub-Saharan Africa display great adaptive potentials but exhibit poor productive performance (Ngere and Cameron, 1972 and Rege *et al.,* 1994).

Table 15. Least squares means for birth weight, weaning weight, yearling weight, pre - and post-weaning daily gains by genotype of calves subclass.

Genotypes	Noof Obs.	Birth Weight(kg)	Pre-weaning ADG (g)	Weaning Weight (kg)	Post-weaning ADG (g)	Yearling Weight (kg)
Overall Average	549	24.18 ±2.31	548.53 ± 38.73	136.96±9.85	408 ± 27.98	203.82±7.11
BS	98	31.50 ±2.89a	665.82 ± 22.06a	168.20 ± 8.57a	532.53± 38.68a	253.56 ±9.21a
Fl	92	26.05± 1.81b	667.80 ± 32.40a	163.15±9.91a	496.75 ± 25.09ab	242.71 ±9.1 la
F2	86	22.22 ±.06c	524.71± 25.80b	130.05 ± 8.61b	467.87 ± 29.61b	205.01 ± 11.02b
Fl-ND	91	21.88 ±1.22c	491.83± 35.91bc	123.11±11. 40bc	417.96 ± 23.71bc	194.05 ± 7.04b
Fl-BS	58	24.75 ±1.91bc	552.95± 41.86b	138.31 ± 9.78b	347.83 ±25.72c	1 88.50 ± 6.74b
5/8BS-ND	41	26.75 ±5.34b	481.37± 28.57bc	122.82 ±10.88bc	338.44 ± 22.07c	177.1 l±7.54c
N'dama	82	18.25 ±2..23d	461.26 ± 41.26c	113.10 ±9.89c	328.43± 26.1 Ic	165.81 ±6.56c
CV%		17.59	30.72	22.67	29.85	19.24
Ind. heterosis (%)		7.11	13.05	14.12	15.41	13.75
Maternal heterosis (%)		5.71	7.05	7.91	7.07	6.63

Columns with the same letter are not significantly different (P<0.05).
Adapted from Ozoje *et al.,* (2005)

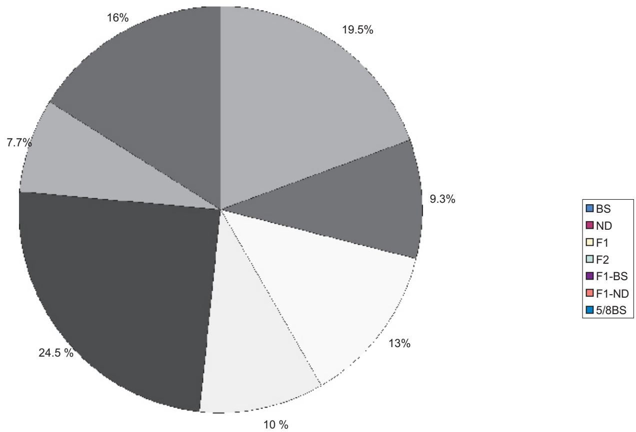


Fig. 4: Percentage mortality at preweaning among pure and crossbred genotypes of N'Dama and Brown Swiss cattle types

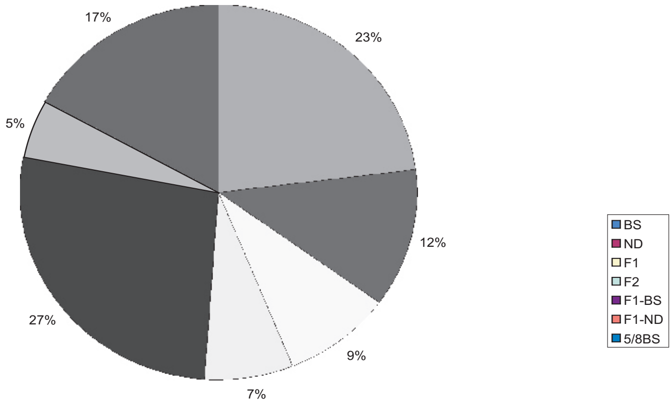


Fig.5: Percentage mortality at post weaning among pure and crossbred genotypes of N'Dama and Brown Swiss cattle types

6.2 Allelic Variations in Qualitative Traits and Livestock Improvement

Another area of focus of my research was the evaluation and exploitation of variation in alleles controlling certain qualitative characters as improvement criteria for economic traits, taking into consideration the pleiotropic nature of most gene actions. The qualitative trait genes I mostly considered were coat colour and wattle genes. Interestingly, relationships were established between these genes and certain quantitative traits of economic importance, thereby establishing criteria for selective improvement using qualitative trait loci. This was a major contribution to knowledge considering the fact that the survival and performance of most breeds and species of animals in this country are left for nature to determine.

The first step I took when this research was started was to examine the distribution profile and allelic frequencies of the selected qualitative trait genes among West African Dwarf sheep and goats. The intent was to study the effective population size of animals carrying the alleles of interest and determine the availability of genetic resource material for utilization in improvement programmes. In a paper, titled 'Coat Colour Genes in WAD Sheep and Goats: A Theoretical Appraisal' and presented at *the World Congress on Genetics Applied to Livestock Production* in 1998, eight alleles were identified at the Agouti Locus in WAD goats and three in WAD sheep. Their gene frequencies ranged from 0.02 to 0.64 in WAD goats and 0.00 to 0.67 in WAD sheep. At the self-colour locus (B), three colour variants were observed in goats and two in sheep with gene frequencies ranging from 0.05 to 0.55 (Tables16,17 and 18). The distribution pattern observed in sheep and goats carrying the undefined white markings were uniform with gene frequencies of 0.19 and 0.65 respectively. The results obtained showed that these genes positively associated with economic traits exhibited moderate to high allelic frequencies which guaranteed a large mating population with little or no threat from mutation, natural selection and genetic drift.

Table 16: : Coat colour variants in West African dwarf goats

Locus	Colour Categories	Allele	No of Obs.	Freq. of occurrence (%)	Possible genotypes
A	White/tan	A^{wt}	53	10.6	A^{wt}/-
	Badgerface	A^{b}	94	18.7	A^{wt}/A^{a}
	Gray	A^{g}	33	6.6	A^{g}/A^{a}
	Bezoar	A^{bz}	31	6.2	A^{bz}/A^{a}
	Swiss markings	A^{sm}	30	6.0	A^{sm}/A^{a}
	Light belly	A^{lb}	17	3.3	A^{lb}/A^{a}
	Mahogany	A^{mh}	15	3.0	A^{mh}/A^{a}
	Gray/badgerface	-	10	2.0	A^{g}/A^{b}
	Gray/swiss markings	-	6	1.2	A^{g}/A^{sm}
	Badgerface/swiss markings	-	5	1.0	A^{b}/A^{sm}
B	Black	B^{r}	102	20.3	A^{a}/A^{a}, B^{r}/B^{+}
	Wild type brown	B^{+}	28	5.6	B^{+}/B^{+}
	Light brown	B^{bl}	10	2.0	B^{bl}/-
S	Black/white markings	S^{sp}	45	9.4	S^{sp}/-
	Wild brown/white markings	S^{sp}	10	2.0	S^{sp}/-
	Light brown/white markings	S^{sp}	6	1.2	S^{sp}/-
	Gray/white markings	S^{sp}	5	1.0	S^{sp}/-

Adapted from Ozoje (1998)

Table 17: Coat colour variants in West African dwarf sheep

		Sheep			
A	White/tan	A^{wh}	167	33.4	A^{wh}/-
	Mouflon	A^{m}	109	21.8	A^{m}/A^{a}
B	Black	B	123	24.6	A^{a}/A^{a}, B^{r}/-
	Brown	b	5	1.0	b/b
S	Black/white markings	S	56	11.2	s/s
	Brown/white markings	S	40	8.0	s/s

Adapted from Ozoje, (1998)

Table 18: Frequencies of the Colour genes in West African Dwarf sheep and goats

	Sheep		Goats	
Locus	**Alleles**	**Gene Freq.**	**Alleles**	**Gene Freq.**
A	A^{wh}	0.18	A^{wt}	0.06
	A^{m}	0.15	A^{b}	0.11
	A^{g}	0.00	A^{g}	0.05
	A^{bz}	0.00	A^{bz}	0.05
	A^{sm}	0.00	A^{sm}	0.05
	A^{lb}	0.00	A^{lb}	0.02
	A^{mh}	0.00	A^{mh}	0.02
	A^{a}	0.67	A^{a}	0.64
B	B	0.57	B^{r}	0.53
	B	0.48	B^{+}	0.42
			B^{bl}	0.05
S	S	0.35	S^{sp}	0.19
	S	0.65	S^{+}	0.81

Adapted from Ozoje, (1998)

In a paper we published in *Small Ruminant Research* in 1998, we studied and compared the reproductive and pre-weaning growth performance of colour variants in WAD goats. Although, fertility rate did not vary much with coat colour, fecundity and prolificacy rate were found to be highly associated with coat colour in WAD goats (Table 19). Goats carrying the black colour allele gave birth at a relatively younger age and had larger litters than goats expressing other colour alleles. We generally observed that the performance increased with increase in pigmentation intensity in coat colour. These results would shift selection pressure in favour of pigmentation intensity and speed up genetic improvement overtime encouraging breeding society for different breeds of livestock species in our environment.

Table 19: Coat colour variation and fertility rate, prolificacy and fecundity in WAD goats

Variables	N	Fertility (%)	Prolificacy (%)	Fecundity (%)
Overall mean	720	150.05±11	182±31	273±39
Coat colour				
Black/Chocolate b rown (E^d, A^a, B^+)	308	162±11a	210±24a	330±39a
Brown (B^{bl})	138	150±14ab	180±30ab	270±29b
White/Tan (A^{wt})	89	142±16b	162±31b	240±35c
Spotted/patched white (S^{sp})	185	148±17ab	188±29ab	282±36b
Test of Significance	*			

Adapted from Ebozoje and Ikeobi (1998)

This paper generated so much interest and citations worldwide that the America pigmy goat society made a brief summary of our results and distributed to every member of the society and Pigmy Goat Breeders Association in America (pygmy goat is the name of West African Dwarf goat in the United States).

Quite a number of my students were trained in this field of research and they are all doing well today. Among them are Tosin A. Adedeji, a Professor of Animal Breeding and Genetics, Ladoke Akintola University, Ogbomoso; Fadare, Adelodun Opeyemi, a Senior Lecturer, Adekunle Ajasin, University, and Ilori, Moses Babatunde, Lecturer 1, Federal University of Agriculture, Abeokuta.

6.3 Multivariate Analyses and Predictive Measures of Performance traits in Livestock Breeds

In my quest to improve the performance of indigenous livestock, some aspects of my research included the use of multivariate statistical procedures to describe the body structure and growth pattern of sheep and goats. Attempting to examine the relationship between body measurement and pre-weaning growth of WAD goats and their F1 crossbred with Red Sokoto goats, Ebozoje and Herbert (1997) developed some prediction equations with which body weight can be obtained from linear body measurement traits with precision rate varying from 95.1 to 99.6 %.

At the University for Development Studies, Tamale, Ghana, where I was a Visiting Professor between 2010 and 2014, I studied variation in body dimensions and characterized the WAD and Sahel sheep breeds with my postgraduate students using multivariate analysis procedures. The results, which was published in *Tropical Animal Health and Production* in 2012 showed two principal components (PC) extracted to discern the structure of the two genetic groups (Table 20).

Table 20 : Eigen values and factor loading after varimax rotation and communality of live weight and linear body measurements of Ghanaian sheep

Character	PC1	PC2	Communality
LW	0.699	0.652	0.913
HW	0.775	0.551	0.904
RH	0.765	0.493	0.828
BL	0.663	0.626	0.832
HG	0.708	0.603	0.865
NG	0.911	0.123	0.847
CD	0.722	0.574	0.850
PBW	0.216	0.942	0.934
Eigen value	6.376	0.599	
Explained variable (%)	79.705	7.486	
Accumulated variable (%)	79.705	87.191	

Adapted from Birteeb *et al., (2012)*

The first PC showed that an animal large for one trait was generally large for all. The second described a subgroup of animals with wide hips. Most of the animals were correctly assigned into their breeds of origin. The most discriminating traits between the two sheep breeds were rump height, height at withers, neck girth and pinbone width. Mahalanobis distance between the two genetic groups was 5.723 ($P<0.0001$). The developed discriminant functions clearly discriminated and classified the Sahel and the Djallonke sheep into their breeds of origin, thus yielding 100%, 93.4% and 90.4 % accurate classification for the rams, ewes and the overall sheep population respectively. The difference between the two sheep breeds may have genetic underpinning which is often facilitated when measurements are restricted to phenotypically pure animals. We concluded that this approach would help in establishing management and conservation policies for the sustainable production of the two Ghanaian sheep breeds (Birteeb *et al.,* 2012).

Analysing the body structure of the WAD sheep in 2014, we employed a multi-determinant approach, using principal component factor analysis to describe the variation in body traits. Extracted factors were varimax rotated to enhance interpretability. The product moments of correlation were positive and significant ($P < 0.05, 0.01; r = 0.18–0.99$) for all pairs of traits. The body traits were categorized mainly into two clusters with the first cluster comprising the heart girth (HG), height at withers (HW), rump height (RH) and body length(BL) while neck girth (NG), CD and pine bone width (PBW) formed the second cluster. The grouping of the traits was slightly different in factor analysis where two underlying principal components (PC) were extracted to discern the variance structure of the WAD sheep. The first principal component which consisted of CD, HW, RH, BL and PBW explained 61.26 percent and the second, 12.92 percent thereby giving a maximum of 74.17 percent generalized variance in body measurements. The traits loaded on the first principal component are closely associated with bone growth hence describing the general body size conformation while the traits (HG and NG) on the second component describe only the thoracic region. We concluded therefore that both the hierarchical cluster analysis and factor analysis grouped body traits similarly but the latter is to be recommended because of the additional ability of indicating the amount of variation explained by the developed factors (Birteeb, Peters and Ozoje, 2014). Similarly, results were obtained in our study with WAD goats when we applied the multivariate principal component analysis to study the morphological characterization of WAD goats in southern Nigeria (Okpeku *et al.,* 2011). Two of these students graduated with Master's degree in Biometry.

6.4 Modeling Lifetime Performance in Nigerian Livestock Breeds

This area of research was a major focal point of my work over the years. In this field, I have trained several students and graduated two Ph. D. students and four Masters' degree students. Unfortunately, some of them see it as a difficult area of research and have tactically veered off. All the same, what matters most is that, wherever they are, they are doing well. According to Winston Churchill, “We shape our buildings; thereafter they shape us” and Alexander the great said and I quote, “I am indebted to my father for living, but to my teacher for living well”.
For a number of years, I studied and predicted growth patterns of pure and crossbred animals using models of different types, comparing different functions and using different prediction criteria. The predictive nature, precision and accuracy of prediction of growth among the different genotypes and breeds varied with the different functions supporting the general claims that growth is not linear in animals. However, the pre-weaning growth period was found to be highly associated with the inflationary growth phase for the genotypes, breeds and species of animals studied.

The first research I undertook in this area was reported in my Ph. D. thesis in 1994, where I compared the growth patterns of pure and crossbred WAD goats using linear, exponential and allometry growth functions. The coefficients of determination which measure the accuracy of prediction were higher with linear equations for body weight (85.6 -95.4%) and allometry for body measurement traits (96.1-99.8%) indicating that growth does not cease at weaning, but crossbreeding alters the average lifetime growth rate changing the shape of the growth curve (Ebozoje, 1997).

Growth curves like other characters that operate in concert with development are critical for the understanding and formation of breeding plans because they shift in response to selection. They are usually considered infinite-dimensional or function-valued traits. Among the statistical procedures available for the analysis of growth data, fitting of non-linear functions offers the opportunity to summarize the information needed to understand the biological phenomenon of growth; an important component of beef production system into a small set of parameters that can be used to drive other relevant growth traits (Lopez, *et al.,* 2000; Perotto *et al.,* 1992;Ozoje *et al.,* 2007,). Modeling the lifetime growth performance of N'Dama cows born and raised between 1992 and 1999 in Fashola Farms, we compared four different growth functions:

Brody	$y_t = A(1\text{-}be^{-kt})$
von Bertalanffy	$y_t = A(1\text{-}be^{-kt})^3$
Gompertz	$y_t = {}_{Ae}\text{-}be^{-kt}$
Richards	$y_t = A(1\text{-}be^{-kt})^M$

We used three different criteria (computational difficulty, goodness of fit based on residual means squares and degree of determination (R^2) to determine the function that best described the lifetime performance of the cows. The fitting of Brody, von Bartalanffy and Gompertz function presented no computational difficulty for any of the cows as all the curves converged to solutions at a short time interval. Evaluation of the goodness of fit based on the average/pooled residuals variance obtained for all the individuals are summarised in Tables 21 and 22.

Table 21: Means ± S.E. of parameters estimates of four growth models fitted for N'Dama cows

Models	Number of animals	Parameters	Means	S.E.
Brody	98	A	251.873	9.71
		b	0.798	0.05
		k	0.072	0.005
von Bartalanffy	92	A	245.436	11.43
		b	0.672	0.06
		k	0.101	0.007
Gompertz	98	A	240.871	9.87
		b	0.571	0.007
		k	0.100	0.01
Richards	92	A	266.467	10.67
		b	0.940	0.04
		k	0.071	0.005
		m	1.090	0.011

Adapted from Ozoje *et al.,* (2007a)

Table 22: Average residual means squares (RMS) for the four growth models fitted

Models	No of animals	RMS
Brody	98	1172.385
von Bartalanffy	92	1472.838
Gompertz	98	1603.806
Richards	92	695.124

Number of cases in which the model specified in the row gave a RMS smaller than the model specified in the column (total number of cases = 92).
Adapted from Ozoje *et al.,* (2007a)

A pair wise comparison between models showed that the Richards functions were superior to the others in terms of the values of average residual means squares (RMS). General differences in fit of the four models as illustrated in Figure 6 revealed that the fit of curves with Richards and Brody varies over the different times periods. This is an important consideration from the standpoint of choosing an appropriate model. A model which yields differences between predicted and actual weight which tends to alternate in signs at short intervals is preferable to a model which yields deviations which tends to alternate in signs at longer intervals.

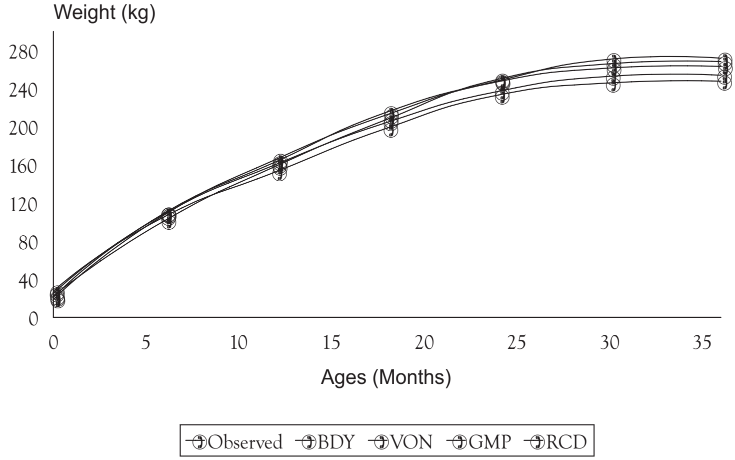


Fig.6: Observed and Predicted growth curve of N'Dama cows using Brody, von Bertalanffy, Gompertz and Richards functions

The distribution of the growth curves according to the values of R^2 obtained with the four models is as shown in Figure 7 and it indicates that the proportion of variation explained was in general high for all the models. The average R^2 values across the 92 growth curves were 0.89, 0.91, 0.92 and 0.93 for von Bartalanffy, Gompertz, Richards and Brody models respectively. Considering the results presented in this study, based on all the criteria used for comparing these models, it was concluded that the Richards function gave the best fit for the data analysed (Ozoje et.al., 2007a).

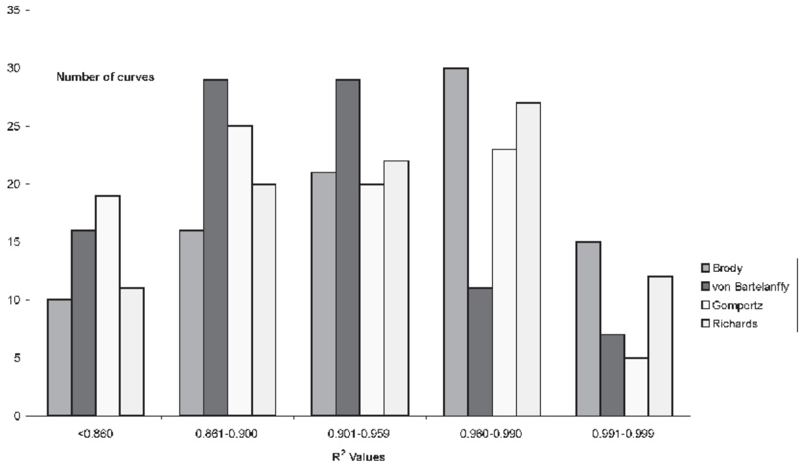


Fig.7: Histogram of the distribution of growth curves according to the computed proportion of variation accounted for ($\hat{R}$ values) by Brody, von Bertalanffy, Gompertz and Richards models.

Analysing the growth curve parameters of these cows, a suitable phenotypic variables for the assessment of growth course and early maturity, Ozoje *et al.,* (2007b) stated that the coefficients of variation were moderately high in both the curve and the predicted parameters except for point of inflection(m) (Table 23)indicating enough room for selection forces to operate successfully. The estimates of heritability for maturing traits ranged from 0.18 to 0.30, while the estimated heritabilities for body weights and growth traits ranged from 0.21 t0 0.47 (Table 24). High correlation coefficients were observed between mature weight parameter (A) and body weights at 180 days, 365 days and 550days of age. Nevertheless, a negative relationship was observed between A and maturing rate index - k,(-0.51) and between A and all maturing parameters associated with stages of growth (degrees of maturity and relative growth rates).

Sire variation was an important source of variation for all the parameters studied except for residual mean squares (RMS) indicating large influence of sire on the entire process of growth within the N'Dama population used. However, the negative correlation between mature weight and maturing rate of index indicates that early maturity cannot be linked to large body size.

Table 23: Statistics of the growth curve and maturing traits parameters predicted from Richards equation

Parameters	Mean	S.E	CV,%
Asymptotic weight, A, kg	265.785	10.671	21.35
Constant of Integration, b	0.931	0.040	10.10
Maturing rate index (k), per day	0.071	0.005	14.81
Point of Inflation, m	1.090	0.011	10.20
Residual mean squares	695.124	17.891	11.76
180-day Weight, kg	109.580	9.893	28.52
365 – day weight, kg	163.471	11.342	25.56
550-day weight, kg	215.564	9.773	23.56
180-day growth rate, g/d	359.62	39.321	30.72
365-day growth rate, g/d	226.43	26.110	29.01
180-day Degree of maturity	0.41	0.081	23.19
365 – day Degree of maturity	0.62	0.110	19.95
550- Degree of maturity	0.81	0.141	17.12
180-day Relative growth rate, $g.d^{-1},kg^{-1}$	3.28	0.611	20.91
365-day Relative growth rate,$g.d^{-1},kg^{-1}$	1.38	0.550	18.89

Adapted from Ozoje *et al.,* (2007b), S.E – Standard error, CV –Coefficient of variation

Table 24: Heritability estimates of predicted growth curve and maturing parameters from the Richards function

Parameters	h^2	S.E
Mature weight,	0.47	0.11
Maturing rate index (k), per day	0.30	0.13
180-day Weight, kg	0.21	0.09
365 – day weight, kg	0.25	0.09
550-day weight, kg	0.32	0.15
180-day growth rate, g/d	0.24	0.10
365-day growth rate, g/d	0.28	0.08
180-day Degree of maturity	0.18	0.09
365 – day Degree of maturity	0. 23	0.10
550- Degree of maturity	0.26	0.14
180-day Relative growth rate, $g.d^{-1},kg^{-1}$	0.19	0.09
365-day Relative growth rate,$g.d^{-1},kg^{-1}$	0.22	0.12

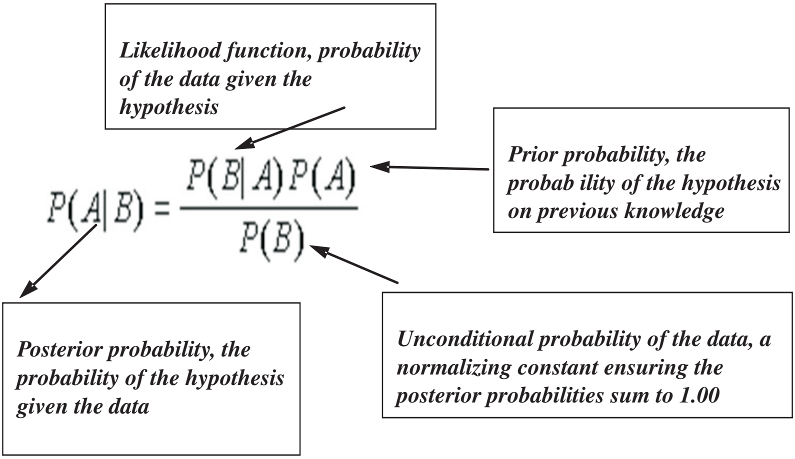
Adapted from Ozoje *et al.,* (2007b)

Working with several of my colleagues in 2005 in a paper published in *Nigerian Journal of Animal Production* (Peters *et al.,* 2005), the growth curve of seven chicken genotypes was modelled comparing Richards, Brody and Gompertz functions for goodness of fit, biological interpretability and computational ease and it was concluded that Brody and Richards overestimated body weight at the early phase of growth. However, the Richards function gave the base estimates of maturing rates. Genetic variation was observed for most of the parameters measured.

With the accumulation of additional data from these chicken genotypes and also having understood that the frequentist theory, whose ultimate goal is the size of p- value and under which *p* -values are framed in the data space, have limitations, we decided to study these data again with a more robust approach - the Bayesian mixed model statistical approach and compared it with restricted maximum likelihood methods in these chicken genotypes using Logistics, Gompertz, von Baertalanffy and Richards functions.

Bayesian statistics is a subset of the field of statistics in which the evidence about the true state of the world is expressed in terms of degrees of belief (Bayesian probabilities). Bayesian estimation and inferenceh as many advantages instatistical modelling and data analysis. The Bayes method for example, provides confidence intervalson parameters and probability values of hypotheses that are more in line with common sense interpretations. It also provides away of formalizing the process of learning from data to up date beliefs in accord with recentnotions of knowledge synthesis. Bayesian methods provide *complete* paradigm for both statistical inference and decision making under uncertainty .It improves on classical estimators in terms of the precision of estimates, because it specifies the priors which bring extra information or data based on accumulated knowledge and the posterior estimate which is based on combined sources of information (priors and likelihoods).

Bayesian method is parameter-free and the user input is not required, instead, prior distributions of the model offer a theoretically justifiable method for affecting the model construction. Secondly, it works with probabilities and can hence be expected to produce robust results with discrete data containing nominal and ordinal attributes. It has no limit for minimum sample size and it is able to analyze both linear and non-linear dependencies. In addition, it assumes no multivariate normal model and allows prediction.



The predictive response of Logistics, Gompertz, von Baertalanffy and Richards growth models were compared based on restricted maximum likelihood (REML) with fixed effect and Bayesian method with normal and student t distributions. Parameter estimates were determined for genotypes, sex and seasons. Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC) and Deviance Information Criteria (DIC) were used to determine model best fit. Overall, the Indian chicken breed, which is a multipurpose breed fit the models better than the other strains of chicken used (White Leghorn, local chicken strains and the FUNAAB Alpha). REML approach with von

Bantalaffy model predicted the asymptotic weight (A) parameter better, while the Bayesian mixed model approach predicted the other function parameters better for all the chicken strains based on student t distribution with the logistic function. The REML and Bayesian approaches with normal distribution were closely related in parameter estimates for all the growth models used. DIC was a better determinant of model best fit than AIC and BIC. Using the Deviance Information Criteria, the Bayesian method (normal and student t distribution) using von Bantalaffy growth function was better in predicting growth pattern providing the best fitted parameters the chicken genotypes used (Abe, 2016; Ige, 2016; Opakunbi,2016)

6.5 Genome Analyses in Nigeria Livestock Breeds

My first major work in this area was to examine the genetic diversity and population structure of Nigerian indigenous goat breeds using DNA markers. Ten polymorphic microsatellites were used and a total of 140 alleles were observed in these goats with expected heterozygosity ranged of 0.599 to 0.921. Mean expected heterozygosity ranged from 0.572 in Red Sokoto goats to 0.892 in WAD goats. Deviation from Hardy-Weinberg equilibrium were statistically significant. Measures of differentiation among the population ranged from 0.048 to 0.191, while some degrees of heterozygosity deficiency were detected as observation for loss in heterozygosity within population values. Genetic distance measured between pair of breeds indicated a lower distance between WAD and RS (0.268) as compared to WAD and Sahel (0.662). The result of this study was published in *Animal Genetic Resources* in 2012 by Moses Okpeku, my first Ph.D. student in Animal Biotechnology.

This work was taken further for better understanding of the importance of genetic diversity for improving selection for animal breeding and genetic conservation programmes by the sequencing of the hypervariable region (HVR1) of the goat mitochondria genome in 291 unrelated Nigerian goat breeds (WAD, RS and Sahel) and comparing them with 336 Indian goats and 12 other sequences of 5 different species of goats around the world. Within and among population variations were 77.25% and 22.74% respectively. Nigerian goats showed high genetic diversity (087). Haplotype groupings in WAD goats separate it from the RS and Sahel concomitant with different demographic history. High genetic admixture denotes different maternal origin for goats (Okpeku *et al.,* 2016).

In 2013, I became interested in the use of candidate gene approach for developing breeding criteria and speeding up selection for improvement of productive traits in livestock. Fertility rate, immune system and adaptive productivity were of particularinterest to me and research group members. After a series of literature searches, we discovered that pregnancy associated glycoprotein gene-1 (PAG-1) has been identified as a pre-natal marker for pregnancy diagnosis in cattle.

The pregnancy-associated glycoproteins (PAGs) are a large multigene family of a larger family of aspartic peptidases expressed in placenta of eutherian mammals and their expression varies spatially as well as temporally during gestation (Butler *et al.,*1982). In cattle, the PAG gene family is comprised of at least 22 transcribed genes, as well as some variants. Pregnancy associated glycoprotein-1 (PAG-1) gene is a trophoblastic protein belonging to the aspartic proteinase super family secreted by different placental cells of many mammalian species. The gene plays vital roles in placetogenesis, foetomaternal unit remodeling and implantation (Jerome *et al.,* 2011). In 2014, we characterized this gene using various bioinformatics techniques because the identification and understanding of the characteristics of the genes encoding those proteins according to Roberts *et al.,* (2008) will be helpful in unravelling the intricacies of embryogenomic functions during pregnancy establishment to improve or increase the rate of fertility in bovine species.

Prediction of protein structure of bovine PAG–1 gene revealed that the entire bovine PAG-1 gene molecule had distinct regions of alpha helices and extended strands separated by random coils(Figure 8).

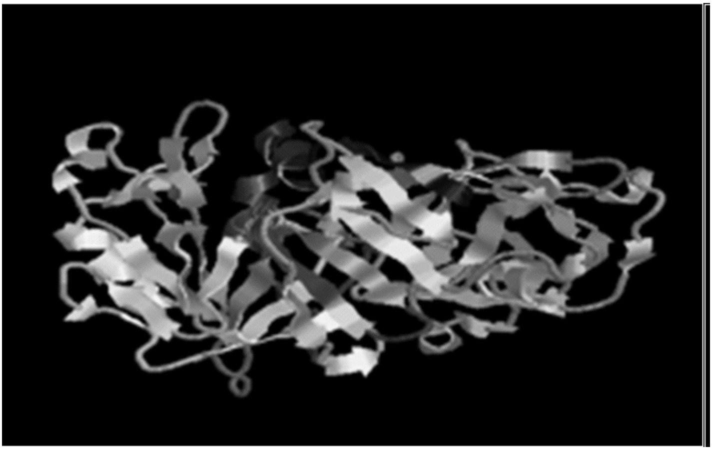


Fig. 8: Tertiary structure of bovine PAG – 1 gene in cartoon model. The alpha helix is depicted as pink coloured spiral sheet and the random coil as blue coloured strain

Bovine PAG-1 protein has an isoelectric potential of 8.98, molecular weight of 42847.0 daltons, instability index of 38.91 and grand average hydropathicity of -0.109. The total number of negatively charged residues (aspartate+glutamine) and positively charged residue (arginine+lysine) in bovine PAG-1 protein were 38 and 43 respectively. The extinction coefficient of bovine PAG-1 was 1.008$m^{-1}cm^{-1}$ at 280nm measured in water and estimated half-life of 30 hours (mammalian recticuocytes, *in vitro*), >20 hours (yeast, *in vivo*) and >10 hours (*Escherichia coli*, *in vivo*). Evolutionary relationship between cattle PAG-1 gene and other PAG family members revealed that bovine PAG-1 gene has the same lineage with PAG-4, PAG-14, PAG-6, PAG-16, PAG-20, PAG-7, PAG-21, PAG-15, PAG-19, PAG-18, PAG-17, PAG-9 and PAG-5. These results were presented in World Congress of Genetics Applied to Livestock Production in 2014.

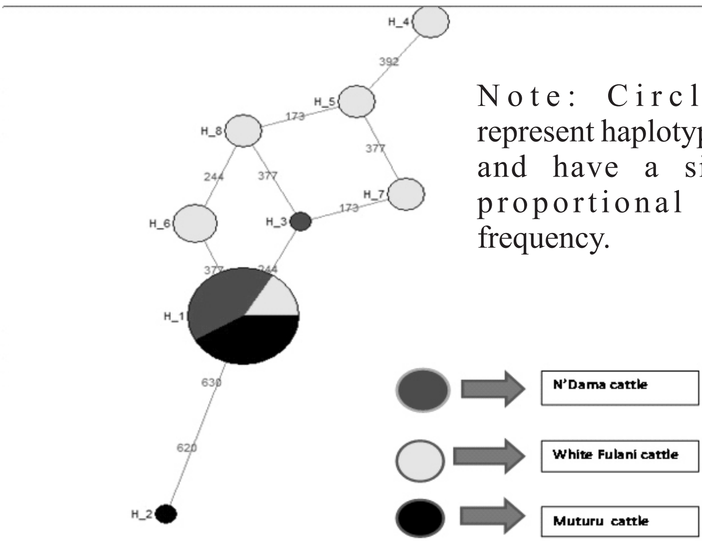
Having characterized this gene, we went further to study its sequence variation in three Nigerian cattle breeds (N'Dama, Muturu and White Fulani). The results, which were presented in the Joint meeting of American Society of Animal Science (ASAS) and Canadian Society of Animal Science (CSAS) in July, 2018 in Vancouver, Canada, showed that six SNPs were observed in exon 4 and surrounding intron of PAG-1 gene of the three cattle breeds. Four SNPs: 173G>A ($\boldsymbol{x}^2$ = 1.75), 244C>A ($\boldsymbol{x}^2$ = 11.11),, 377C>A, ($\boldsymbol{x}^2$ = 20.89) and 392G>A ($\boldsymbol{x}^2$ = 0.51) were observed in exon 4 of White Fulani, while two, 620A>G ($\boldsymbol{x}^2$ = 0.01) and 630G>A ($\boldsymbol{x}^2$ = 17.38), were observed in intron 5 of Muturu. Mutation 244C>A ($\boldsymbol{x}^2$ = 10.41) was shared by White Fulani and N'Dama. Out of the six SNPs within exon 4 and surrounding intron 5 of PAG-1 gene, N'Dama had one transversion mutation which is the only SNP identified within its coding region, Muturu had two intronic transition. Eight haplotypes were identified in exon 4 and the surrounding intron 5 of bovine PAG-l gene with White Fulani having the highest haplotype diversity (0.82), nucleotide diversity (2.7 x 10^{-3}) and average number of nucleotide differences (1.74).Sequence conservation values across the three cattle breeds were high. Haplotype distribution of PAG-1 exon 4 and surrounding introns in N'Dama, Muturu and White Fulani cattle are shown in Table 25.

Table 25: Estimated values of linkage disequilibrium for SNPs in exon 4 and surrounding intron of PAG-1 gene of Muturu and White Fulani cattle

Breed	Site 1	Site 2	Distance	r^2	P-value
White Fulani	173G>A	244C>A	71	0.609	0.000***
	173G>A	377C>T	204	0.048	0.410
	173G>A	392G>A	219	0.195	0.040*
	244C>A	392G>A	148	0.147	0.050*
	377C<T	392G>A	15	0.126	0.100
Muturu	620G>A	630A>G	10	1.000	0.040*

*p-value <0.05, ***p-value <0.001
Adapted from Aderoju, 2016

Haplotype1 was shared by the three breeds while the remaining seven haplotypes were unique to specific populations. Among the seven unique haplotypes, haplotypes 4-8 were specific to White Fulani breed, haplotype 2 was specific to Muturu and 3 to N'Dama.The relationship among the observed haplotypes of exon 4 and surrounding introns of PAG-1 gene of the three cattle breeds is shown in Figure 9. Haplotype 1 was shared across the three cattle breeds. Haplotype 3, 5, 6, 7 and 8 clustered together, while haplotype 2 radiated from haplotype 1 and is clearly separated from other haplotypes.Analysis of Molecular variance (AMOVA) results revealed that percentage variation within population for the gene in the three breeds was greater than variation among populations.



Note: Circles represent haplotypes and have a size proportional to frequency.

Fig. 9: Media Joining network of Muturu, N'Dama and White Fulani PAG-1 exon 4

Recently, I graduated two Ph.D students in this field. One of them worked on molecular and population genetics of interferon regulatory factor -3 gene in three Nigerian cattle breeds and the other worked on the analyses of interferon regulatory factor-5 gene and its association with productive and adaptive traits in Nigerian indigenous chicken genotypes. Interferon regulatory factors are transcription mediators of virus, bacteria and interferon induced signalling pathways and so they play a crucial role in antiviral defence, immune response and cell growth regulation (Barnes *et al.,* 2002). The function of a specific Interferon Regulatory Factor (IRF) is determined by the combination of cell-typespecific expression, its transactivation potentials and its ability to interact with other IRF members. The results of these two works showed that linkage disequilibrum existed among the SNPs identified. Phylogenic studies between exon 7 of IRF-5 gene of the indigenous chicken genotypes revealed that the Red jungle fowl formed the ancestral lineage of Nigerian indigenous chickens. Prediction of selective events revealed that both adaptive and purifying selective forces are acting on IRF-5 in Nigerian indigenous chicken genotypes. With IRF-3, it was discovered that the three Nigerian cattle breeds used shared a single SNP in exons 5 and 6 of the candidate gene but it shared two SNPs with the White Fulani. The Muturu also had the highest value of genetic diversity indices as revealed in variation in exon -3 of the gene (Durosaro, 2018; Mohammed, 2018).

Conclusion

Mr. Vice Chancellor, distinguished guests, ladies and gentlemen, I have during this lecture showed through our research that Nigerian livestock has great genetic potentials, although their present performance status shows that they are late maturing, slow growing and modest milk producers. Our research results with West African Dwarf goats have showed that we can improve their productive performance within the West African region without compromising their productive adaptability. We also noted that survival rate among goat genotypes generated can be substantially increased by utilizing the complementarities of genes effects. Underlying all animal breeding programmes is the fact that neither all animals nor all breeds are equal, and that productivity is an average measure of the efficiency of production which can be expressed as the ratio of output to inputs used in the production process. Our studies also established the need for a paradigm shift in the use of animals with extreme variability of productive adaptability for the improvement of our indigenous livestock species because certain important traits like productive longevity or lifetime performance can hardly be compromised in any production system.

The pleiotropic and thermoregulatory nature of the coat colour genes are very important parts of our research findings. Interestingly, relationships were established between these genes and certain quantitative traits of economic importance, thereby establishing criteria for selective improvement using coat colour distribution in mammalian livestock.

With our multivariate studies and growth functions analyses, we were able to establish that high genetic variability exist for productive traits expressed by these breeds and species of livestock can be exploited for increased productivity utilizing the advantages created by additive gene effects(breeding values). Identification of variable SNPs in candidate genes for example, as shown by my various reports on genome analyses, will speed up selection and developmental processes that will enhance faster rate of productivity because developing countries like Nigeria are faced with the challenges to rapidly increase agricultural productivity to help feed their growing populations.

Recommendations

Mr Vice Chancellor sir, in the course of this lecture, I have chronicled my research career and contribution to knowledge in the last 25 years or so, trying to provide improved breeds for the Nigerian livestock industry. Sir, I have worked and interacted with a lot of people and have visited a lot of developed nations of the world and I know what livestock industry is all about and what makes for growth of the industry. The Nigerian livestock industry is bedevilled with myriads of problems and if this industry must grow and provide the protein need of the average Nigerian, the performance of our local livestock breeds will have to improve significantly.

In many of the developed countries of the world, the livestock industry is one of the biggest money spinners and the largest employer of labour. I came back from the annual joint conference of American and Canadian Society of Animal Sciences held in Vancouver British Columbia, Canada last July and the livestock industry in that country contributes nothing less than 10% to the nation'sGross Domestic Product (GDP).

There are pertinent issues and problems obstructing the growth and development of livestock industry in Nigeria. If Nigeria can muster the will-power to address these problems, the enabling environment will be created to allow Nigeria harness the potentials of its livestock resources with attendant improvement. My recommendations are as follows:

1. **Record Keeping:** Nigeria does not even have accurate records of its livestock numbers, let alone of the performance records of the breeds of livestock in Nigeria. Pedigree record of performance of livestock is needed to define a breeding goal and develop a sustainable breeding programme for improvement. It's so sad that every time any researcher or individual want to initiate research related to improvement in the performance of livestock in Nigeria, they have to start from the scratch, accumulating foundation stock and building reference populations. As a challenge, I would be glad if anyone can either provide us with the records of performance or point to the progenies of the research works our predecessors in the breed improvement programmes of Nigeria livestock. No wonder, somebody once said and I quote "Nigerian Agriculture is on the Run: Refuses to move". We will not

develop this way! Countries with developed livestock industries have standard record-keeping procedure and have records of performance of their livestock. These countries have established National Record Keeping Centres that collate livestock performance records nationwide. It is compulsory for every farmer to send in the records of the performance of their animals well identified. Recently, I visited three dairy farms in Vancouver, Canada, one of which belonged to the University of British Columbia and the other two were privately owned. We w**ere** made to understand that the record keeping process in Canada is stricter than that of the United States of America. Every livestock farmer must, as a rule, send in the performance records of their livestock regularly. The regulators also visit all the farms nationwide. If we have the records of the performance of our livestock, we can monitor their performance and develop national breeding programmes for improvement. Nigeria must set up a national record keeping centre for all its livestock breeds if we really want to improve the performance of our livestock and develop the livestock industry. It is the responsibility of government to set up this centre and fund it as it is done elsewhere in the world.

2. **Management System:** Over 90% of the Nigerian livestock are in the hands of pastoralist and peasant farmers who manage them extensively with little or no control over breeding process. These animals are not identified because they are not tagged and indiscriminate breeding goes on uncontrollably. Identification of progenies becomes very difficult, and therefore, pedigree and lineages are difficult to record. Nigeria must encourage ranching so we can monitor the performance of our livestock and develop breeding criteria and techniques for their improvement.

3. **Policy Somersault:** In the first place, Nigeria does not appear to have a national livestock development policy and even if we have a policy for livestock development today, will it really be sustainable going by the way policy changes in Nigeria once a new government takes over the helms of affairs? As Nigerians, we should learn to sustain policies, especially those put in place for developmental processes. New administrations can improve on the framework of existing policies if they think such policies are not good enough, but to out-rightly discard such is not good for the development of any nation. Alexander the great once said and I quote "Remember, upon the conduct of each depends the fate of all". If we must take our position among the leagues of nations in the world, we must change our attitude in this respect.

4. **Research Funds:** Funding is a major problem for research anywhere in the world. Nevertheless, national development is a challenge and leaders face up to it. Developing the productivity of the livestock of a nation is the responsibility of the nation and its people. No stranger will do it for you. In fact, others would prefer to flood your market with their products than develop yours for you. China just introduced a dairy breed of cattle in the just concluded ASAS/CSAS annual joint conference in Vancouver,Canada. It took them 29 years to develop this breed. No external funding! I am very sure that no external funding agent will give you money for a project that will take 29 years. Funding for development is critically interwoven with policy focus and attitude of policy makers. Winston Churchill ones said and I quote, "Attitude is a little thing that makes a big difference". Every developed countries of the world excelled on the basis of research findings and they put a lot of money into research. Nigeria must learn from them. These countries set up funding research agencies from their annual

budgets for the purpose of development. Examples of such research agencies are USDA and NIH in the United States of America., CIDA in Canada, SIDA in Sweden and Royal Society in the U.K to mention a few. In addition, they encourage organizations to sponsor research locally. Farmers' organizations and breeds societies sponsor research. But in Nigeria, the reverse is the case. Nigerian companies and organization sponsor research in other people's countries for what they want sell to Nigerians. Nigeria needs to amend its laws in this respect. Organizations and companies operating in Nigeria must be made to fund research locally. Again, I quote Winston Churchill who said “It is no use saying, 'We are doing our best.' You have got to succeed in doing what is necessary”.

5. **Breeding societies:** Nigeria should encourage the formation and promotion of breeding societies for its livestock. Breeding societies all over the world set standards for their animals and discourage indiscriminate breeding. They encourage strict record keeping and performance monitoring. Breeding societies fund research and create healthy competition for improvement and productivities. In Kenya for example, the Boran Cattle Breeding Society started less than 25 years ago, today the Kenyan Boran breed of cattle is developing fast and it's now a popular breed for milk production. Its rate of performance in recent years has almost doubled.

6. **Work ethics:** Our work ethics in Nigeria is generally poor. Most times and on the average, we are not thorough and we do not show integrity. This reflects in many things that we do. Imagine a situation where a farm attendant would steal research animals, egg and sometimes deliberately slaughter a chicken because he/she wants to go away with one for a number of reasons. I have also noted that, as a people, we sometimes like to cut corners and in so doing,

we reports wrong research results that are not repeatable. I have heard a lot of people complaint about the Chinese on issues of non-repeatability of research results. Some of us publish similar research results too! I believe as Nigerians generally, we need attitudinal change and a mindset reset.

Acknowledgements

God has been good to me! This day I bow my knees to the King Eternal, Immortal, the only wise God, and the Father of light, the Creator of all things and the giver of life for His immense grace, favours and privileges. His mercies are too much to quantify. He lifted me out of the horrible pit and out of the miry clay, He set my feet upon the Rock and established my goings. Blessed be the name of JEHOVAH for ever!

I have passed through a lot in my life and have experienced a lot too in my life, but the most memorable of them all was when I committed my life to the LORD Jesus Christ. Ever since, like the "Pilgrim Christian", I made the Cross of the LORD Jesus Christ my focus and daily fasten my eyes on it, "lest that by any means, when I have preached to others, I myself should be a castaway". According to John Piper; *Life is wasted if we do not grasp the glory of the cross, cherish it for the treasure that it is, and cleave to it as the highest price of every pleasure and the deepest comfort in every pain. What was once foolishness to us—a crucified God—must become our wisdom and our power and our only boast in this world.*" That old rugged cross is the emblem of our salvation! Therefore regularly, I sing this hymn:

The Old Rugged Cross!

On the hill far away stood an old rugged cross,
the emblem of suffering and shame;
and I love that old cross,
where the dearest and best,

for a world of lost sinners was slain,

Refrain:
so I cherish that old rugged cross,
till my trophies at last I lay down,
I will cling to that old rugged cross,
and exchange it someday for a crown.

Mr. Vice Chancellor sir, I am extremely grateful to my parents, especially my father, Honourable Solomon Abiodun Ebozoje, for his love, commitment and investment in my life and education. He was always there for me when I was growing up. He never stopped teaching and encouraging me. He would relay to me his experiences when he was in school and tell me how to face the difficult situations of life. From his experiences and the books he had read, my father would tell me stories and use them to help mend my ways. My father studied English Language and Literature in English and graduated from the University of Ife, Ile Ife. When I was growing up, he would always tell me and I quote, “Twenty boys cannot always call themselves boys for the next twenty years”. In twenty years, while some would move on and upward, others would drop off and the nomenclature would change. Work hard to be among them that would move on and upward. I believe that today, his wishes for me have been accomplished. I am also eternally grateful to my mother, Mrs. Christy Oleomo Ebozoje for her motherly care, love and affection. She supported my dad and held the homefront when dad was away studying. She is a wonderful mother.I appreciate the love and support of my uncles and cousins. Most of them were there for me when I was in school. I pray that God will continue to keep and uphold them and their families.

My special thanks and gratitude go to my teachers, mentors and people that influenced my career positively, starting with my teachers at the primary and secondary school levels for laying a good foundation for my development. Many of them are always happy to identify with me whenever they come in contact with me. I am indebted to my Ph.D supervisor, Professor Livinus Ngere for the training and guidance I received from him. I am very grateful to the following people who influenced my career in Quantitative and Statistical Genetics positively in many ways. My contact with them either changed my thinking, ways of doing things, and sometimes challenged me to learn more and do more: Daniel Gianola of University of Wisconsin-Madison, he is literarily a wizard in Statistical Genetics, a Professor in three Departments; namely: Poultry Science, Dairy Science and Statistics and Medical Information. William G. Hill, Population Geneticist at the University of Edinburgh, Jerry Taylor, University of Missouri, Columbia, Missouri, Vincent Ducrocq of French National Institute of Agricultural Research (INRA), Carlos Bustemante of Stanford University, California, Romdhane Rekaya of University of Georgia, Athens, Rohan Fernando of Iowa State University and Gustavo de los Campos of Michigan State University.

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I appreciate the current Vice Chancellor of this great University, Professor Felix Kolawole Salako for giving me the opportunity and privilege to present my inaugural lecture, because without his approval, I would not be standing before you today to tell my story. I appreciate his absolute frankness and drive. He is committed to the truth and desires to move this University to an enviable height. God will help you Sir. I appreciate the various and significant contributions of all the past Vice Chancellors of this great University. I pray that wherever they are, God will continue to guide and guard them for the fulfilment of His purpose.

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Now, unto him that is able to do exceedingly abundantly above all that we ask or think, according to the power that worketh in us, unto him be glory……………. throughout all ages, world without end. Ephesians 3:20-12 (KJV).

Mr. Vice chancellor sir, distinguished ladies and gentlemen, “Hitherto had the Lord helped us”. I thank you all for your attention. God be with you.

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